ONLINE PEDAGOGICAL INFRASTRUCTURE AND THEIR EFFECT ON LEARNING IN PUBLIC UNIVERSITIES. THE CASE OF MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY, KENYA

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Curriculum and Instruction of Masinde Muliro University of Science and Technology.

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DEDICATION

To my family; Mother Jane Aoko, Father George Owidi, Wife Colleta and Children; Priscila, Daniel, Rebecca, Shadrack and Bill.

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ABSTRACT

The demand for higher education has tremendously increased in the past few decades. With increased population in universities and unplanned pandemics like Covid-19, technology has provided universities with the infrastructure to facilitate online learning. In accepting these technologies, implementation challenges leave stakeholders dissatisfied. Post covid 19 pandemic exposed universities lack of capacity to conduct online learning and as a result delayed learning occurred. Masinde Muliro University of Science and Technology (MMUST) as a public university also witnessed drawbacks which were pointers to challenges of implementing online pedagogical infrastructure. The purpose of this study was to investigate online pedagogical infrastructure used in public universities and its effect on learning. The study was conducted at MMUST. Mixed methods research design was adopted in this study. The study population consisted of 7,000 students, 400 members of faculty, 60 university management staff and 6 ODEL staff. Stratified and Random Sampling techniques were used to select the respondents. The sample size included 397 students, 210 faculty members, 6 ODEL staff, and 55 university management staff. Questionnaires, Interviews, Observation and Content Analysis were used as data collection instruments. The instruments were checked for content and face validity and piloted in three schools within the university. Cronbach alpha coefficient of internal consistency was used as a reliability measure where alpha (α) = 0.833 and 0.76 were obtained for faculty and students' questionnaire. Data collected was cleaned, organized, and analyzed using tables, frequencies, percentages, means, standard deviations and ordered logistic regression analysis. The study revealed that inadequacy of necessary equipment, absence of approved online learning policy and unreliable internet to support online learning greatly affected the use of online infrastructure for learning. The data collected were used to test hypothesis in order draw relevant conclusions at 0.05 level of significance. The data from students and faculty showed that use of online pedagogical infrastructure does not affect learning ***(Wald =0.07, $X^2_{(1)}$ =17.475, p=4.177)***. It was also noted that the perception of online pedagogical infrastructure users affects learning ***(Wald =1.627, $X^2_{(1)}$ =10.285, p=0.025).*** The study further determined that the challenges currently faced by the university significantly affect learning ***(Wald =0.673, $X^2_{(1)}$ =2.767, p=0.041).*** It is recommended that the university should provide necessary resources, train both faculty and students, employ technical staff in ODEL and more so, improve bandwidth for internet connectivity within the university. The outcome of the study contributes to the body of knowledge by forming an important basis for promoting quality online learning. The findings are envisaged to guide policy makers in the formulation of policies that would ensure appropriate development, implementation, and maintenance of online learning infrastructure.

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ACRONYMS AND ABREVIATION

ANOVA - Analysis of Variance

ATL - Attitudes Towards Learning

BI - Behavioral Intention

BUCERED - Butula Center for Education Research and Development

CAI - Computer Assisted Instruction

CSE – Computer Self-Efficacy

CT - Communication Theory

CUE – Commission for University Education

CVI - Content Validity Index

ERIC – Education Resource Information Center

ESRC - Economic and Social Research Council

FGDs - Focus Group Discussions

HEA - Higher Education Academy

HLI - Higher Learning Institutions

ICT - Information and Communication Technology

ISAP - International Society of Anti-Infective Pharmacology

IT – Information Technology

JISC - Joint Information Systems Committee

LMS - Learning Management Systems

MIT - Massachusetts Institute of Technology

MMUST - Masinde Muliro University of Science and Technology

MOOCs - Massive Open Online Courses

MOODLE- Modular Object-Oriented Dynamic Learning Environment

OCI - Open Content Initiative

ODEL - Open Distance and E-Learning

OECD - Organization for Economic Co-operation and Development

OER - Open Educational Resources

OCLT – Online Collaborative Learning Theory

PEOU - Perceived Ease of Use

PhD – Doctor of Philosophy

PWQ - Perceived Web Quality

SACat – Streaming-Aware Conflict-Avoiding Thrashing

SPSS – Statistical Package for Social Sciences

SSA - Sub-Saharan Africa

TAM - Technology Acceptance Theory

UNESCO - United Nations Educational, Scientific and Cultural Organization

OPERATIONAL DEFINITION OF TERMS

Blended learning

A blended learning approach consists of both in-person classroom lectures and remote asynchronous learning sessions, in which course materials are delivered in person and students engage in discussions within a virtual learning environment. The student is highly dependent on technological resources and engages in independent study.

Computer-based education

Utilization of a computer, whether connected or not, for the purpose of managing, accessing, and presenting vast quantities of data in an innovative, interactive, and engaging fashion.

Distance Learning

refers to instruction that is not continuously monitored by an instructor since students and lecturers are not in the same space or building. However, students derive advantages from the strategic planning, expert guidance, and effective instruction provided by a supportive institution. The term "distance education" pertains to educational settings that emphasize the physical separation between the learner or a group of learners and the learning source.

Distributed learning

In the context of this research, dispersed learning refers to a form of self-paced learning where the practice of acquiring knowledge is divided into shorter intervals over an extended period of time, typically exceeding three months or one year. A learning community that encompasses diverse sources of information, including the active participation of students.

e-learning

Institutional design, development, and delivery of technology-enhanced learning experiences utilizing a variety of media, including video conferencing, audio and videotapes, the web (online), and computers (multimedia CD-ROMs).

Faculty

The term "as used in this study" pertains to the academic personnel comprising assistant lecturers, lecturers, senior lecturers, assistant professors, and professors affiliated with Masinde Muliro University of Science and Technology (MMUST).

Instructional Design:

The practice of developing instructional interventions that facilitate student cognition, learning, interaction, and performance involves adopting a student-centered perspective, anticipating potential challenges, catering to diverse learning preferences, providing meaningful learning experiences, and ultimately enhancing the attainment of desired learning objectives.

Learning

This is the process of acquiring knowledge, skills and attitudes that leads to a relatively permanent change in behavior. This requires mentally reorganizing the acquired knowledge and connecting it with what one already knows. Learning is used in this study to mean knowledge acquisition from the online infrastructure through interacting with online content. This variable was measured through investigating whether the instructional objectives are being achieved or not using observations of online activities, content analysis of online infrastructure by students and Likert scale questions relating to the instructional objectives.

Online Pedagogical Infrastructure

Online infrastructure as used in this study refers to the hardware, software and transmission media used to create intercommunication of computers and users over the internet for the purpose of learning. At Masinde Muliro University of Science and Technology, MOODLE is the main pedagogical software used to facilitate online learning.

Online Learning

Web-based learning, commonly referred to as online learning, is a widely recognized term. The utilization of the Internet and the World Wide Web (WWW) enables students to engage in interactive learning experiences, regardless of geographical constraints, temporal limitations, and physical locations. E-learning refers to a mode of education that utilizes the Internet as a medium for delivering instructional content to individuals or groups of learners who are geographically or temporally distant. Online learning can take place among individuals who are geographically dispersed or among colleagues who are located in the same physical space, using corporate intranets and local area networks (LANs). The defining characteristic of online learning is the utilization of network communication systems as the primary mode of content delivery.

Online Pedagogy

As used in this study, online pedagogy refers to teaching and learning over internet supported infrastructure used by the university, specifically MOODLE.

Prospects

Prospects is used in this study to indicate the likelihood of online pedagogical infrastructure to provide better avenue for learning compared to the traditional face-to-face classroom learning in line with whether it reduces the cost of education, improves accessibility to education, improves academic performance, and whether it facilitates better collaboration and interactivity amongst learners compared to face-to-face learning.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The concept of online learning begun in the late 20th century when the Open University of United Kingdom introduced blended learning in 1969 that played a crucial role in the introduction of distance learning in higher education (Snježana, 2015). Its main role was to provide a wide range of freely accessible educational material with the support of internet-based pedagogical infrastructure (Lane, 2021). The materials that the Open University provided remained copyrighted hence failed the test of the outlined freedom policy at its inception. They also faced resistance since most people valued the traditional face-to-face approach to learning than the new blended or fully online approach.

The Open University later partnered with William and Flora Hawlett Foundation in initiating the Module-Based Open Content Initiative (OCI) commonly known as Open Learn (OpenLearn, 2022). They offered learning materials that were still copyrighted but allowed personalized non-commercial use that allowed modifications in the documents (Aguti, 2015). Although they received a lot of backing from universities, they still failed the test of freedom of online instruction. In a statement, Aguti (2015, p57) states that "there is no perfect technology that can provide effective and conducive learning without human intervention."

In 2001, Massachusetts Institute of Technology (MIT) began publicly availing learning materials on the internet. Like Open University and Open Learn platform, the materials remained owned by MIT and were accessible at a fee (Goldberg, 2001).

Athabasca University (AU) joined the community of Open Online Universities in 1972 and offered its first online course titled “World Ecology”. With the support of the government of Alberta, Australia, it changed its course to make it a government funded institution which offered purely online courses with minimal physical interactions (Alan, 2006). Its online curriculum realized high success rates due to advancement in technology adapted to support online education and funding by the government (Athabasca, 2021). By 2002, 93% of the students were able to access computers for internet-based education use at Athabasca University. These computers had 80% access to stable internet connectivity which greased the wheels of web-based education within Athabasca University (Alan, 2006).

The efforts of these initial institutions have received compliments from several collaborators as many universities now use online learning. In the last decade, the Higher Education Academy (HEA) – which is a scheme for professional membership based in United Kingdom (UK), whose role is to promote excellence in higher education, and the Joint Information Systems Committee (JISC) - a non-profit organization that provides digital solutions for UK education and research, promoted the use of Open Educational Resources (OERs), which are resources for learning and teaching made freely available on the internet (JISC, 2012).

According to Hanna & Wood (2011), the education consortium of Harvard and MIT, and the Coursera Online Initiative which partnered with Princeton University, Stanford University, University of Michigan, and University of Pennsylvania rapidly advanced a large quantity of freely accessible online courses for their students. They provided full programs with assessment modules and collaborative learning

environments. At the early stage of inception, they faced various challenges that they had to overcome before achieving the success of online education (Aguti, 2015).

Online education is conventional in numerous ways (Makokha & Mutisya, 2016). The question of whether or not online courses or programs of study are superior to in-person degrees has generated considerable debate (Snjeľana, 2015). The suggestion is that online courses ought to exhibit a positive distinction or be superior to in-person classroom experiences. Merely transferring hard copies of printed materials to a digital platform does not contribute to student learning any more than assigning them reading material and observing them while in class (Lynnette, 2004).

A study by Lancelord (2017) at the university of South Africa (UNISA) on students' perception of online learning indicated that most students faced challenges based on how learning is facilitated on the online platform. The challenges he identified ranged from administrative, policy, technological and attitude of the learners. At the same time, he found out that if properly implemented, it could effectively promote learning. This is because a section of learners preferred a particular unit to be handled online rather than face to face.

In developing countries, Kenya included, there is a notable shift towards online education (Salmon, 2018). Every university, although facing a lot of technological challenges, is determined to use online infrastructure to facilitate learning. This has been caused by a surge in demand for higher education, resulting from 100% transition policy declared by the Ministry of Education in Kenya which has seen university enrollment expand tremendously (Salmon, 2018). Salmon further explains that limited facilities at the universities, insufficient number of staff, and limited funding by the government, has elevated the need for online education. Varied

platforms and infrastructure like MOODLE, Blackboard Learn, WebCT are examples of the infrastructure that the Kenyan Universities have adopted.

Eventualities like Covid-19, which barred learners from physically accessing learning institutions also led to the rush and adoption of online infrastructures to facilitate online learning. Lynnette (2004), however, explains that until all the universities and other learning institutions reach the level of technology excellence, there will still be three elements of "online" interaction: *Face-to-face with some Online Instruction, Online Instruction with some on-site requirements* and *Purely Online Instruction.* She further states that if purely online education was implemented without infrastructural readiness, then it would be rushed revolution which will negatively alter the meaning of education and main objectives of instruction.

Besides the challenges of Online Learning Infrastructure, there are many notable benefits such as: widening access to the reach of many learners in a flexible manner, increasing the efficiency in the administration of online learning, improving technology-supported pedagogy, training, increasing the research quality and reducing the rate of public spending on education (Arkorful & Abaidoo, 2014). According to Ssekakubo, Suleman, & Marsden (2011), most third world countries, online learning projects either fail wholly or partly therefore failing to deliver on their promise. As revealed by Nyerere, Gravenir, & Mse (2018), 90.8% of the e-learners were dissatisfied with the online learning delivery and 85.6% of the e-tutors indicated that they were demoralized in performing their responsibilities in online learning.

Determining the prospects and challenges of online learning regarding their effects to learning can be analyzed in various perspectives; the challenges may or may not

significantly affect learning and the prospects can make the learning in online platforms better (Patil, 2015).

Research by Khadiza & Meher (2022) in Bangladesh indicates that student's attitude has positive effect to the online interaction, the use of internet, self-efficacy, and self-determination of the students. This shows that the attitude of the users of any online pedagogical infrastructure affects the process of learning. Abdullah & Azzedine (2011) however indicate that the course design and technical support affect the attitude of learners towards using online infrastructure for learning.

Nwankwo (2015) and Kooli et. al (2019) found that there was a general negative attitude towards the implementation of the online learning platforms. With hurried implementation of the online learning systems was a contributing factor to the negative attitude. Online pedagogical infrastructure therefore needed to be investigated to determine their effects on learning in public universities in Kenya. In carrying out this investigation, it was important to establish the status of what is currently being done at the university, the effects of the processes being carried out on learning, the attitude of the system users such as faculty members, students, technical staff, and university management on using the online infrastructure.

MMUST is one of the universities on the verge of implementing full online learning for numerous courses using MOODLE, (an acronym for Modular Object-Oriented Dynamic Learning Environment), as the online pedagogical infrastructure. It is an open-source Learning Management System (LMS) used to facilitate online learning.

Speaking to one student at the university why he could not do his examinations online, he responded by saying:

> *"I have never known how to navigate the learning system being used for online learning, I also didn't know where the examination link was and therefore, I got stack".*

While trying to implement online learning system, a situation arose where the university faculty had to teach face-to-face (traditional approach) besides teaching online before they could administer classroom-based examinations after realizing that nearly half the university students did not sit the online examinations.

Another student giving reasons why he declined to do the examinations after studying online, said;

> *"...In examinations you write what you have been taught or what you have learnt, to me I didn't learn anything, the materials were scattered all-over and choosing what was relevant was difficult. Online video classes could not work because of internet connectivity."*

A senior lecturer in the School of Education regarding challenges he experienced with the online examination said:

> *"I don't know what went wrong, only 200 students were able to sit my examination out of a total of 1200".*

The question therefore was, why were more than half of the students not able to sit online examinations?

A post-graduate student who had enrolled in the ODEL platform and interacted with the system for one year had to register for face-to-face mode again to continue with her studies, in her remarks she stated,

> *"...we have not done much, and I feel I wasted a whole year...".*

The question is why were these students feeling dissatisfied? Online learning being an emerging field and not fully developed, especially in developing countries, most

recent studies like (Alan, Paul, & Brian 2016, Zozie 2020, Salmon 2018, Aguti 2015 & Lynnette 2004) focused on how to effectively develop online instructional systems and infrastructure with very few studies focusing on the effects they pose to learning.

Interaction and socialization are keys to effective online education. Unfortunately, the online infrastructure provides minimal use of interaction and socialization amongst students. Triggers of the challenges that both the students and faculty members face on the online learning infrastructure are based on the factors that hinder interaction and socialization (Zozie, 2020).

1.2 Statement of the Problem

Online learning has many promises and opportunities (Alham, 2021). Despite this, universities face implementation challenges in e-learning leaving the stakeholders with uncertainties on its effectiveness (Al-Azawei & Domninic, 2018). A post Covid-19 pandemic analysis of online learning indicated that most public universities lacked the capacity to conduct online learning (Colin, 2022). This led to delayed learning due to inadequate online infrastructure to facilitate the process (Jack, 2022). MMUST is on the verge of implementing online pedagogical infrastructure. Being a university, whose vision is to be a premier university in science, technology, and innovation, it is expected that it would have a seamless online pedagogical infrastructure that would enable uninterrupted learning. However, during the pandemic, it witnessed several drawbacks which were indicators to challenges of implementing online pedagogical infrastructure.

According to George and Mutisya (2017), MMUST did not have a clear e-Learning policy in spite of having a functional ODEL directorate. Furthermore, there was no e-Learning policy on the university website (MMUST, 2022). MMUST being a

university of science and technology, it is expected that there exists effective integration of technology in all its functions including its core mandate, which is teaching and research. However, there are questions that remained unanswered. This is with respect to ease of use of the pedagogical infrastructure, challenges of online examination, the preference of Zoom, Google Meet and Microsoft Teams instead of MOODLE. These unanswered questions led to the need to find out the current methods and practices of online pedagogical infrastructure in MMUST. It is against this background that this study was formulated to investigate the online infrastructure and their effects on learning in public universities.

1.3 Purpose of the Study

The purpose of this study was to investigate online pedagogical infrastructure in order to establish its effect on learning in public universities.

1.4 Objectives of the Study

The objectives of the study were;

i. To Establish the status of online pedagogical infrastructure used at MMUST.
ii. To determine the prospects of online pedagogical infrastructure and how they affect learning in MMUST.
iii. To determine the effect of using online pedagogical infrastructure on learning at MMUST.
iv. To investigate the challenges of use of online pedagogical infrastructure and how they affect learning in MMUST.
v. To establish the attitude of users towards application online pedagogical infrastructure in facilitating learning in MMUST.

1.5 Research Questions

This research sought to find answers to the following questions:

i. What is the status of online pedagogical infrastructure used in MMUST?

ii. What are the prospects of online pedagogical infrastructure on learning at MMUST?

1.6 Hypotheses

The research was guided by the following research hypotheses which will be tested at 0.05 level of significance:

HO_3: Use of online pedagogical infrastructure has no effect on learning in MMUST.

HO_4: Challenges of use of online pedagogical infrastructure have no effect on learning in MMUST.

HO_5: Perception of users of online pedagogical infrastructure has no effect on learning in MMUST.

1.7 Justification of the Study

The rationale for advocating for effective online learning is based on the premise that online learning technologies are not fully utilized. Although the term online learning has often been used by various scholars in universities worldwide, there is still inadequate research focusing on its use, prospects, and challenges in promoting effective learning in comparison to traditional face-to-face learning.

Prior to Covid-19 Pandemic, Universities in Kenya did not give much thought to having online infrastructure that could facilitate online learning. In the past two years, Kenyan universities have been on the verge of implementing online learning. There is

need for these institutions to apply good practices that facilitate effective online education and address challenges of using the technology.

This study was necessary because many universities may make mistakes of having an online infrastructure that does not enable learners achieve educational objectives and thus produce ill-prepared graduates who do not meet the requirements of the employment industry. Hughes et al., (2006) argue that developers of online learning are preoccupied with developing more advanced technologies for online learning systems rather than providing the practitioners with leverage to offer effective learning and teaching processes. Zozie (2020) suggested that it is important for the researchers to investigate the Perception of students and members of faculty as they use online infrastructure, the prospects and challenges of applying online infrastructure in teaching and learning, user-support on these infrastructures and how the age of faculty affects the use of online infrastructure.

1.8 Significance of the Study

Since online learning was considered applicable in the education sector, many institutions and policy makers have been looking forward to finding solutions to the problems of online learning. The findings of this study will hopefully be of great importance to the Universities adopting online learning platforms, Instructional Material Designers who are tasked with the responsibility of designing online learning resources to acquire skills of designing learner friendly online resources, and Institution Policy makers in laying down required standards for online infrastructure. The findings may be helpful to the faculty tasked with the responsibility to handle online learning by enabling them to inculcate good online learning practices and understand how learners feel about online learning environments.

The findings of this study could help in identifying the key tools and technologies that a university should have in place to support the implementation of online learning. The findings of this study form the basis upon which higher institutions of learning will be able to identify the unique challenges that affect proper implementation of online infrastructure and how these challenges can be resolved or forestalled.

1.9 Scope of the study

The study was conducted in MMUST located in Kakamega County, Kenya. The population of the study were students, faculty, ODEL staff and the University Management. The focus of the study was the status of online pedagogical infrastructure used by the university, prospects and challenges of the infrastructure and how they affect learning, effects of using online infrastructure on learning and finally the perception of the users of online pedagogical infrastructure. Regarding the status of the infrastructure, the study looked at; tools supporting document processing, equipment for supporting online learning, ease of use of the online infrastructure for the faculty members and students, and finally assessment of courses taught online. The study was guided by communication theory which was supported by Technology acceptance Theory (TAM), Online Collaboration Theory and E-learning Theory. Mixed Methods Approach to answer the research questions.

1.10 Limitation of the study

Ordinal data was collected using both the faculty and students' questionnaires. During the analysis, ordered logistic regression was used which requires the outcome variable to be categorical in nature. This was a limitation since data had to be analyzed based on whether the infrastructure has effect on learning or not restricting other factors that could have partially contributed to learning. To counter this limitation, analysis was

therefore conducted on the basis of how much the respondents agreed or disagreed with various independent variables as factors affecting learning while using the online infrastructure. Similar studies in future could adopt the use of interval data to further avert this limitation and confirm the findings of the study.

The population used in this study included the faculty, students, ODEL staff, and the university management. Among them are those using online infrastructure for teaching and those not using it. Of interest to the present study were their views on online infrastructure use for teaching and learning regardless of whether they use it or not. This limited the respondents who did not use the online platform since they did not have appropriate information regarding online learning. To handle this limitation, the statements in the questionnaires were simplified and during interviews, the researcher was able to probe for more information on questions raised thereby getting enough views to complement data collected from questionnaires.

With limited accurate published data from relevant institutions regarding the success of online learning implementation in public universities in Kenya, the study relied on the information published on the various websites of public universities. This was a limitation regarding secondary data since the findings of the present study may be generalizable to all the public universities in Kenya. The study therefore relied on published documentations of public universities in other developing countries to compare its findings.

1.11 Basic Assumptions of the study

In studying the online pedagogical infrastructure used by public universities and their effects on learning, it was assumed that:

- Faculty members have used or interacted with online learning platforms within the university.
- There is a high access to the online learning platform within the university. The contrary was expected to be true for students who access online learning resources away from the university.
- Students use online learning platforms for various courses.
- The university had the necessary equipment to support online learning.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature on online infrastructure. It begins by looking at what online infrastructure is, then the status of online infrastructure in various institutions in general, prospects of online infrastructure, effects of using online infrastructure, challenges of online infrastructure and the perception of online infrastructure users. The literature further looks at the theoretical framework and conceptual framework upon which this study was based.

An extensive literature with up-to-date and reliable reference was undertaken. The sources of literature used in this study included theoretical literature, empirical and general literature as documented in; paper-based journals, books, electronic journals, conference proceedings, relevant databases (SACat, ERIC, ISAP), and websites of research papers, and journals of online educations. The various bibliographies of articles and journals provided rich sources for further literature review.

The figure 2.1 below indicates the diagrammatic overview of how the literature review was conducted.

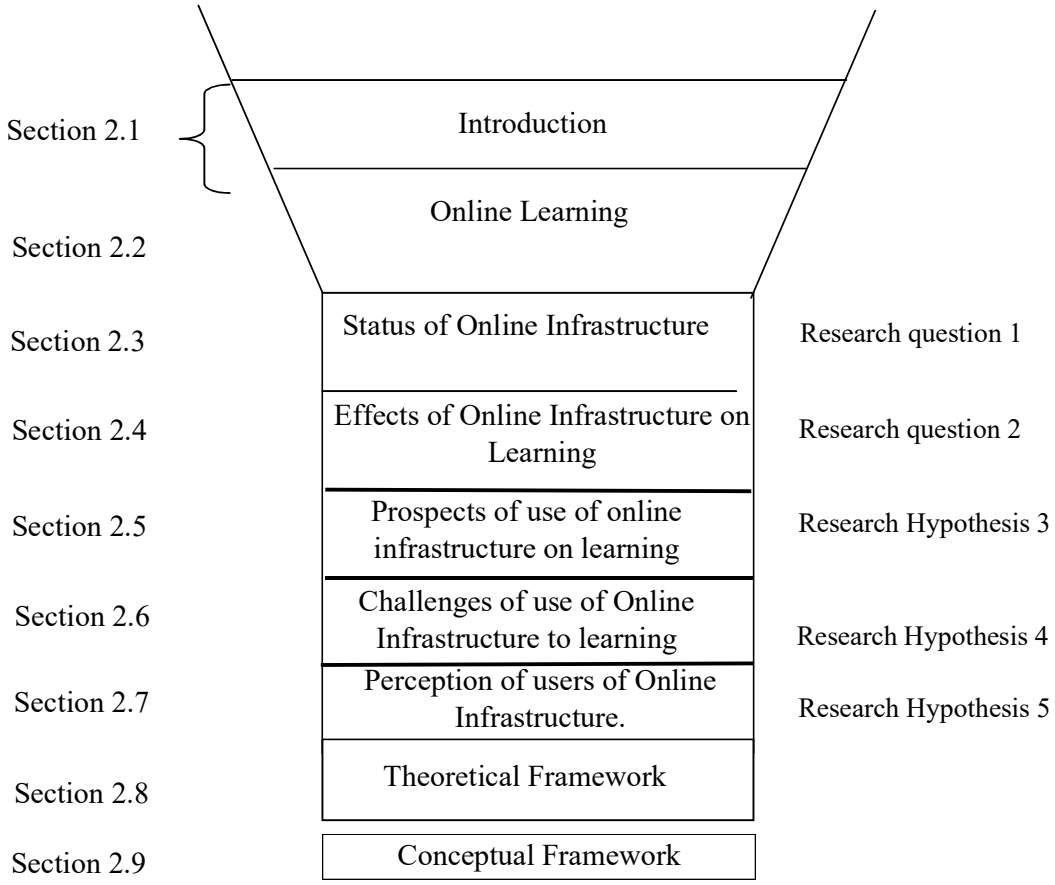

Figure 2.1: The Diagrammatic Representation of the Structure of Literature Review

2.2 Online Learning

Online learning is a form of learning that relies on the Internet as the primary delivery mode for presentation and communication of curriculum to students irrespective of time and geographical location (Appana, 2008). The concept of online learning begun in the late 19th century when the Open University of United Kingdom introduced blended learning in 1969. This innovation played a crucial role in the introduction of distance learning in higher education (Snježana, 2015). Its main role was to provide a wide range of freely accessible educational material with the support of internet-based pedagogical infrastructure (Lane, 2021).

Various platforms have played important roles in ensuring that online learning is a possibility in universities. The most popular online learning platforms includes; Blackboard Learn, Moodle, NEO LMS and Open edX (Liu, Lomovtseva, & Korobeynikova, 2020).

There are potential benefits that have been realized by universities who have successfully invested in online learning. Such benefits include; increased access to education, lowered cost of education, improved quality of learning, lifelong learning, better preparation of students, profit making and reduced infrastructure cost (Aguti, 2015). Despite the numerous benefits, limitations have equally been evident in this popular learning environment. Such limitations include; high initial cost of implementation, insufficient organizational preparedness, technology phobia amongst users, and unavailability of necessary equipment to support online learning.

2.3 Status of online pedagogical Infrastructure in Universities

Online infrastructure also known as Web Application Infrastructure or Web Infrastructure refers to the physical hardware, software and transmission media used to create an interconnection of computers and users on the internet (BitPipe, 2021). BitPipe further explains that this infrastructure includes use of computers, Internet Servers, Internet Storage, Web Servers, Internet Network Equipment, and Infrastructure software. The present study focuses on the online pedagogical infrastructure used in public universities.

Successful online learning implementation requires that a university must first identify the need for online learning, formulate a policy document, involve experts, acquire necessary technologies and train faculty members on the use and importance of online learing (Alan, Paul, & Brian, 2016). These findings are relevant to this

current study since there is need to understand challenges regarding the aforementioned factors in public universities in Kenya.

Implementing online learning and digital integration is a process that cannot be done at once. An institution must ensure that all necessary preparations are in place before they can begin to implement online infrastructures (Clark & Mayer, 2016). Even though their findings indicated that the implementation process cannot be done at once, close attention must be paid to good online learning practices used by various successful institutions. It is therefore necessary in the current study to understand online infrastructure operations of the public universities and whether the operations have led to effective online learning.

Introducing e-learning into university education brings about diverse changes in economical, organizational, and technical level, however, the current observable practice in Kenyan public universities shows that e-learning has been without putting much consideration of the expected benefits that can be measured (Aguti, 2015). It is important for the public universities to understand the prospects and challenges of online learning so that the policies may be aligned to them. The insights made by Aguti have therefore prompted the questions; how do they use online pedagogical infrastructure facilitate learning? And how ready are the universities to fully implement online learning in developing countries?

Online learning has become necessary to all levels of education in Public Universities. Arguments by Aparicio, Bacao, & Oliveira (2015) on their study indicates that online learning systems have witnessed an increase in research and usage in the past decade. Post covid-19 pandemic recorded a high uptake of online learning where learners did not have to physically go to the universities to learn. They applied for courses online,

verified fee payment online, studied online, accessed their academic performance online and even attended online graduations with the support of technology. They further stipulated that users, technology and services are key dimensions that comprise online learning infrustructure. Despite the benefits that these authors mentioned, online infrastructure had indicated problematic circumstances to its users with regard to resource usage and access. Students and faculty members therefore became stranded when they could not meet their expectations on the online system. They however did not give the necessary interventions that could be implemented to avert such scenarios.

Online infrastructure comprise of three basic elements; hardware, software and user-support team Abdul (2020). The three must operate together for successful online learning. Without sufficient hardware, it is difficult to operate software and even provide support to online learning infrastructure users. It was however noted that little had been done to ensure availablity of the three elements in universities implementing online learning.

For sustianable global education to be realized, online learning infrastructure provides a platform for universities to provide increased access to quality education. In investigating the growth rate of online infrustructure usage in universities, OECD, (2012) and Kong et. al (2018) found out that there was 65% and 85% growth rate world wide respectivly. This indicates there is increase in adoption of online learning worldwide. Zinn (2000) and Mason & Rennie (2006) documented a chart of termilogies that various scholars have given the process of learning with the support of technology. (*See Appendix 11*). This shows a positive trend of new inventions that are supporting technological adoptions for online learning.

According to Hoekstra (2013), Agyemang and Dadzie (2010), United Kingdom's Open University had provided a wide access of higher education because of successful implementation. Snježana (2015) further explains that the Open University of United Kingdom reduced the cost of University Education by nearly half the cost while still offered quality education. These findings indicate that if online learning is properly implemented in public universities, then its benefits can lead to quality education at reduced costs. But without proper integration, benefits of online education are a dream not realizable by the public learning institutions in Kenya and other developing countries.

With availability of necessary equipment and software, online learning has proved to be the gamechanger in university education. These infrastructures can only be made available with appropriate funding from the government. Globally, universities have adopted open-source LMS and commercial LMSs based on the level of preparedness and funding (Raymond, Angela, & Emily, 2018). Electronic companies have continued to avail cheaper devices that can be acquired easily (Ding et al, 2019). Even though in their study they indicated that companies have made available devices that can support online learning, these devices still have limited access in developing countries. Universities still have difficulties acquiring them (Yong, Que, & Xiaoli, 2021).

The demand for knowledge has made universities and colleges to develop Massive Online Open Courses (MOOC) platforms learning and acquisition of skills (Helen, 2007). She further stated that this form of learning has also enhanced the development of blended learning. Ding et. al,(2019) cited that these benefits that have been realized in most developed countries (Ding et. al, 2019) while developing countries still

struggle with implementation challenges. These studies however did not highlight the challenges that developing countries have faced that have hindered proper implementation of online learning, furthermore that courses supported in MOOC are only meant for individual development and growth and are not aligned with the curriculum in public universities. Similarly, Odebero (2015) in studying the place of MOOCs in Africa's Higher Education (HE) found that with proper planning, global education is achievable by cost effective online courses offered online. He however indicated that the challenges that African HE institutions face must fast be addressed for such a success to be achieved and that most of such institutions are only using the web technology to post course description and outlines, market programs and courses and also to outline the fee structures.

In Malaysia, the use of online infrastructure as an educational media provided a timely solution to the problem of the working class who were constrained in terms of time and were not able to access higher education (Githens et al. 2014, Ramayah, 2016 & Joseph, 2019). In implementing online learning, they adopted the hybrid approach in which multiple platforms such as LMS, print media, onsite-based instruction, audio, and computer-based interaction were used. Depending on blended mode of learning alone may not solve the educational problems in the event another pandemic in like Covid-19 re-occurs. It is important for developing countries to exploit approaches that can enable them to facilitate learning despite physical restrictions.

In India, Arun & Vrishali (2021), in their measured results, found that there was increase of literacy from 65.38% in 2011 to 74.04% in 2021 due to integration of online learning. Similarly, the learner's satisfaction rate along with perceived ease of

use and access also improved in comparison to traditional learning (Piyush & Shweta, 2021). These benefits are achievable if all necessary steps are taken during the implementation of online learning. The above studies were however done in private universities and could not reflect the picture in public universities.

In North America, Adams (2016) studied the role of proprietary softwares in facilitating online learning. In his findings, commercial software was more widely used than open source softwares. Some of the commercial softwares identified in their study included; Blackboard Learn, Desire2Learn, TalentLMS, Cross-Knowledge, Litmos, SKILD solutions. In Kenya, most public universities have however adopted the use of open source softwares given the financial constraints (Salmon, 2018). This could be a contributing factor to the unsuccessful implementation of online learning in public universities in developing countries. This could also be explained by lack of technological equipment and low bandwidth internet that cannot support online learning in many parts of Kenya.

In studying levels of internet usage for education, Miniwatts Marketing Group (2019) found that 37% of the African population had access to internet in comparison to Latin America/Caribbean and the Middle East in which 67% of the population had access to quality internet. They also found out the North America and Europe had higher usage of the internet at the rate of 89% and 87% respectively. They further found out that the use of the internet in Africa was growing very fast irrespective of low internet usage per population. These findings showed that in the period 2000-2019, the growth rate of Africa's usage of internet was 11.533% which is significant compared to Asia whose growth rate was at 1.825% and Latin America/Caribbean at 2.377%. This growth was facilitated by the availability of ICT technologies and

improved internet access. With this higher rate of internet adoption, it is expected both public and private universities in developing countries will properly adopt online learning platforms.

Despite the innovations and adoption of internet-based technologies, face-to-face traditional classroom approach is still the main method of instruction in public universities. The literature reviewed shows that developing countries are still experiencing various implementation challenges with success being pegged on availability of necessary technologies.

Focusing on Sub-Saharan Africa (SSA) which covers and are of 24 million square kilometers, comprising of 53 countries and a population of 1.03 billion people (UN Statistics, 2017, World Bank, 2016). Most universities in these countries have adopted the use of online learning with mixed success results. The United Nations Millennium Development Goals required SSA countries to provide education to all children by 2015. UNESCO (2018) report indicated that SSA had the biggest number of school dropout children in adolescent age with a total of 96.9 million in 2016. In comparison to other developing countries like Caribbean and Latin America (12.7 million), the Western Asia and Northern Africa (18.5 million) and Southern Asia (95.8 million), the SSA is still lagging. One main factor that contributed to the dropout was the increased level of poverty. To solve this problem, governments in Africa adopted strategies such as training more teachers, 100% transition of leaners from one level to another, construction more schools, providing free primary and secondary education, but the resource at their dispensations have never been enough to solve this problem.

According to Leary and Berge (2007), distance education has existed since 1950's in SSA with different approaches. The success of distance learning programs had been pegged on to the support of other universities which are overseas with instructions being received by means of print material, text, radio, and email. With advancement in technology, LMS have changed the dynamic of distance education and have provided more options which can be used to access learning materials, online classrooms and interactive online education activities using internet. A typical University operating virtually in this region is the African Virtual University based in Kenya which allows the learners to collaborate with other universities in the United States (Joseph, 2019).

According to Mkonongwa and Komba (2018) there is improved use of internet and e-learning adoption in the African Universities. In research carried out in 23 universities in Africa, they found out that this rapid increase in access is as a result of the support given by various donors such as the Ford Foundation, Rockefeller Foundation, and World Bank amongst. However, they also found out the greater access of internet is still concentrated in the areas near major towns and cities to the disadvantage of rural areas which do not enjoy the access of quality connectivity. Even though several universities were able to access the internet there is still lack of local technological expertise and ICT infrastructure required in implementing online learning. The rate of adoption of Open-Source software with limited technical support has also led to the reduced uptake of the general use of online infrastructure as a medium of facilitating learning (Mkonongwa and Komba, 2018).

Isaac, Zhiwei, & Cephas, (2022) carried out a case study on usage intention of e-Learning Systems in Ghanaian Tertiary Institutions, the case of University for

Development Studies. Their data revealed that all the respondents used the online learning platform for both learning and teaching during the COVID-19 even though they faced a lot of challenges. The constructs they used in their study included Perceived Usefulness, Attitude, Self-Efficacy, Social influence, Perceived Ease of Use, Perceived Trust, and Facilitating Conditions. Out of the seven hypothesis they used in their study, four indicated that both the learners and the teachers had difficulties in utilizing the eLearning infrastructure. Furthermore, their study also suggested that experienced users and tutors should be given a mentoring role in using the online learning infrastructure to promote the continuous use of the online system. If faculty do not embrace the continual use of online learning platforms, this affects the uptake of the mentoring role. With lack of interest and improper training of users, adequate use of online learning infrastructure for quality learning cannot be realized.

By the year 2015, most universities in Kenya had started some elements of online learning on a blended mode in which most activities were done the traditional way Kennedy (2018). However, the demand for higher education still outweighed the number of universities. To bridge this gap, institutions adopted e-learning approach to provide flexibility and cater for those employed (Nyerere, 2016). Kashorda & Waema (2014) indicated in their research that lack of appropriate expertise and teacher resistance barred most universities from effectively using the Learning Management Systems (LMS). Similar research studies in Kenya by Ssekakubo, Suleman, & Marsden (2011), Tarus, Gichoya, & Muumbo(2015), Makokha & Mutisya (2016), Muuro, Wagacha, Kihoro, & Oboko (2014) indicated that inadequate ICT facilities, financial constraints, poor internet connectivity, absence of operational e-learning

policies, inadequate technical skills in course development and facilitation of online courses as the main challenges public universities face.

According to the study conducted by Wambugu and Kyalo (2013), it was found that the University of Nairobi (UoN) played a pioneering role in introducing Distance Education (DE) in Kenya during the 1960s. This was achieved through the implementation of a correspondence course focused on teacher training. The curriculum was enhanced by the inclusion of regional and on-campus in-person tutorials, as well as seminars. In 2004, the University of Nairobi (UoN) had successfully created its own Learning Management System (LMS) known as Wedusoft, as documented by Omwenga and Rodrigues (2006) and Ssekakubo, Suleman, and Marsden (2011). The Chisimba LMS was subsequently chosen and implemented by the university in partnership with its development collaborators, followed by a transition to the Claroline LMS (Ssekakubo, Suleman, & Marsden, 2011).

Kenyatta University (KU) is an educational institution that boasts a well-established e-Learning department known as the "digital school". KU adheres to a similar e-Learning framework and maintains support centers across all regions of the country, providing comparable services to those offered by the UoN (Nyerere, Gravenir, & Mse, 2012). Jomo Kenyatta University of Agriculture and Technology (JKUAT) uses open-source e-learning platform known as MOODLE. The mode of learning at JKUAT is a blended approach in which the learner's study with the support of the online learning platform, they have instructional materials prepared and customized for use for the various courses and a policy that guides their online learning (George & Mutisya, 2017). These studies revealed that e-learning is at its infant stage in

universities in Kenya. Most of the universities lacked senate approved e-learning policies to guide structured implementation. A few faculty members and students used e-learning while an average of 5% of the courses taught at the universities were offered online on a blended mode. Most of the online uploaded modules were simply lecture notes and not interactive (George and Mutisya, 2017). Most of the other public universities that have emerged, MMUST included, have resorted to adoption of free open-source learning platforms, specifically MOODLE.

With emergence of Covid-19 Pandemic, most public universities in Kenya were caught unawares regarding online learning. According to Kevin & Robert(2020), when the government of Kenya ordered the closure of schools and universities on 20th March 2020, most of the private Universities moved quickly to finalize the implementation of e-learning initiatives for students. KCA University, a private university, was already administering online end of semester examinations using their e-learning platform. They also entered a bundle partnership with Telkom Kenya on a 'Soma na Telkom' initiative. Strathmore University, also a private University immediately moved their classes online and produced manuals for online learning for both faculty members and Students immediately. Mount Kenya University together with United states International University-Africa (USIU) partnered with Safaricom, an Internet Service Provider (ISP), through 'Remote Learning Mobile Data Bundle Subsidy' package to facilitate the students and the teachers with sufficient internet to carry out e-learning. Kevin & Robert(2020) further states that Public Universities were also not left out, Nairobi University, Dedan Kimathi University and Kenyatta University also moved to acquire customized online learning infrastructures to use for online learning. Nairobi University became the first public University to successfully

conduct online examination of a commercial online learning application known as Claroline.

Masinde Muliro University of Science and Technology (MMUST) first implemented online learning in 2016. The online infrastructure is managed by the directorate of Open, Distance and eLearning (ODeL). The goal of the initiative was to provide a hub for both print based and e-learning materials for students from diverse learning backgrounds (MMUST, 2020). The online Learning Platform is based on MOODLE learning tool, an Open-Source online learning platform. The Directorate listed over 150 programmes that they support on the online platform ranging from PhD, Masters, Post-Graduate Diplomas, Degree Programs, Diploma Programs and Certificate Programs. Even though these programs are listed online, they are not studied on a purely online mode, they use adopted is a blended mode approach in which learning takes place online via the support of video conferencing and examinations are done in physical classrooms. Literature review on the status of online infrastructure use in public universities in Kenya revealed that inadequate information has been published to give clear status of online pedagogical infrastructure.

Wamae (2020) in his study indicated that very few success stories of online learning implementation exist in Kenya. He illustrated various parameters of online learning in public universities in western Kenya such as Maseno University, Kibabii University, and Jaramogi Oginga Odinga University of Science and Technology (JOOST). His findings were documented in the table below:

Table 2.1: Sample Public Universities in Western Kenya where observations were made on online learning (Wamae, 2020)

ISSUE → / University ↓	Software used for online learning	Literature / research on online learning status	Open Educational Resources (OER) access and e-repository	E-Learning policy	Purely eLearning Courses
MMUST	MOODLE	None	Restricted access	Does not exist	Available
MASENO	MOODLE	None	Full Access	Exist	Available
JOOUST	MOODLE	None	Full Access	Exist	Available
KIBABII	MOODLE	None	Full Access	Draft policy exists	Not Available

JOOUST and Maseno universities had implemented most features of online learning that enabled them to facilitate effective eLearning and online examination monitoring. Kibabii University and MMUST have partially implemented eLearning in which face-to-face learning is blended with online learning via zoom and google meet applications. This therefore pointed to the need to investigate online learning infrastructure at MMUST.

2.3.1 Use of Online Infrastructure for Learning in the Universities

According to Lynnette(2004) until all universities reach the level of technology excellence, there will still be three elements of "online" interaction: Face-to-face with some Online Instruction, Online Instruction with some on-site requirements and Purely Online Instruction.

Many Universities are adopting the use of purely online instruction in the e-learning platforms. Alan (2006) explains the overal learning framework for an online infrastructure that any post secondary institution should adopt. This is as a result of the success that the Athabasca Open Online University have experienced in using the framework. In his discussions he explains that online infrastructure for education

should be build by putting together learning outcomes (i) which the courseware development team (ii) translates into learning theories and develops learning materials. These materials were then be delivered by Learning Management Systems (LMS) (iii) which interfaces with other digital resources and the library (iv), related services (v), and Student Information System (SIS). This is done through a secure server (vii) that authenticates the login by the user. The students connect to these services via a user-friendly user's portal (viii) in which one login leads to access to all services. The Figure 2.2 below illustrates the how the framework of online learning infrasture should be structured.

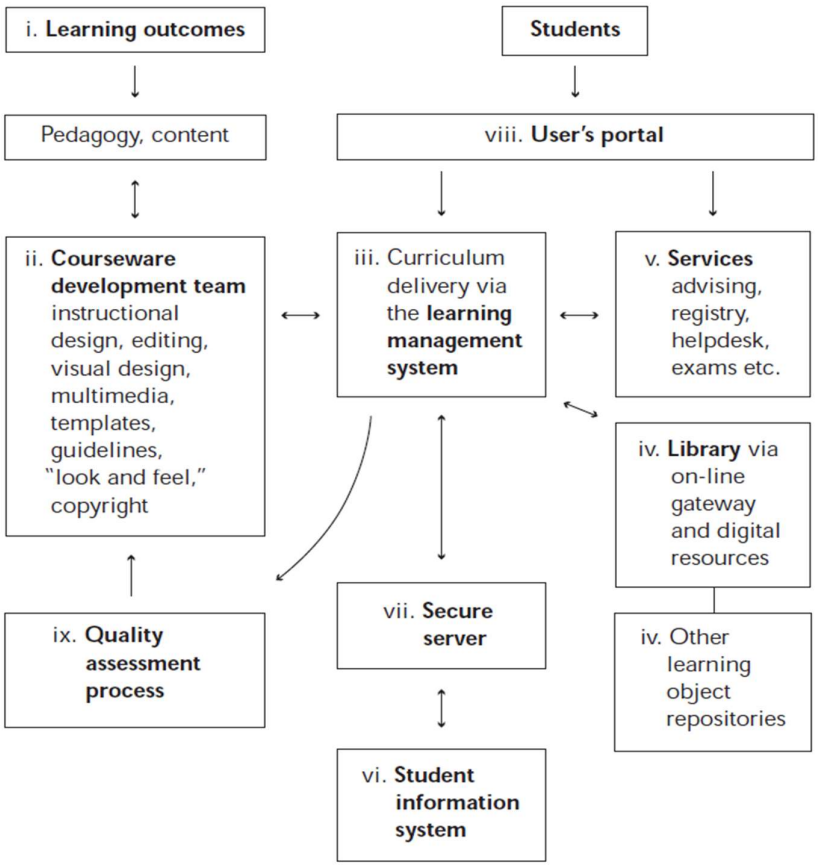

Figure 2.2: An Online Learning Infrastructure Framework (Source: Allan (2006))

2.3.2 Factors Facilitating Learning in Online Environment

According to Aguti(2015), proper evaluation of e-learning or any learning infrastructure depends on Learner/Student variables (learning history, physical characteristics, learner motivation, learner attitude, familiarity with technology and learner motivation) (Kalyanasundaram & Madhavi, 2019); learning environment (institutional learning environment, physical learning environment, subject environment) (Belson, et al., 2017); contextual variables (political context, socio-economic factors, geographic location and cultural background); technology factors such as (connectivity, software, hardware, mode of delivery and the media) (Belson, et al., 2017) and pedagogic factors (nature of the learner, methodologies, accessibility issues, learner support, learner autonomy, flexibility, accreditation, examination, assessment and certification) (Felix, 2021). These factors should be studied with respect to public universities to determine whether online learning is affected by these factors and to ascertain the degree on their impact.

2.3.2.1 Online Infrastructure System Design

Altay (2014) carried out a study to promote proper design and use of computer softwares and systems using a leaner-centered design approach. He chose learner centered design because of the provision of individualized interacions and multi-modal presentations of contents such as use of interactivity, visual, texts, audio among other multimedia aspects. To test the claims, he used exploratory study in mixed reseach approach to determine how learner centered design approach contributes to effective use of computer softwares as medium to facilitate learning. His study population consisted of 350 respondends who were engaged in learning using computers. Some of the factors he tested in the project were; effectiveness of

interfaces, simple-straightforward instruction, match between content and time allocated, ease of use and interactivity. Adams (2016) also pointed to the similar factors as key issues affecting online instructional system design. It is on the basis of this factor in addition to technological support and availability that learners can achieve the intended objectives from the instructional materials. This study, therefore, focused on the design issues that students and faculty members face while using the system.

2.3.2.2 Internet / Network Connectivity to support online infrastructure:

Online learning has become bandwidth intensive (Wong, 2021). The use of LMS and demand for live video enabled online classrooms require that the internet or network connectivity be of considerable speed. The learners should have nearly equal opportunity in accessing the online learning infrastructure to have a reflective uniform online learning environment equivalent to the traditional on-campus learning. Rimba, Izlan, & Sakka (2020) in their study on the challenges faced by learners during the covid-19 pandemic period found out that 90.9% of the learners had only 50% effective internet access. And that most of the learners who accessed the internet did so using the mobile phones which could not allow them to effectively complete the assignments and attend online classes effectively. They found out that only 9.1% of the learners used laptops while studying online. In their findings, Rimba et al (2020) determined that implementing online learning in environments with limited internet access is a big setback for using online infrastructure as medium to facilitate online learning. Research carried out in Indonesia, APJJ (2018), on the National Internet User Penetration Survey (NIUPS) showed that most internet users who benefit in using the internet for educational purposes are concentrated in Towns which is at 55%

access level. While those in rural areas only have 5.2% internet user penetration level. Arifa (2020, p.16) states that limitations of internet access is one of the difficulties experienced by the user of online infrastructure for home-based learning. Online infrastructure demands sufficient internet bandwidth to support online learning. These studies, however, did not determine the sufficient levels of internet required for relevant number of students. They also did not provide solutions on how to support areas outside urban centers on how to access online learning given the limited internet access.

2.3.2.3 User Training on online infrastructure usage:

To effectively use online learning infrastructures, proper training for various users is key Aguti (2015). She further iterates that universities have approached training and support in different ways. Some provide formal seminar trainings, others provide one-on-one training for the faculty members prior to beginning their online teaching. Effective delivery of online learning requires that the university or school maintains an online training staff team who are ready to provide training for the new students and the staff whenever they need it. Schroeder (2001) elaborates that untrained students and staff should not be allowed to use the online infrastructure for learning. They should first complete the training to enable them to achieve the instructional objectives using the online infrastructure as a medium for facilitating online learning. If these trainings are done with non-trained personnel, then quality learning may not be realized. Understanding how and whether training is carried out in public universities on online learning formed part of the present study.

2.3.2.4 Usable instructional materials:

Simply dumping typed or printed information on these online infrastructures does not promote learning any more than handing out pages to students and watching them read during class (Lynnette, 2004). She further explains that given that there is a shift in learning approach from face to face to online environment, this calls for a shift in the designing of the materials that are used. Lee & Hannafin (2016) postulated the concept of "own it, learn it, and share it" in their study. The instructional materials usable on the online learing platforms should be developed in a way that the learners should own them, learn from them and share with their colleages. Through this they make sense of the content in it and gain more knowledge. From in international perspective, Wong (2021) indicates that "own it, learn it, and share it" provides several implications with regard to practical application. These practical applications can be considered by scholars and educators for the online digital learning environments and online instructional material designers. With sudden shift to digital environments, learning may not be achieved in a degree comparable to classroom learning if appropriate platforms and properly structured instructions are not in place. Learning resources used in the online infrastructureshould be customized to accommodate appropriate concentration span and cognitive load. Study by Wong(2021) did not however investigate if the users actually felt comfortable with the resources given for online learning and whether the members of faculty had sufficient time and skills to design materials that they can own and share.

2.3.2.5 Interactivity of online infrastructure platforms:

Effective online collaboration requires four main components: Learner preparation, Learner activities, Learner Interaction and Learner transfer (Mohamed, 2018). These

components work together to enhance effective online learning. Instructional material designers should therefore ensure that they incorporate an approach that supports these key elements in designing their instructions. The designers however may have the technical skills and not pedagogical skills leading to platforms that do not deliver quality learning.

A study conducted by Terry(2017) on 93 university students on interactivity in a collaborative online environment indicated that, Student-Student interaction, Student-Content, Student-Teacher interaction, Teacher-Content interaction, Teacher-Teacher, and Content-Content Interactions are the determinants of successful online learning. The main constructs on the current study are interactions and socialization. This article suggested that a proper analysis of technological aspects of online collaborative learning environment should be studied to determine its effects on learning and performance. This called for an in-depth analysis of prospects and challenges of the online platform in the facilitation of learning. Understanding the challenges could aid effective online infrastructure design.

2.3.2.6 University Policies on e-learning

According to Czerniewicz & Brown (2009), the findings on their research on how policy affects successful implementation e-learning indicated that without policy, technology supported learning may not be successfully implemented. Aguti (2015) also confirms these findings and further elaborates that for online learning to thrive, members of staff need to be engaged in the policy formulations to properly describe the responsibilities and roles and in creation of a sustainable e-learning.

A study by George & Dorothy (2016) indicates that most public universities in Kenya operate eLearning platforms without senate approved eLearning policies. In their

findings, they pointed out that MMUST did not have eLearning policy as compared to other public universities which had eLearning policies approved by the senate and others had eLearning policies not yet approved by the senate. Without a policy, it is difficult to realize the success of online learning infrastructure. Their findings were documented as shown in the table below.

Table 2.2: E-Learning Policies (source: George & Makokha, 2016)

University	Status of e learning policy	Remarks
MAU	Policy is not yet approved by University Senate; however, there are guidelines approved by senate.	Currently e-learning is embedded in the ICT policy.
UoN	Open, distance and e-learning policy was approved by senate in 2005.	The policy is not yet fully implemented.
KU	A draft policy has been submitted to the board of Open, Distance and e-Learning (ODEL) Institute after which it will be submitted to University Senate for approval.	The policy document is operational in its draft form.
MU	Policy was approved by University Senate in 2010.	The policy is not yet fully implemented.
JKUAT	Draft e-learning policy is ready and awaiting approval of University Senate.	Currently e-learning is embedded in ICT policy.
MMUST	Policy does not exist.	E-learning operates within the university's ICT policy.
EU	Draft e-learning policy is ready and awaiting approval of University Senate.	The policy document is operational in its draft form.

Key: KU – Kenyatta University, MU – Moi University, UoN – University of Nairobi, EU – Egerton University, JKUAT – Jomo Kenyatta University of Agriculture and Technology, MMUST – Masinde Muliro University of Science and Technology.

Improved adoption of online learning is supported by the fact that online learning has been taken seriously by public universities recently at the strike of Covid-19 pandemic (Mashile & Matoane, 2020).

Based on the information on public universities websites and social media pages, e-learning implementation struggle cuts across all public universities. On the MMUST website, the eLearning policy is not clearly articulated amongst other policies listed (MMUST, 2022).

2.3.3 User-Support in Online Infrastructure

According to Schroeder (2001), both the learners and faculty members came to the e-Learning infrastructure with an extensive experience acquired from the traditional face-to-face classroom. Their expectations were that the same kind of support they

receive in the traditional setup was available in the online environment. Similarly, Uppal (2017) in his study investigated the issues affecting the learner centered approach while using online platform. He also found out that here is need for human intervention for online support to be successful. Students believe in having someone to talk to them when they are stuck or in need unlike having a software to respond to their learning needs. System users have different feelings and approaches to learning, it is therefore important that a human proctor is involved in the process of online learning.

2.4 Effects of Online infrastructure on Learning

The use of classrooms, buildings, equipment, and laboratories have effect of the learning process adopted by the students (Janssen, Jeremie, & James 2017). This is because learners are in a familiar environment in which they can collaborate and learn. Similarly high-quality and efficient technological infrastructure are important to the process of learning. This is supported by Peter, Fay, Yufan, & Lucinda (2016) whose study on the appropriateness of a learning environment found out that a properly planned infrastructure promotes learning if similar classroom conditions are taken to the online infrastructure.

To ensure uninturrupted global education, there is need to address infrastructural challenges that universities and technical institutions face (TeachPro, 2022). Factors such as electricity, internet and learning equipments facilitate online learning if properly incoporated with the pedagogical skills. Even though this was apositive suggestion, developing countries face challenges of insufficient technological equipments that can effectively support online. Therefore the diffence between

developed countries and developing countries will still exist until equal technological excellence is achieved (Allan, Paul, & Brian, 2019).

Zozie (2020) studied the online interaction of students at Mzuzu University in Malawi. The findings of his study showed that 15% of the students required training to successfully use the collaboration platforms, 35% cited that they were unable to use the platform and 55% indicated that they were able to use the collaboration tools successfully. However, they indicated that power outages affected internet connectivity which eventually affected online learning. Being a study conducted in a public university, the findings of the current study were obtained from a public university to draw comparisons and confirm the challenges public universities face.

Khaled & Amori (2022) carried out analysis of post covid-19 academic performance of the United Arab Emirates University, United Arabs Emirates (UAE). They adopted Correlational Design approach in which performance of students across three schools using online learning platform in the university was monitored. The outcome indicated that 75% of the students who used online learning performed better than those who did not use the online learning platform. They concluded that the future of education relies on online learning in which learning becomes student centered and the lecturer plays a guidance role to the student.

2.5 Prospects of Online Learning Infrastructure in Universities

Online education is associated with several benefits which can help in solving educational problems in developing countries. The future of education is to have education for all which is affordable and accessible. It is expected that online infrastructure should be able to improve academic performance of students, reduce the cost of education, enhance knowledge retention, use smartphones to enable education

on the move, enhance socialization and collaboration, improve teaching efficiency and to provide for customized learning experiences for the student.

According to Simamora, Fretes, Purba, & Pasarbibu (2020), universities should prepare teachers and students with pedagogical readiness so that engage in qualitative teaching and learning experience with or without technology. Online learning integration helps in the realization of improved academic performance while keeping quality education Salmon (2018). He studied 389 JKUAT students, 64% of whom realized improved academic performance in comparison to those that did not use online learning infrastructure. Alhothli (2015) investigated impact of MOODLE on learning at Montana University using Solomon Four Quasi Experimental design to investigate effects on academic achievement. His finding showed that the students who used MOODLE registered high academic achievement than those who did not use MOODLE online learning platform. It is evident that using online learning infrastructure can improve academic performance. The current study will therefore relate on whether online infrastructure indeed improves academic achievement of student based on the lecturer's perspective.

Technology integration in education has become its own form of literacy because of how often it is used in daily life activities (Drexel, 2021). This is creating life skill to the learners so that they can use the technology the contexts outside the education domain. Many careers use applications like Microsoft Office or Google docs. With the learners interacting with these online collaboration tools in classroom setup, it confidence to continue using them anywhere in their daily operations and helps in knowledge retention. Papia (2016) also indicates that cognitive load can greatly be reduces if instructional materials are designed for online infrastructure use.

Based on the observation done by Grand Canyon University, USA, on technology integration in classroom setup the use of technology has benefits that improve university's competitiveness (Grand-Canyon, 2020). The finding of their study shows that technology can allow learners to be able to write, spell words and even do mathematical computation. Secondly, increases productivity and creativity in students and faculty members in which it allows the learners to access whatever resources they need and when they need them. Finally, it was determined from their study that education cost was evidently reduces because of the use of online learning platform. The present study will investigate the role of online infrastructure in enhancing productivity and creativity of its users.

Automation and Future Focus are other benefits that can be gotten because of using technology in learning (Uppal, 2017). Automatic grading systems in LMS, teacher automation, the use of artificial intelligence to determine learner capabilities have greatly impacted the education sector. Both the learner and the teacher are greatly benefiting from the role played by technology. Mohammed (2018) from the findings of their study suggested that collaboration and interaction are highly achievable when using online infrastructure for learning. Use of online infrastructure improves enhances project achievements amongst users separated by geographical features. Students can collaborate on projects across the world.

Kevin & Costley (2021) in their study found that "technology is a powerful contributor to learning if it is used to deepen students' engagement in meaningful and intellectually authentic curriculum". Many learners have shown the advantages of using learning technologies in classroom setup especially in engaging the learners in critical thinking and problem solving.

A study conducted by Yang (2011) in examining the experiences of pre-service teachers implementing technology in math lessons however disagrees with the findings of Kevin & Costley (2021). He states that technology cannot change the perception and performance of learners in mathematics. Similarly, Nwankwo (2015) and Kooli, Zidi, & Jamrah (2019) carried out studies on the student's learning experience and perceptions, and attitudes of online course content and interaction respectively. They found out that there was a general negative attitude towards the implementation of the online learning platforms. One contributing factor by the two authors was the hurried implementation of the online systems.

Study by Snježana (2015) and Lane (2021) both found out that Open University of the United Kingdom and Athabasca University have provided relative cheap and quality education with 78% and 65% increment compared to other university offering on campus face-to-face education. This shows that online learning has the power to improve access to university education if properly implemented. This study will also seek the respondent's opinion on whether online learning platform has provided open access to education given the high demand of university education.

Mohammadi, Sarvestani, & Nouroozi (2020) investigated the prospects of using mobile phones for learning. In his findings, 74% of the respondents showed that the use of online learning platforms in smartphones is preferable by many. Salmon and Joanne (2022) found out that the gaps in online learning can be harmonized by adopting mobile-based applications for learning.

This study, therefore, determined the general impact of technology on the learners whether positive improvement is recorded or not.

2.6 Challenges of using Online Infrastructure in learning

There are many challenges to overcome while implementing e-learning in higher institutions of learning (Mohammed, 2020). Most online learning initiatives tend to fail entirely or partially due to various barriers to online learning in developing countries. Odebero (2015) indicated that despite successful implementation of MOOCs in developed countries, developing countries in Africa were still faced with many challenges. He further indicated that in Kenya, despite the guidelines to the Higher Education (HE) institutions by the Ministry of Education that 10% of all income in HE institutions to be invested in IT infrastructure, corruption consumed most of the financial resources allocated for such resources hindering successful implementation in all HE institutions.

The use of technology-based distance education has become popular among universities (Joseph, 2019). It has been seen as a promising cost-effective and an answer to the African problem of high demand of education with limited resources. For the African situation, these hopes have turned to be disillusionment because of the challenges that are related to IT digital infrastructure and economic situation for developing countries. Joseph further explains that even though developing countries in Africa still face challenges regarding online learning implementation, this dream has come true elsewhere in the developed nations.

2.6.1 Challenges to the Members of Faculty

Three major challenges affect implementation of online pedagogical infrastructure: academic challenges, technological challenges, and administrative challenges (Elsie, 2022). The challenges were investigated factoring the views of the faculty and students.

2.6.1.1 Academic Challenges

According to Mohammed (2020) users of online infrastructure particularly faculty members face numerous challenges while implemeting online learning. The key challenges that he found out in his research included; limited of time required to develop e-learning content, inadequate interaction between students and faculty members, insufficient time for preparing online exams or assignments, lack of awareness regarding ways to integrate the software into teaching and finally inaccessibility of course notes and feedback about materials. Similarly, Marzilli et al. (2019) found out that most faculty members do not have time to set and administer examinations, they found out that faculty members have other tasks assigned to them by the university hence no time to collaborate with learners in the online platform. These challenges if not addressed in time affects the implementation of online learning infrastructure hence delayed successful online learning.

2.6.1.2 Technological Challenges

Implementation of e-learning requires that the implementors to have the knowledge of the technology that they are using. Lack of technological skills have been noted by various scholars as a key challenge affecting successful online learning implementation (Hadullo, Oboko, & Omwenga, 2017 and Mohammed, 2020). Other than lack of requisite skills, other technological challenges identified by these scholars included insufficient technological equipment, inadequate technical support, limited necessary adaptive technology, technological background, unavailability of training courses provided by the institution and the complexity of the e-learning platform being used. Successful implementation of online learning requires that technological challenges are adequately addressed. These studies however did not recommend on

how these challenges can be addressed to enable universities struggling with implementation avert the challenges.

2.6.1.3 Administrative Challenges

Online learning requires the support of the administration for its success to be realized. (Aguti, 2015). Without this support, even if good technology is acquired by the institution, it might not serve its purpose. Some of the administrative challenges that have been identified included limited administrative support, problems with internet access, limited administrative encouragement, negative comments about e-learning, inadequate ICT and e-leaning infrastructure provided by the management and finally incompetent administrators given charge of online learning department (Mohammed, 2020). Most public universities in Kenya have operated either with draft online learning policies which are not approved by their respective sanate committees and therefore could not be circulated for use or with unclear policies regarding how activities in online learning should be conducted (George & Dorothy, 2016, Wamae, 2020). This greatly affects learning on these platforms leaving students and members of faculty even more confused in the process. A case study in Nigeria in which a student could not secure a job after graduating from an online program which was conducted without a clear policy to guide it (Shirley & Rodney, 2004). Findings by George and Dorothy (2020) shows that most kenyan public universities are still struggling with administrative support guided by polices. This study will therefore seek to shed light on the post-covid 19 pandemic support of public university adminstrations.

2.6.2 Challenges to the Students

Students also face similar challenges that can be classified as administrative, academic, and technological challenges.

2.6.2.1 Academic Challenges

Inadequate user-support by the administration, limited interaction between the students and members of faculty, inadequate time for preparing online examination, inaccessible course notes and materials, and limited funds to pay fee and also to buy internet bundles to access online platform were some of the challenges that Mohammed (2020) and Sergey, Sviatlana, E., Kasiet, & gulnara (2021) identified as the major issues that affect implementation of the e-learning with regard to the academics line of the learners. Similarly, Colin (2022) on students' online challenges states that isolation, distractions, and poor time management are key issues that affect online learning amongst students. Two of the above studies were however conducted in private universities and could not be generalized to the challenges that students face in public universities regarding online learning. The studies were conducted in the post covid-19 pandemic and therefore will form a good comparison platform with the current study.

2.6.2.2 Administrative Challenges

Both students and faculty members are affected by the administrative challenges. Findings by Mohammed (2020) indicate that problems with internet access, negative comments about e-learning, and inadequate ICT and e-learning infrastructure are key challenges that affect students administratively. Technical support is one of the other challenges that administratively affect the implementation of online learning by the students. Alongside these challenges, administration needs to make online learning a

priority to be able to meet the demands of the "digital native" learners whose understanding of use of technology is high compared to the previous generations (Gillet, 2017). Just as traditional face-to-face learning is supported by public universities, similar support should be given to online learning to equate the quality of education online and physically. Willard (2022) however, states that most public universities in developing countris have not given online learning a feel and priority similar to classroom learning and therefore the challenges of online learning keeps pilling. Limited funding and resource availability could be limiting factors to successful implementation.

2.6.2.3 Technological Challenges

Not every learner has the technical know-how of using technologies that support online learning (Felix, 2021). Mohammed (2020) found that inadequate technology and software required for online learning access is a challenge for learners who may want to learn in personalized environments away from the university. Limited technical support by the faculty members and administrators affects how learners use online learning platform. This arises from the fact that the learners must learn by themselves how to use the technology and handle the challenges that arise because of them using it. Complicated softwares used for online learning, Inaccessibility of audio and video material, Portable Document Format (PDF) and PowerPoint was also a major challenge. Furthermore, inadequate training courses provided by the institution are a challenge to the learners since not all learners understand the proper operation of computer systems Mohammed (2020). A good online infrastructure for learning should be such that it is easy to use (Carrol et al., 2017, Al-Araibi et al., 2019, Ali et al. 2018a, Mtebe and Raisamo, 2014). They argued that most institutions have good

platforms but faced technological use challenges on the side of students given the fact that prior knowledge of computer use was insufficient. The learners therefore cannot successfully learn using the Learning Management Systems (LMS) amidst the challenges highlighted. The table below indicates the summary of these challenges.

Table 2.3: Summary of challenges to online infrastructure use (Source: Author, 2023)

No	Key Issue	Identified challenges	Literature
1	**Academic Challenge for the Members of Faculty**	i Lack of time required to develop e-learning content. ii Lack of interaction between students and members of faculty. Lack of necessary time for preparing online exams iii Lack of awareness regarding ways to integrate the software into teaching. iv Inaccessibility of PowerPoint/PDF/data projection during lectures v Inaccessibility of course notes and feedback about the materials.	(Mohammed, 2020), (Hadullo, Oboko, & Omwenga, 2017), Uppal (2017), Marzilli et al. (2019). Salmon (2018)
2	**Technological challenges for the Members of Faculty**	i Lack of technology / software required for home access. ii Lack of technical support iii Lack of necessary adaptive technology iv Inaccessibility of audio/video materials, pdf, and PowerPoint v Technological background vi Lack of training courses provided by institution. vii The eLearning software is too complicated. viii Insecurity of online data	(Mohammed, 2020), (Aguti, 2015), (Hadullo, Oboko, & Omwenga, 2017), Uppal (2017), Marzilli et al. (2019). Eltahir (2019), (Al-Azawei & Domninic, 2018), (Nwabufo, 2013)
3	**Administrative challenge for the Members of faculty**	i Lack of administrative support ii Problems with internet access iii Lack of faculty role iv Lack of administrative encouragement v Negative comments about e-learning vi Inadequate ICT and eLearning infrastructure	(Mohammed, 2020), Eltahir (2019), Naveed (2021), Stoffregen et al. (2016), Al-Azawei (2018), Kisanga et al. (2017), Wamae(2020), George & Dorothy 2016
4	**Academic Challenge for Students**	i Lack of interaction between students and members of faculty ii Lack of time required to have online exams/assignments. iii Inaccessibility of course notes / materials	Eltahir (2019), Naveed (2021), Stoffregen et al. (2016), Al-Azawei (2018)
5	**Technological challenges for Students**	i Lack of technology / software required for home access. ii Lack of technical support/advice iii Inaccessibility of audio/video materials, pdf, and PowerPoint iv Technological background v Lack of training courses provided by institution. vi The eLearning software is too complicated	(Mohammed, 2020), (Aguti, 2015), (Hadullo, Oboko, & Omwenga, 2017), Uppal (2017), Marzilli et al. (2019). Eltahir (2019), Esterhuyse and Scholtz (2017), Islam et al. (2015), Al-Azawei et al. (2018), Nwabufo et al. (2013)
6	**Administrative challenge for Students**	i Problems with internet access ii Negative comments about eLearning iii Inadequate ICT and eLearning infrastructure iv Institutions preparedness/ readiness to implement eLearning	(Mohammed, 2020), Eltahir (2019), Naveed (2021), Stoffregen et al. (2016), Al-Azawei et al. (2018),

2.7 User Perception and the Online Learning Infrastructure

As stipulated by Rimba, Izlan, & Sakka (2020), the attitude of both faculty and the students affects the effectiveness of online learning. Based on the post covid-19 pandemic survey on the problems learners experienced during the pandemic, they found out that 74.2% perceived that e-learning is less effective and ineffective compared to traditional classroom learning while 64.3% felt dissatisfied with how online learning was conducted during the covid-19 pandemic. However, they also cited that power fluctuations, unreliable internet, inadequate training contributed to the negative attitude registered by 62.3% of the faculty members.

Research by Winahyu (2020) on the problems of distance learning suggests that many of the lecturers ignored the idea of online learning before Covid-19 pandemic, this affected their perception towards it and most faculty members refused to adopt it. Only 8% had positive attitude and confidence in using online learning and 9.6% had used the e-learning platform prior to Covid-19. Insufficient knowledge of technology, age, and inadequate training were cited as some of the factors that seemed to be contributing to poor perception of the faculty members and students in Indonesia. This study used a survey approach and recommended that the same approach could be used in studying other aspects of online learning.

Faculty members' attitude towards new learning technologies greatly impacts their acceptance of the same technologies (Hart and Laher, 2015). In a study conducted at the university of Witwatersrand in South Africa, the attitude of faculty members was generally positive regarding acceptance of online learning technology and that their perceptions enhanced the successful implementation.

Cultural attitude towards e-learning can promote or hinder how an institution implements in e-learning. In their study, Fard, Rostamy, & Taghiloo (2009) found out that the cultural attitudes of a society or organization needs to be open and positive in order to enable effective adoption of online infrastructure use for learning. It is therefore important to study the role played by attitude on eLearning plain the public universities in Kenya since most of the studies have shown that attitude of users affects online learning.

Kartal(2010) studied the effectiveness of multimedia approach to online instruction on 89 college students at Instabul University in Turkey by carrying out a test on computerized instructional material contents in an informal style that is personalized. The findings indicated that learning improved when the style of language used was formal and conversational integrated with more that one multimedia style.

2.8 Theoretical Framework

There are several Theories that support online learning and online instructional material design (Sergey, Sviatlana, E., Kasiet, & gulnara, 2021). Based on the objectives of this study, three theories clearly informed the theoretical framework of this study. These theories include E-learning Theory, Technology Acceptance Theory (TAM), Online Collaborative Learning Theory (OCLT) and Communication Theory (CT). Based on the theoretical literature studied in this review, these theories come are handy in supporting issues in the online learning environment. According to (Gregor, Martin, Fernandez, Stern, & Vitale, 2006), a framework "classifies the important factors in the information systems development can imply that these factors are casually connected with successful systems development". The four theories are hereby briefly explained.

2.8.1 The Technology Acceptance Model (TAM)

This model was first suggested by Davis (1989). The model presumes that the information systems acceptance and use by an individual is based on the Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). According to Davis (1989), perceived usefulness (PU) can be defined as "the degree of believe in a person on a particular system enhances the job performance on that person". PEOU was also defined as the degree in which a person cultures the believe that the using a particular information system is free of effort. The model the suggested is shown in figure 2.3.

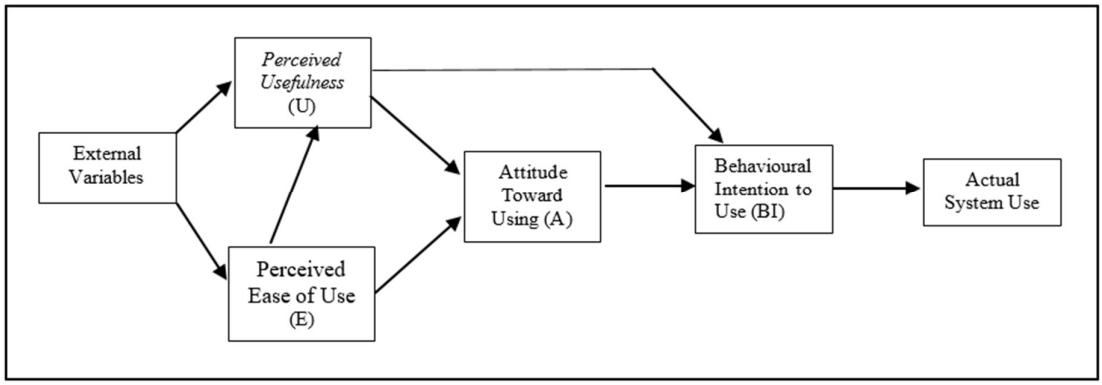

Figure 2.3: The TAM flow model (Source: (Davis, 1989))

The above TAM illustration indicates that Behavioral Intention (BI) to use technology can be determined Attitude towards using (A) and Perceived Usefulness (U). BI = A + U. According to the findings of their model, Hu, Clark, & Ma (2018) found out that accepting or rejecting technology depends on the teacher's perception of the following factors: Ease of Use of the technology, usefulness of the technology, subjective norm, and self-efficacy in computers.

This theory is relevant to this study in the sense that the use of any online infrastructure, whether commercial or open-source software depends on the ability of the users to accept the use of technology. It further creates the factors upon which the

model of the study is formulated. TAM theory provides the ability to link to other theories which forms the basic structure of the study such as communication theory, online collaborative theory, and the eLearning theory.

2.8.2 E-Learning Theory

Formulated by Wang(2012) and later improved by David(2015), this theory indicates that the principles upon which e-learning is built are cognitive science principles which illustrates how the design and use of technology in education enhances the concepts of effective learning. The building blocks of this theory are based on the Cognitive Load Theory (Sweller, Van, & Paas, 2019). David (2015) asserts that Cognitive Load Theory "is the amount or degree of the mental effort placed on the working memory". If the learners are presented with a lot of instructional information in an online environment or face to face classroom, the brain may suffer from an overload since the working memory of the brain is limited.

Other two studies carried out by Kartal(2010) & Kurt(2011) on university students of different universities indicated that learning can increase if personalization is intergrated in the instructional materials that are being learnt. Kartal studied the effectiveness of design principle on 89 college students at Instabul University in Turkey by carrying out a test on computerized instructional material contents in an informal style that is personalized (Kolesnikova, 2019). The findings indicated that learning improved when the style of language used was formal and conversational integrated with more that one multimedia style. Kurt also studied the personalization effect using formal style with 22 students and conversational style with 23 students. With the use of an achievement test, questionnaire and cognitive load scores for both

the groups, he found out that there was significant difference between the students who used the personalized approach and those that used formal approach.

Simply damping literature in any online learning platform cannot promote learning anymore than giving the students notes in classroom and watching them read. There is need to properly design the instructional materials that are used for the online infrastructure in order to prevent the learners from being fatigued. Online instruction should be interesting, precise and interactive. This theory was important for this study in determining the appropriatness of the instructions that the learners are exposed to.

2.8.3 Communication Theory

The proposition of communication theory can be attributed to S. F. Scudder in the year 1980. According to Zozie (2020), it is asserted that communication occurs among all organisms inhabiting the Earth, but with varying methods of communication. This theory has seven primary components that exert an influence on the manner in which information is conveyed. These include Sender (or Encoder) which is the information source or the equipment which initiates the message. The receiver, often referred to as the decoder, represents the intended audience for the communication. The Message refers to the factual data or signal that is transmitted from a sender to a receiver. The Medium, also known as the Channel, denotes the specific means employed to convey the message, such as print, speech, or other technologies like telephones, the internet, or even smoke signals. Noise refers to any technical or semantic barriers that impede the effective delivery of a message, such as issues with visibility, static electricity, or poor ink quality. Interpretation refers to the many processes undertaken by a recipient in order to decode and comprehend a given

communication. In conclusion, feedback refers to the transmission of information from a receiver back to the sender, encompassing the receiver's reaction or response to a communicated message.

This theory is relevant to this study in the sense that “Online Infrastructure” is used as a medium of communication between the faculty members (senders) and students (receivers). The information being communicated is the course content. (Message). The process of online learner is affected by various factors like internet fluctuations, lack of power or electricity, interference from the surroundings, amongst other factors (Noise). The learner is far away from the teacher and there is the need to interpret the online notes, or class recordings to make sense of the information being communicated (Interpretation) and finally the learner’s reaction based on his interpretations in known as the Feedback. This theory, therefore, helped in understanding how information is communicated on the online learning platform. Furthermore, it helped in conjunction to collaboration theory to inform how students are to conduct collaborative and interactive learning.

2.8.4 Online Collaborative Learning Theory (OCL)

This theory was developed by Harasim (2012). According to Harasim, collaborative learning refers to the process in which students work together on some common instructional materials in small groups in order to achieve a common goal. The online instructional learning materials should be influenced by the development of effective online collaborative learning environment. This theory provides a model of learning in which the learners are supported and encouraged to work as a team to create knowledge: to explore, to invent new approaches to innovate with the aim of solving problems rather than mere reciting of what they presume the right answer.

According to Bonk and Reynolds (1997), the promotion of higher order thinking on the Internet necessitates the development of demanding activities that facilitate the connection between new and existing information, the acquisition of meaningful knowledge, and the utilization of metacognitive abilities. Consequently, it is the instructional strategy employed, rather than the technology itself, that ultimately impacts the caliber of learning. While this theory motivates the learner to be fully active and engaged, it postulates that the teacher plays an important role as the link to the knowledge community. It is therefore relevant to the current study given the fact that the interaction between the student and the teacher forms the basis of online support. In very few occasions will the student involve the technicians in the learning process. The teacher should therefore be able to support the learner in the same manner it is done in the traditional face to face classroom.

Based on the analysis of the synthesized factors promoting effective use of online learning infrastructure, the theoretical model in the figure 2.4 was developed.

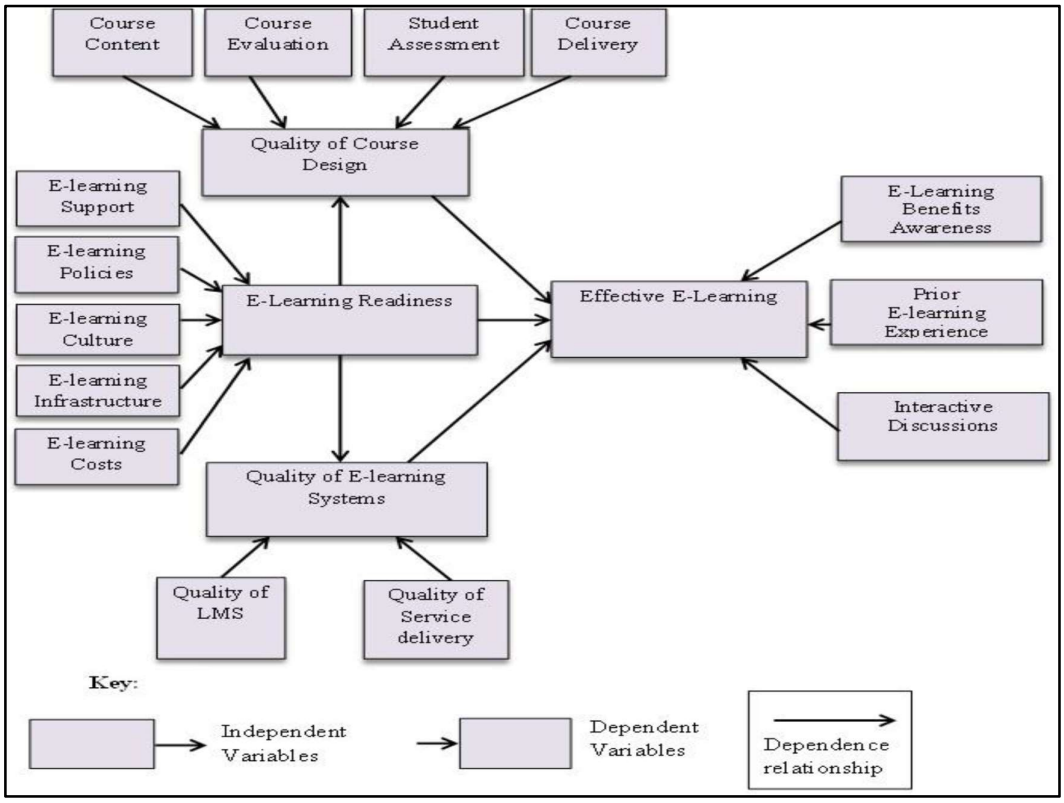

Figure 2.4: Online Infrastructure Theoretical Model (Source Harasim, 2012)

2.9 Conceptual Framework

The Conceptual Framework of this study was developed based on the empirical literature, Technology Acceptance Theory (TAM) and the Communication Theory (CT). Diagrammatically, the Conceptual Framework of the study is represented in Figure 2.5.

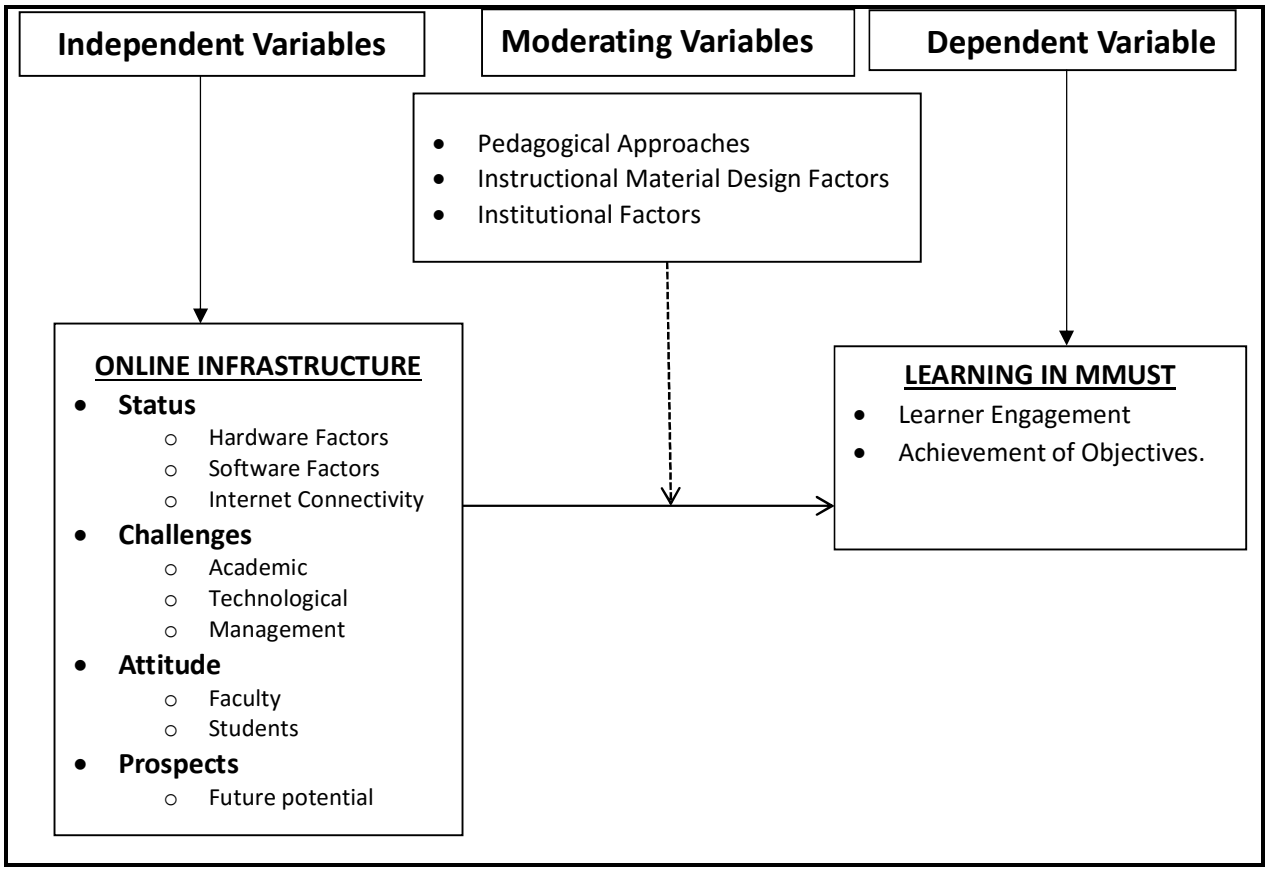

Figure 2.5: Conceptual Framework (Source: Author, 2022)

2.10 Summary of Literature and Knowledge Gap

There is a shift in learning from traditional face-to-face to blended learning and online learning in the higher institutions of learning. A lot of effort has been placed on the instructional design of the online learning materials and the softwares that can aid the process of learning. However, little has been done on how the online infrastructure has impacted the process of learning in achieving the instructional objectives. Moreover, studies have identified that success in an online learning environment requires more than a well-designed infrastructure. In order to harmonize the comparative nature of online learning and traditional face-to-face learning, there is therefore needed to look into the impact of the various online learning infrastructures

in facilitating learning in universities. This research filled this gap by identifying the key challenges of online infrastructure and devising the better approach to online learning infrastructure usage. The literature studied points to unclear online learning policies approved by the senate to support online learning activities in various institution. MMUST is one of the universities with unclear and uncirculated eLearning policies. Without a policy, it is difficult to implement successful online learning.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Overview

This chapter deals with the description of the methods that were used in carrying out the research study. The technologies used in data collection, methods that were employed such as the sampling techniques, research instruments, and data analysis techniques are explained in this chapter. The research sites and the people selected as the participants are also explained in this chapter. This was a social science study. According to The Economic and Social Research Council (ESRC) (2016) social science is defined as the study of society and how people behave and impact one another. The social phenomenon to be investigated in this study was based on the available evidence regarding the use of online infrastructure for learning. This qualifies it to be a social science study.

3.2 Research Design

This study adopted descriptive survey research design which attempts to provide description of the social setting. Facts are gathered about an occurrence without any variable manipulation. Data is then gathered from the subjects in their natural setting. This leads to description, analysis and explanation of the circumstances that prevailed in the current study. The descriptive survey design catered for observations, document analysis, questionnaires, and interviews (Creswell, 2018). Creswell further indicates that, any survey research provides a quantitative or numerical description of attitudes, trends or opinions of a population, questionnaires or structured interviews for data collection is therefore used with the intent of generalizing from a sample to a population.

This study adopted pragmatist paradigm approach which advocates for the use of mixed methods as a pragmatic way to understand human behavior (Biesta, 2010). Online learning provides a socially divergent approach to learning in which one is expected to interact in-person with the learning system and derive meaning from it. The pragmatist research philosophy was chosen because it identifies the many ways in which one can interpret the world and do research. Braun & Clarke (2013) agree with this concept citing that it can be used to create a conceptual framework to facilitate a study. One's ontological and epistemological orientation governs his or her research approach and therefore this can be quantitative or qualitative. To match the pragmatist research philosophy, the study used both quantitative and qualitative approaches. This was achieved by using primary data collection where organized questionnaire was deployed for the interaction with primary research respondents. The qualitative method was used to handle the non-numeric qualitative data collected using interviews.

3.3 Location of the Study

The study was conducted at MMUST from where the participants were drawn. MMUST is a public university based in Kakamega County, Kenya. The University started as a college that was established in 1972, then called Western College (WECO) which was a college of Arts and Applied Sciences. In 2002 it became a constituent college of Moi University and thus named Western University College of Science and Technology (WUCST). In 2007 WUCST was awarded a charter to become the seventh public university in Kenya. It was later named after a famous politician from western Kenya; Masinde Muliro to become Masinde Muliro University of Science and Technology (MMUST). According to Hadullo (2017), if contextualized, an institution's vision can form the basis of a case study. The vision of

MMUST is to be a premier university in science technology and innovation. This informed the choice of the study location since from its vision it endeavors to become a leading university in technology and innovation. Online pedagogical infrastructure being an aspect of technological innovation, it is expected that it takes precedence regarding its adoption and use. In addition, MMUST is a public university funded and controlled by the government.

The main campus is located 1 Km from Kakamega Town, along the Kakamega-Webuye Road. The geographical coordinates of the university are 0.2827° N, 34.7519° E. The institution is located 42 Km from Webuye, 60 Km from Bungoma town and 58 Km from Kisumu city. Kakamega town is a peri-urban town in which technological advancements are fast developing.

3.4 Study Population

The study focused on MMUST main campus which has a population of 7,000 students, an estimated 400 faculty members (full time and part-time), 60 management staff and 6 ODEL technical staff (MMUST, 2019). The total population therefore was 7,466. The student population was consistent of regular on-campus undergraduate and postgraduate students. The faculty population considered all teaching staff who were accessible during the data collection. The university has 11 schools offering both on-campus and blended learning. The current study considered all the schools and the 44 departments constituting them.

3.5 Sample Size and Sampling Procedure

3.5.1 Sample Size

The sample size for students, faculty, management staff and ODEL technical staff was determined from target population using the Yamane's formula (Yamane, 1967).

$$n = \frac{N}{1 + N(e^2)}$$

n = the desired sample size

N = the total population

e = the level of statistical significance

Therefore, the sample size for students is:

$$n = \frac{7000}{1 + 7000(0.05^2)} = 378.3 \approx 378$$

$$\text{Non-response} = \frac{5}{100} \times 378 = 18.9 \approx 19$$

$$Total\ sample\ size = 378 + 19 = 397$$

The sample size for faculty members:

$$n = \frac{400}{1 + 400(0.05^2)} = 200$$

$$\text{Non-response} = \frac{5}{100} \times 200 = 10$$

$$Total\ sample\ size = 200 + 10 = 210$$

The sample size for management staff:

$$n = \frac{60}{1 + 60(0.05^2)} = 52.2 \approx 52$$

$$\text{Non-response} = \frac{5}{100} \times 52 = 2.6 \approx 3$$

$$Total\ sample\ size = 52 + 3 = 55$$

Table 3.1: Sampling Frame

	Respondents	Population	Sample Size	%	Sampling Technique
1	Students	7000	397	5.7	Stratified Sampling, Systematic random sampling
2	Faculty Members	400	210	52.5	Stratified Sampling, Systematic random sampling
3	ODEL Staff	6	6	100	Saturated Sampling
4	Management	60	55	91.7	Random Sampling

3.5.2 Sampling Procedure

All the 11 schools participated in this study. Given that schools have different populations of students and faculty, Stratified Sampling was used to organize these respondents into strata. According to Al-Azawei & Domninic (2018), stratified sampling can be proportionate or dispropropotionate in which proportaionate is when the stratum have all equal numbers while disproprotionate is when the stratum have different numbers. Given that schools have different population of students and staff, disproportionate stratified sampling was used. Other than the school strata, the data was further organized into sub-stratum based on the level of learning which included; certificate, diploma, undergraduate, masters and doctorate. After identifying the population in each school strata in which all levels of learning are factored, the Sample Proportionate Formula suggested by Kothari (2017) was used to get the sample of students and faculty to participate in the study;

$$Sample\ for\ the\ strata\ (\boldsymbol{nh}) = \frac{Strata\ Population\ (\boldsymbol{Nh})}{Total\ Population(N)} * Sample\ Size(\boldsymbol{n})$$

Where; **nh** – sample from every strata

n – sample size (obtained by Yamane's Formula)

N – total population

Nh – strata population

From table 3.2, the sample size of students from SAVET for example was calculated as;

$$Sample\ for\ Students\ (SAVETstrata) = \frac{572}{7000} * 397$$

$$=32$$

$$Sample\ for\ Faculty\ (SAVET\ strata) = \frac{44}{400} * 210$$

$$=23$$

The strata samples were then found as given in table 3.2;

Table 3.2: Strata Population and Sample Size

	Strata	Student Population	Student Sample Size (nh*i*)	Faculty Population	Faculty Sample Size (nh*i*)
1	SAVET	572	32	44	23
2	SASS	750	43	41	21
3	SOBE	566	32	47	24
4	SCI	460	26	34	17
5	SDMHA	960	54	50	25
6	SEDU	2480	141	63	33
7	SEBE	230	14	26	14
8	SOM	167	9	29	15
9	SONAS	432	25	28	14
10	SNMP	178	10	20	10
11	SPBHBST	205	11	27	14
		7000	397	400	210

Population Source (MMUST, 2019B)

All the schools within the university and their respective departments were listed in order to identify the strata from which the respondents were picked. To ensure all the schools were well represented, systematic random sampling was used to obtain a total of 210 faculty members and 397 students across all schools. For faculty, a total of **nh***i* (sample obtained from Kothari, 2017 formula) faculty members were selected from

every school to participate in the study. All the faculty in every school were listed in alphabetical order. The population of faculty in every strata (**Nh***i*) was then divided by sample needed in every school (**nh***i*) to obtain a result ***y*** *(which is the selection interval).* Every $\boldsymbol{y}^{th}$ item was then picked until the total of **nh***i* faculty members were obtained. Similar procedures were repeated for students to obtain 397 students to participate in the study. Fraenkel & Wallen (2009) suggests that if the population is small, choosing the entire population is ideal for proper representation. The population of ODEL staff was 6, therefore no sampling was used on ODEL staff. For the management, random sampling was used to obtain 55 respondents. Every member of the sample had an equal chance of being selected and therefore it was deemed unbiased. The names of the respondents were written in pieces of paper and rolled to ensure non visibility of the written text. They were then placed in a container in which 55 samples were picked randomly and the container is constantly shaken after every pick.

3.6 Data Collection Instruments

The necessary data for achieving the objectives were gathered from primary and secondary sources. The secondary data were acquired from pre-existing documented materials that are pertinent to the function of online infrastructure in supporting learning inside universities. On the other hand, the primary data were collected through the creation and distribution of questionnaires to the participants. The survey instrument was a combination of open-ended and conditional items. Open-ended questions were employed in order to provide respondents with the opportunity to freely express their thoughts and opinions. Conversely, contingency questions were utilized to elicit specific and precise information from the respondents. The researcher

developed the instruments following a comprehensive evaluation of the literature, which was conducted to align with the research objectives. The conceptual framework was then constructed based on the factors identified in both empirical and theoretical literature. The aforementioned criteria served as the foundation for the inquiries employed in the instruments. The validity and reliability of the tools were assessed by specialists in order to determine their effectiveness. The equipment utilized in this study included:

3.6.1 Questionnaires

A questionnaire refers to a compilation of topics or inquiries that are presented to a study participant with the anticipation of obtaining responses (Kothari, 2019). The questionnaire was chosen as the preferred method of data collection due to its capacity to maintain confidentiality and its potential to save time. Additionally, the use of questionnaires can enhance the reliability of the data by minimizing the influence of interviewer bias. The cost is lower and it can be applied to a large number of participants. The questions were constructed utilizing the methodology proposed by Churchil and Lacobucci (2018). Two Likert scale surveys with a 5-point rating system were employed to collect ordinal data. Participants were asked to indicate their level of agreement with a statement using five response options. (1) Strongly disagree; (2) Disagree; (3) Neutral; (4) Agree; (5) Strongly agree. This approach was selected since it enables the participants to indicate their preferred degree or level of pleasure in relation to the specific variable being examined (Agyemang & Dadzie, 2010). Two questionnaires were utilized in the study.

3.6.1.1 Students Questionnaire

This questionnaire was used to obtain data from the student responses. The subject matter encompasses four distinct components: Factors influencing the efficacy of learning, technological resources accessible for learners in domestic settings, technological resources accessible for learners inside the university context, and The perspective on online learning (*see Appendix 2).*

3.6.1.2 Faculty Questionnaire

This questionnaire contains questions for faculty members regarding the role of online pedagogical infrastructure in facilitating online learning. The questionnaires were pilot-tested before they were used in the study (*See Appendix 4*).

3.6.2 Interview Guides

An interview schedule is an outline of questions that form a basis for and guide the interviewing process (Kathuri and Pals, 1993). Among the advantages of interview are that it is flexible and probe the respondents deeper (Nachmias, 2016). Moreover, interviews have a higher response rate than the questionnaires. This tool was used to obtain qualitative data that helped in supporting data obtained from questionnaires, content analysis and observation schedules. The interview schedules used in this study are explained below.

3.6.2.1 Faculty Interview Schedule

This interview schedule helped in getting the opinion of faculty members on the use of various elements of online pedagogical infrastructure. The interviews were conducted for faculty members from various departments to ensure that appropriate information is captured across various departments (*See Appendix 3*).

3.6.2.2 ODEL Technicians Interview Schedule

ODEL Staff are the administrators of the online learning platform being used by the institution. Information was collected from these participants since they are directly involved in the daily operations of the online learning management system that the university uses. It was important to interview them because they experience challenges paused by the online learning platform. (*See Appendix 6*).

3.6.2.3 University Management Interview Schedule

The management are those who are concerned with allocation of the resources that are used by all academic and non-academic sections of the university. For online learning to be successfully implemented at the university, the management should be fully involved and provide the support necessary for the implementation process. This interview schedule therefore sought to clarify the position of the management in supporting online pedagogical infrastructure implementation. (See Appendix F).

3.6.3 Online Learning Interaction Observation Schedule

Non- participant observation was used to establish how the students interact with the online platform. Creswell and Piano (2014) suggested that before data is collected, it is important to develop a list of what is to be observed for easier administration of the study process. Therefore, aspects of the online infrastructure that were observed were the degree to which various components of the platform were being used. The degree was then classified as Low (1), Medium (2), or High (3). The result of the observation is documented in *Appendix 9*.

3.6.4 Online Infrastructure Content Analysis

The use of content analysis dates back to 1920's in the united state of America, where a large quantity of data from mass media such as newspapers and radio was analyzed

(Altay, 2014). Conventional, summative, or directed approaches to content analysis are often used in different system analysis (Clootrack, 2023). In this study, directed content analysis was used to analyze the online infrastructure used by the university known as MOODLE. The aim of the analysis was to determine the availability, adequacy and use of components supporting learning in the online infrastructure used. This enabled the discovery of the availability and use of user support tools, data security and privacy, interactive tools, collaboration tools, System user manual, reporting tools, Linkage to Open educational Resources (OER), Online Examination Proctoring Tools, Linkages to University Digital Library, Relevant Course Content (*See appendix 8*).

3.7 Quality Assurance Strategies

Quality Assurance refers to the laid down strategies and policies that ensure that data integrity, quality and reliability are maintained at every stage of the research. (ChangeWorks, 2019). This helped in preventing errors from entering the datasets, taking precautions before the data was collected and establishing procedures of using the data in the study. This was ensured by carrying out validity tests, reliability tests and piloting.

3.7.1 Pilot Study

A pilot study was conducted as a preparatory phase for the main study. The results of the pilot study were used to refine the research methods, identify potential issues, and make necessary adjustments to the study design. Instruments for data collection were tried in a pilot study to assess their appropriateness in which 35 faculty and 105 students were randomly selected from three (3) schools within the university. The schools used in the pilot study were randomly selected. The respondents who

participated in the pilot study were informed on the duration for filling in the questionnaires and that the information they provided was to be treated with utmost confidentiality. Of the 35 questionnaires given to faculty 30 were duly filled while out of 105 questionnaires given to students, only 80 were successfully filled and returned.

Analysis of the pilot study findings showed that certain items within the questionnaires and interview schedules were not clear to the respondents. Some respondents indicated that the questionnaires were too long and therefore they could not fill them. Others said that the confidentiality of the information they were providing was in question and needed assurance that the responses would only be used for the purpose of the research. A few members of the faculty also indicated that some questions were not clear enough on the information they were seeking. Four administrators were interviewed during the pilot study and their views regarding the question items were helpful in restructuring the questionnaire and the interview schedules.

The responses were important in adjusting the instruments, especially reducing the length of the questionnaire by five questions, four other questions were combined to form two questions. Unclear questions were made clear based on the comments obtained during the interview. The data collected was further used in gauging the reliability of the research instruments.

3.7.2 Validity

Bostic and Jonathan (2017) provide a definition of validity as the degree to which instruments accurately measure their intended constructs or the amount to which data analysis results faithfully represent the phenomena being investigated (Mugenda & Mugenda, 2004). The validity of a research instrument is established when its

contents are deemed to be pertinent, suitable, and sufficient in a manner that enables the acquisition of ample information to address the research inquiries. This study was grounded on the concepts of face validity and content validity. In order to ascertain content validity, the instruments were administered to two specialists affiliated with the School of Education at Masinde Muliro University of Science and Technology (MMUST). The task at hand involves evaluating the underlying construct that the instrument aims to quantify. The other expert was tasked with assessing the extent to which the group of items effectively captures the underlying notion being investigated. This was to improve the validity of the instruments and to evaluate the relevance of each item in the instrument in connection to the objectives and rank each item on the scale of extremely relevant (4), somewhat relevant (3), slightly relevant (2), and not relevant (1). The derivation of the Content Validity Index (CVI) was conducted in the following manner: The calculation involves dividing the sum of items scored 3 or 4 by both supervisors by the total number of items in the questionnaire.

Mathematically, this is expressed as:

$$\mathrm{C.V.I} = \frac{\text{Agreed items by both } experts}{\text{Total number of items}}$$

According to Kothari (2017), the attainment of face validity in research instruments is accomplished by employing the expertise of a panel of experts to assess the pertinence and inclusiveness of the various components of the research instrument. In order to ensure face validity in the present study, the data collection methods were enhanced by incorporating input from supervisors, faculty members, and experts possessing relevant expertise in the subject matter. Through a thorough examination

of each individual item, the aspects of clarity, readability, and ambiguity were taken into consideration and dealt with accordingly. This measure was used to verify that every item fulfilled its intended purpose in accordance with the established objectives. The determination of content validity for the instruments was accomplished through the piloting of the research instruments, constituting the initial step of the project. The data obtained from the pilot study was assessed based on its credibility, relevance, and scope in order to address the research questions and encompass all components of the theoretical framework that guided the investigation. Subsequent modifications were implemented in response to the outcomes of the preliminary investigation, the researcher's practical experience during the pilot phase, and the advice provided by specialists, all aimed at enhancing the effectiveness of the research instruments.

3.7.3 Reliability

Reliability refers to the extent to which a research instrument consistently produces data across multiple trials, while controlling for other variables (Roy, 2014). The present study employed the Cronbach alpha coefficient as a measure of internal consistency dependability due to its practicality. The use of all components within the research instrument renders it more convenient in comparison to alternative procedures, as it necessitates only one test administration strategy (Tavakol & Dennick, 2011). A preliminary investigation was conducted in three educational institutions that were randomly chosen from a research sample consisting of 140 individuals. A reliability test was conducted on the four independent variables, namely software factors, hardware factors, internet connectivity factors, and online pedagogical infrastructure, as well as the dependent variable, learning at public

universities. The alpha coefficient was calculated using data collected from the pilot testing of each of the two questionnaires.

$$\alpha = \frac{\left[\frac{k}{k-1}\right]}{\left[1-\left(\frac{1-\sum_{i=1}^{n} S_i^2}{S_x^2}\right)\right]}$$

$w\square ere$

$k = t\square e\ number\ of\ items\ on\ t\square e\ test$

$S_i^2 = t\square e\ obtained\ variance\ for\ item\ i$

$S_x^2 = t\square e\ variance\ of\ t\square e\ total\ test\ scores$

Various researchers employ varying threshold values for alpha, which, as indicated by Tavakol and Dennick (2011), span a range of 0.7 to 0.95. According to George and Mallery (2003), the alpha coefficient values can be interpreted as follows: an alpha coefficient greater than 0.9 is considered excellent, greater than 0.8 is considered good, greater than 0.7 is considered acceptable, greater than 0.6 is considered doubtful, greater than 0.5 is considered poor, and a value less than 0.5 is considered unacceptable. This particular interpretation was employed in the context of the present study. The reliability test results for the Faculty and Students Questionnaire are displayed in Table 3.3 and Table 3.4 using SPSS version 26.

Table 3.3: Reliability Test for Faculty Questionnaires

Variable	Cronbach alpha if item deleted	Cronbach alpha
Online infrastructure	.855	
Hardware factors	.783	
Software factors	.804	
Internet connectivity	.890	0.833

From Table 3.3, the results show that Cronbach's alpha **0.833**, which indicates that the reliability test for the faculty questionnaire was good for scale with this specific sample.

Table 3.4: Reliability Test for Students Questionnaires

Variable	Cronbach alpha if item deleted	Cronbach alpha
Online infrastructure	.781	
Hardware factors	.788	
Software factors	.721	
Internet connectivity	.744	0.762

From Table 3.4, the results show Cronbach's alpha of **0.762**, which indicates that the reliability test for the student's questionnaire was good for scale with this specific sample.

The data obtained from interviews was juxtaposed with the data obtained from questionnaires. The comparisons revealed a high degree of congruence in the data, with very small exceptions. Given the absence of any noteworthy deviations observed in the data obtained via questionnaires, the reliability of the data acquired through interviews was similarly deemed to be high.

3.8 Data Collection Procedure

Permit for data collection was sought from the National Council for Science, Technology, and Innovation (NACOSTI), through Directorate of Post Graduate Studies (DPS), MMUST. Quantitative data was collected from Students and Members of Faculty using questionnaires (see *Appendix 2 and 4*). Two forms of questionnaires were used, web-based Google Forms and printed questionnaire. Both questionnaires were similar in structure and content. Faculty members, management, and ODEL staff

were interviewed to obtain qualitative data. To ascertain the status and usage of online infrastructure by the university, Content Analysis of the MOODLE platform was done based on the access rights provided by the ODEL (*see Appendix 8*). Non-participant observation was used to determine how the learners used the system, their frequency of login to the system, difficulties while using the system, interaction, and collaboration amongst them. (*See Appendix 3, 5 and 6*).

3.9 Data analysis

The essence of data analysis is to present the data that has been collected from the field in a way that can easily be interpreted. In this study qualitative data was sorted, organized, and categorized into themes and sub-themes to aid the process of analysis. Quantitative data was sorted, organized using tables, coded, and analyzed. Both descriptive and inferential statistics were used.

3.9.1 Descriptive Statistics

The descriptive statistics that were used in this study include frequencies, percentages, and means. Frequencies were used to show the count of individual items as per the responses of the respondents. Percentages and means were also used on demographic data for clarity on individual data and to show the differences in averages. These descriptive statistics were chosen since they provide clarity and are easy to interpret by many people. For all the objectives, descriptive analysis was used based on ordinal data collected. Qualitative analysis of the findings from the interviews were triangulated with data collected from observation schedules and MOODLE content analysis to support the findings from the questionnaires.

3.9.2 Inferential Statistics

Ordered Logistic regression analysis was used for hypothesis testing. This method was chosen because the data that was collected was ordinal in nature in which values were orderly arranged from Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. According to Creswell (2015), Ordered Logistic Regression provides accurate measures in such situations. This technique uses a predictive analysis in which the dependent variable is the effect and independent variable is the cause. The data collected for objectives three, four and five were tested using ordered logistic regression. The following null hypothesis were tested at 0.05 level of significance. For **HO_3,** the variables that were tested are online infrastructure use (independent variable) and learning in public universities (dependent variable). For **HO_4,** challenges of online infrastructure use (independent variable) and learning in public universities (dependent) were tested, for **HO_5**, the variables that were tested were, perception of online pedagogical infrastructure users (independent variable) and learning in public universities (dependent variable). To determine the existence of statistically significant differences among the various groups of variables, *p* value was used in checking the significance of the variables and whether to reject or accept the hypothesis.

Table 3.5: Summary of Data Collection, Analysis and Presentation Techniques

Study objectives	Data Collection Method	Data Analysis Techniques	Data Presentation
Establish the status of online pedagogical infrastructure in the university.	❖ Questionnaire ❖ Interview ❖ Content analysis ❖ Observation Schedule	❖ Frequencies ❖ Standard Deviations ❖ Percentages ❖ Mean	❖ Tables ❖ Textual presentation
Determine prospects of online pedagogical infrastructure and how they affect learning.	❖ Questionnaire ❖ Interview ❖ Content analysis ❖ Observation Schedule	❖ Frequencies ❖ Standard Deviations ❖ Percentages ❖ Mean	❖ Tables ❖ Textual presentation
Determine effects of using online pedagogical infrastructure for learning.	❖ Questionnaire ❖ Interview ❖ Content analysis ❖ Observation ❖ Schedule	❖ Frequencies ❖ Standard Deviations ❖ Percentages & Means ❖ Ordered Logistic Regression	❖ Tables ❖ Textual presentation
Investigate the challenges of use of online infrastructure and how they affect learning.	❖ Questionnaire ❖ Interview ❖ Content analysis ❖ Observation Schedule	❖ Frequencies ❖ Standard Deviations ❖ Percentages ❖ Mean ❖ Logistic Regression	❖ Tables ❖ Textual presentation
Establish the perception of users towards application of online infrastructure in facilitating learning.	❖ Questionnaire ❖ Interview	❖ Frequencies ❖ Standard Deviations ❖ Percentages ❖ Ordered Logistic Regression	❖ Tables ❖ Textual presentation

3.10 Ethical Consideration

Kathuri and Pals (1993) argue that any research project should always stay within the scope of a sound ethical study. Key ethical considerations were undertaken and discussed as follows;

Before carrying out the study, the researcher sought permission from the university and was issued with a research permit to conduct the study (*see Appendix 13*). Permission was further sought from the National Commission for Science, Technology, and Innovation (NACOSTI). This was granted and permit issued (*see Appendix 14*).

Plagiarism involves taking someone else's research or academic work / ideas and using them as one's own. This is considered academic theft and is therefore unethical. Plagiarism in this study was taken care of by ensuring that citations are done accurately, proper use of quotation, paraphrasing and adding ideas was done. To ensure academic integrity, the content of this thesis was checked using Turnitin, an online originality check software and the results showed that the level of plagiarism meets the required standards which is approximately 20% or below according to the MMUST postgraduate research guidelines. Reciprocity ensured that the findings of this study were shared with the university from where the data was collected so that they can appreciate the value of the research and assimilate the suggested solutions to the problem investigated.

Respondents were served with a letter of introduction that took care of informed consent; confidentiality and clearly informing them of various aspects of the study. The researcher further ensured that the respondents were not exposed to any substantial risks by not exposing any information that can be used to identify a respondent both during data collection and reporting.

Anonymity was achieved by separating the identity of the individuals from the information that they gave. Questionnaires numbers were used instead of personal information of the respondents. In further maintaining confidentiality, the information provided by the respondents was not revealed publicly other than for research purposes. The researcher also reassured the respondents the study was purely academic and voluntary, and that any information provided in the course of the study would be used purely for research purposes.

Objectivity ensured that there was no personal bias in the collection, analysis, and interpretation of data. In the present study, the researcher remained neutral and was not influenced by opinions, prejudices and personal feelings while conducting the study.

CHAPTER FOUR

PRESENTATION, INTERPRETATION, AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter presents results, interpretation, and discussion of the findings. The demographic characteristics of the respondents are presented followed by description of the variables and descriptive statistics. The rest of the findings are presented in context of the objectives of the study which were; to establish the status of online pedagogical infrastructure used at MMUST, to determine the effect of using online pedagogical infrastructure on learning in MMUST, to determine the prospects of online pedagogical infrastructure and how they affect learning in MMUST, to investigate the challenges of online pedagogical infrastructure and how they affect learning in MMUST and to establish the perception of users towards application online pedagogical infrastructure in facilitating learning in MMUST.

The study sought to answer the following research questions:

i. What is the status of online pedagogical infrastructure used in MMUST?
ii. What are the prospects of online pedagogical infrastructure on learning at MMUST?

The study also sought to answer the following research hypotheses:

HO_3: Use of online pedagogical infrastructure has no effect on learning in MMUST.

HO_4: Challenges of use of online pedagogical infrastructure have no effect on learning in MMUST.

HO_5: Perception of users of online pedagogical infrastructure has no effect on learning in MMUST.

4.2 Questionnaires Return Rate

Table 4.1: Questionnaire return rate.

Unit of observation	Data collection method	Target population	Sample size	Usable response	% effective response rate
Students	Questionnaires	7000	397	360	91%
Faculty	Questionnaires	400	210	173	82%

Table 4.1 shows that a total of 397 questionnaires were issued to students. Of these, 375 (94%) were returned. 15 (4%) of the returned questionnaire were dropped out of the tally for having significant gaps in response on various items. Usable questionnaires for students were 360(91%).

A total of 210 questionnaires were issued to faculty members. Of these, 185 (88%) were returned. Of the returned questionnaires, 12 (6%) were dropped from the tally for having significant gaps in response on various items. Usable questionnaires for faculty members were 173(82%). According to Babbie (2002), response rate of 50% and above is adequate for analysis therefore 91% and 82% were a good response rate.

4.3 Students' Demographic Data

The students were asked to give information about themselves on the following items: Gender, course enrolled in, faculty, MOODLE platform for E-learning, online

examination, and confidence in MOODLE platform for E-learning. The results are presented in Table 4.2.

Table 4.2: Students Demographic characteristics

VARIABLE		Frequency	Percent%
Gender	Male	181	50.3
	Female	179	49.7
Age	15 - 20 Years	58	16.1
	21 - 29 Years	235	65.3
	30 – 39 Years	54	15.0
	40 and above Years	13	3.6
Course	Doctoral Degree	16	4.4
Enrolled	Master's Degree	37	10.3
	Postgraduate Diploma	9	2.5
	Bachelor's Degree	261	72.5
	Diploma	30	8.3
	Certificate	7	1.9
School	School of Agriculture, Veterinary Sciences and Technology	37	10.3
	School of Arts and Social Sciences	38	10.5
	School of Business and Economics	30	8.3
	School of Computing and Informatics	33	9.2
	School of Disaster Management and Humanitarian Assistance	29	8.0
	School of Education	58	16.1
	School of Engineering and Built Environment	15	4.2
	School of Medicine	32	8.9
	School of Natural Sciences	15	4.2
	School of Nursing, Midwifery and Paramedics	30	8.3
	School of Public Health, Biomedical Sciences and Technology	30	8.3
Duration for	1 Semester	90	25.0
using E-	2 Semesters	167	46.4
learning	1 Academic Year	98	27.2
	2 Academic Years and Above	5	1.4
Online	YES	54	15.0
examination	NO	306	85.0
I feel confident	YES	74	20.6
in E-learning	NO	285	79.2

The results in Table 4.2 show that there were nearly average number of male and female respondents in the study as shown by 181(50.3%) and 179(49.7%) respectively. On age, most respondents, 235(65.3%), were between 21-29 years and the smallest group were those above 40 years as indicated by13(3.6%). Most respondents, 261(72.5%), were enrolled in Bachelor's Degree program while Certificate, Postgraduate Diploma and Doctoral degree students registered lower numbers as indicated by 7(1.9%), 9(2.5%), and 16(4.4%) respectively. On the faculty which the students belonged to, the results show that many respondents, 58(16.1%). This implies that the school of education has the largest population in the university. School of Computing and Natural Sciences had the lowest participation in the study and indicated by 15(4.2%).

Significant students, 147 (46.4%) indicated that they had used MOODLE for a duration of 2 Semesters while (5)5% indicated that they had used MOODLE for 2 Academic Years and above. This implies that MOODLE could have been used frequently during the covid-19 pandemic which lasted for a period 1 academic year and therefore frequency of use was on the two semesters. The researcher also sought to find out whether the students had successfully done examination on MOODLE platform. Most respondents, 306(85%) indicated that they have never used MOODLE to conduct examinations successfully while only 54(15%) had successfully done examination online. This implies that the mechanism to successfully conduct examination online has not been put in place by the university. Most respondents, 285(79.2%), had no confidence in the MOODLE platform used for online learning at the university. This implies that a lot still need to be done for successful implementation of the platform so that the users can have confidence in using it.

4.4 Faculty Demographic Data

This section presents the demographic characteristics of the lecturer respondents.

The respondents were asked to give information about themselves on the following items: Gender, age, highest professional qualification, current designation, faculty, experience with E-learning, using ICT in teaching and access to internet. The results are presented in Table 4.3.

Table 4.3: Faculty Demographic characteristics

Variables		Frequency	Percent
Gender	Male	106	61.3
	Female	67	38.7
Age	21 – 30	31	17.9
	31 – 40	38	22.0
	41 – 50	58	33.5
	51 or Older	46	26.6
Qualification	Doctorate Degree	109	63.0
	Master's Degree	60	34.7
	Postgraduate Diploma	4	2.3
Designation	Teaching Assistant / Tutorial Fellow	29	16.8
	Assistant Lecturer	29	16.8
	E-Learning Technologist	15	8.7
	Lecturer	26	15.0
	Senior Lecturer	51	29.5
	Associate Professor	14	8.1
	Professor	9	5.2
Faculty	School of Agriculture, Veterinary Sciences and Technology	12	6.9
	School of Arts and Social Sciences	35	20.2
	School of Business and Economics	12	6.9
	School of Computing and Informatics	5	2.9
	School of Disaster Management and Humanitarian Assistance	18	10.4
	School of Education	32	18.5
	School of Engineering and Built Environment	5	2.9
	School of Medicine	16	9.2
	School of Natural Sciences	4	2.3
	School of Nursing Midwifery and Paramedics	24	13.9
	School of Public Health, Biomedical Sciences and Technology	10	5.8
Experience	Novice	28	16.2
	Intermediate	79	45.7
	Experienced	66	38.2
ICT Use	1 to 5 years	69	39.9
	6 to 10 years	49	28.3
	11 to 20 years	36	20.8
	21 years or more	19	11.0
Access to internet	Daily	93	53.8
	Weekly	52	30.1
	Monthly	24	13.9
	Never	4	2.3

In Table 4.3, the results show that most respondents, 106(61.3%), were male. The result also shows that a large number of the faculty, 58(33.5%), were between the age of 41-50 years. On the other hand, the results show that most respondents, 109(63%), had PhD level of education. On the designation of the respondents, there was an even distribution amongst the tutorial fellows, assistant lecturers, lecturers. There was, however, a small number of Associate Professors, 4(8.1%) and Professors, 9(5.2%). The largest number of respondents, 51(29.5%) were senior lecturers. This implies that senior lecturers form the largest number of staff at the university, and they are between the age of 41-50 years old. Most of these respondents were however from School of Education, 32(18.5%) and School of Arts and Social sciences, 35 (20.2%).

The researcher also sought to find out the experience of the respondents. He found out that most respondents 79(45.7%) had intermediate experience while 66(38.2%) were experienced. On the number of years, the respondents had used ICT, the results show that most of them, 69(39.9%) had used ICT for 1-5years. This implies that technology for learning is a recent field with less than a decade of use in the developing countries. The study also sought to find out the accessibility of internet by the respondents. From the results, majority, 93(53.8%), had daily access to the internet.

4.5 Analysis of Likert Type Scale Data

The study employed a five-point Likert scale for the purpose of data gathering. The rating scale utilized in this study consisted of five response options: Strongly Agree (SA) with a numerical value of 5, Agree (A) with a numerical value of 4, Neutral (N) with a numerical value of 3, Disagree (D) with a numerical value of 2, and Strongly Disagree (SD) with a numerical value of 1. The utilization of Likert-type questions

was employed in this study to gather data. These questions were designed to collect Likert-type data on a single variable, which were then aggregated into a summative scale. This approach enables the utilization of nonparametric tests. In order to adhere to the Likert scale assumption of equidistance, the present study implemented the equidistance value of 8 as proposed by Carifo and Perla (2007). Given that each variable was assessed using distinct Likert scale items, with a range of 3 to 10 items, on an attitudinal scale spanning from 1 to 5, the resultant summative score encompassed a range of 10 to 30. The study employed a scale with an equidistance of 5 to assess the participants' responses to the objectives, ranging from "strongly disagree" to "strongly agree." In the given dataset, there are five data points representing varying levels of agreement. The first two data points, 10 and 10, indicate disagreement. The subsequent data point, 15, represents a neutral stance. The fourth data point, 20, signifies agreement. The final two data points, 25 and 25, strongly indicate agreement. The dataset concludes with the value 30. The adopted scale for individual issues, ranging from a low of 1 to a high of 5, was consistent with the expression "1 strongly disagree." I respectfully disagree with the statement. The data provided indicates a neutral value of 3. Both parties are in agreement. Both the numbers 5 and 5 exhibit a high level of agreement.

4.6 Objective one: Status of Online Pedagogical Infrastructure used by the University.

The study sought to establish the status of online infrastructure used by the university forming the basis of objective one.

A five-point Likert scale was used to determine the status and whether the online infrastructure was used or not.

4.6.1 Accessibility of Various Technologies

The study sought to establish whether the various online infrastructures were easily accessible to facilitate online learning. The mean, the standard deviation (SD) and the composite mean were computed. The result of the Likert is shown in Table 4.12.

Table 4.4: Students' response on accessibility of online infrastructure

Potential Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Std
Internet	-	142 (39%)	-	103 (29%)	115 (32%)	2.47	1.297
Laptops	-	172 (48%)	-	159 (44%)	29 (8%)	2.96	1.052
Printer	43 (12%)	60 (17%)	-	193 (53%)	64 (18%)	2.51	1.288
Smartphone	-	230 (64%)	42 (12%)	88 (24%)	-	3.39	0.854
Ipad	32 (9%)	81 (24%)	26 (7%)	161 (45%)	54 (15%)	2.67	1.241
Tablet	23 (6%)	111 (31%)	25 (7%)	155 (43%)	46 (13%)	2.75	1.203
Radio	66 (18%)	195 (54%)	-	75 (21%)	24 (7%)	3.57	1.197
Television	17 (5%)	177 (49%)	14 (4%)	124 (34%)	28 (8%)	3.09	1.154
Desktop Computer	-	102 (28%)	25 (7%)	177 (49%)	56 (16%)	2.48	1.063
Composite mean and Std						**2.589**	**1.0329**

Based on the data shown in Table 4.4, it is apparent that the kids did not have access to the internet. The majority of participants, specifically 218 individuals comprising 61% of the sample, reported an inability to get a dependable internet connection suitable for engaging in online educational activities. The internet mean, which had a mean score of 2.47 and a standard deviation of 1.297, was found to be lower than the composite mean of 2.589. This suggests that the internet had a negative impact on the

composite mean. The item's standard deviation exceeded the composite standard deviation of 1.0329, suggesting a greater variability in responses for the item compared to the variable. Without reliable internet, access to online infrastructure for learning is not possible. The findings on unreliable internet confirmed Miniwatts Marketing Group (2019) who found out that 63% of the African population did not have access to stable internet. Wamea (2020) also found out that unreliable internet and limited bandwidth contributes to the negligible online learning success stories in Kenyan public universities. Kevin and Robert(2020) however, suggested that internet connectivity problem can be solved if public universities partner with the private sector to ensure cheaper and reliable internet connectivity for students for online learning.

Majority did not have access to Ipads, Tablets, Laptops, Printers and Desktop Computers. This is supported by Kennedy (2018) who found out that inadequacy of necessary equipment by the students and the faculty hinders implementation of online education in public universities. This further explains the observation made on the online learning platforms in which only a few students consistently logged into the online learning platform with the average indicated as two logins per week.

The results further show that Television, Radio, and Smartphone were more accessible to students where 230(64%) agreed that smartphones were most accessible, 42(12%) were neutral while 88(24%) disagreed. Even though students had access to smartphones, most of the online learning platforms are not tailored to explicitly operate on smartphones. It was observed that the students could not complete tasks given by faculty even though they had smartphones. This is supported by Rimba, Izlan, & Sakka (2020) who found out that 90% of the students had relatively high

access to smartphones. They however, had challenges completing tasks online compared to 9.1% who had laptops and could successfully complete online tasks. Elsewhere, Kevin and Robert (2020) suggested that Tablets and IPADS cannot be considered substitutes for laptop computers regarding online learning which supports the findings of the present study. This is due to the wider display that they provide. This, however, cannot be achieved if learners are unable to access such devices.

4.6.2 Students' Confidence to Use Online learning Technologies.

The study sought to find whether students used the listed online infrastructure confidently. The mean, the standard deviation (SD) and the composite mean were also computed. A five-point Likert scale was used to confirm the responses. The result of the Likert is shown in table 4.5.

Table 4.5: Students' response on the use of Online Pedagogical infrastructure

Potential Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Internet	65 (18%)	181 (50%)	-	90 (25%)	24 (7%)	3.48	1.231
Laptop Computer	48 (13%)	186 (52%)	-	113 (31%)	13 (4%)	3.40	1.164
Desktop Computer	66 (18%)	151 (42%)	-	117 (33%)	26 (7%)	3.32	1.293
Smartphones	65 (18%)	179 (50%)	-	91 (25%)	25 (7%)	3.47	1.240
iPad	-	247 (69%)	56 (15%)	-	57 (16%)	3.37	1.089
Tablet	65 (18%)	179 (50%)	-	92 (26%)	24 (6%)	3.45	1.257
Printers	67 (19%)	173 (48%)	-	94 (26%)	26 (7%)	2.05	1.026
Composite Mean and Std. Dev.						**3.22**	**1.186**

Table 4.5 show that the students were confident in using online learning equipment as this is due to the interest indicated towards using the internet, tablets, IPADS and smartphones. Majority, 246(68%), 244(68%) indicated that they could confidently use various smart devices and the internet respectively. This can be associated with the fact that smartphones were easily accessible. Even though the internet was not accessible to many, the students had the skills and confidence to navigate through it.

Students were also confident to use various technologies even though they could have no access to them at the university. A general lack of equipment necessary for online learning was noted by the students. This could be due to the economic backgrounds of the students and unfordable costs of items like laptops and iPads. This is supported by the findings of two previous studies; In the pre-covid 19 period, CUE (2017) indicated that Kenyan Public universities lacked the capacity to conduct full online learning since the students did not have the necessary equipment. A study done in rural China in the post covid-19 period showed that economic status of students affected online learning (Sherry, 2021).

4.6.3 Faculty opinion Status of Online Pedagogical Infrastructure at the University

The study sought to find out from faculty members the status of online pedagogical infrastructure at the university. A five-point Likert scale was used. The result of the Likert is shown in Table 4.6.

Table 4.6: Status of Online Infrastructure – Faculty Response

STATUS OF ONLINE INFRASTRUCTURE AT MMUST							
Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Mean**	**Std**
Availability of Online Platform: I am aware of online learning platform at MMUST	29 (16.8%)	59 (34.1%)	9 (5.1%)	34 (19.7%)	42 (24.3%)	3.01	1.48
Policy: The university has circulated the policy guiding online learning implementation to both faculty members and students.	27 (15.6%)	56 (32.4%)	72 (41.6%)	18 (10.4%)	___	2.47	0.88
Internet Connectivity: The university internet is reliable to support online teaching and learning	24 (13.7%)	54 (31.4%)	74 (42.80%)	21 (12.1%)	___	2.53	0.88
Training: The university has adequately trained its faculty members on use of online learning infrastructure.	11 (6.4%)	69 (39.9%)	58 (33.5%)	35 (20.2%)	___	2.66	0.869
Hardware Availability: There is sufficient upgraded state-of-the art hardware for online learning provided for the faculty members.	26 (15%)	48 (27.7%)	77 (44.3%)	22 (13.0%)	___	2.55	0.898
Software Availability: There are sufficient updated software for document conversions and document editing provided by the university to support online learning	35 (20.2%)	37 (21.5%)	67 (38.7%)	30 (17.3%)	4 (2.3%)	2.60	1.066
Full Online Courses: The university has mounted academic programs that are purely online with no physical learning aspects.	23 (13.3%)	64 (37%)	39 (22.5%)	47 (27.2%)	___	2.64	1.023
ICT equipment: The university have ICT equipment used to complement online learning activities	13 (7.6%)	48 (33.5%)	62 (35.8%)	40 (23.1%)	___	2.75	0.898
Both blended and Online learning modes are used to facilitate learning at the university.	6 (3.5%)	52 (30.1%)	33 (19.1%)	58 (33.5%)	24 (13.8%)	3.24	1.13
Students are comfortable using online learning platform used by the university.	20 (11.6%)	40 (23.1%)	67 (38.7%)	46 (26.6%)	__	2.80	0.962
Composite Mean and Std						**2.727**	**1.011**

From the findings in table 4.6, 74(42.7%) disagreed that there was state-of-the art hardware for online learning provided by the university while 77(44.3%) were neutral. This shows that many faculty members were not sure whether the university has provided the latest hardware to support online learning. This implies confusion regarding the state of the hardware supporting online learning at the university. The results also show that 60(34.7%) disagreed that students were comfortable to use online learning platform provided by the university while 46(26.6%) agreed and 67(38.7%) were neutral. This implies that faculty members were not aware whether the students were comfortable using the online learning platform provided by the university. This is supported by findings from the interview in which one respondent indicated that:

> *" ...I don't understand most components of the system, it is therefore difficult for me to gauge the learner's experience. We tried to use a survey to capture the entry behavior of our learners at the beginning, but it did not work, the students didn't respond to the survey except for a few...**ID17**"*

Regarding the state-of-the-art hardware for online learning, one respondent during an in-depth interview confirmed the fact that they were not sure whether the university has provided necessary hardware to facilitate online learning. He said:

> *"……. the university have given us some devices that we can use for online learning, we have projectors, printers, and at most three desktop computers. These can only be used by the members of faculty at the department and may not be very helpful to serve all the members of faculty regarding teaching and learning. So, for online learning, the members of faculty must depend on their laptops and printers to do most of the online tasks…however am not sure what has been given to the other departments, maybe they have enough devices for online learning or maybe they don't... **ID16.**"*

These findings closely match Walimbwa (2008) who conducted a study in three East African Universities; University of Dar es Salaam (Tanzania), University of Nairobi

(Kenya) and Makerere University (Uganda). He found out that only 2% of the faculty members interviewed from the three universities agreed that there was learner satisfaction with the online learning activities. Similarly, three studies in rural India by Abdullah and Azzedine (2011), Jaiswal (2013) and Felix (2021) indicated that most universities have partly upgraded their hardware to the latest hardware thereby hindering equity among faculty members regarding online learning.

It is significant to note that 45.1% disagreed that the internet was reliable, 12.1% agreed while 42.8% were undecided. This confirms the assertions by the students who had similar sentiments. Faculty members cited inadequate training with 80(46.3%) disagreeing that there was adequate training while 35(20.2%) agreed that the training was adequate. This is supported by Aguti (2015) who posits that 65% of the faculty members had no adequate training. Similarly, Winahyu (2020) indicated that most faculty members ignored the training of online learning before covid-19 as only 9.8% had prior training. Furthermore, most universities had not trained their faculty members on online pedagogical infrastructure use which confirms the present findings (Mohammed, 2020).

Most faculty members shared similar sentiments in which respondents had the following sentiments regarding training:

> "*...I have been using the e-learning platform for the purpose of assignments and notes that I share for the students. It has made my work easier. There are a lot of things that I still don't understand regarding online learning and if the university could train us properly on this system, why would we not use it? As it is now, I still can't use it...***ID I7.***"*
>
> "*.... We are the users of this system, but we do not know how it operates. Members of Faculty are not using the MOODLE for teaching, they are using Zoom, Google Meet, Skype, and things like that to teach students online and call it online learning. Me included I particularly use Google Meet. My view,*

*very little has been done to induct us properly on the operations of this platform…***ID 8***."*

This is further corroborates the report generated by Directorate of Quality Assurance, MMUST, dated 6th March, 2023 and referenced MMU/COR:201003(68) in which they stated students were complaining that online classes were confusing and that faculty members were using platforms which could not accommodate all the students.

The findings in table 4.6 interestingly show that most students were neutral in responding to key issues regarding the status of online infrastructure used by the university. This implies that either they lacked information regarding online learning or there was a general confusion regarding online infrastructure used by the university. This tends to suggest a need for further investigation to understand reasons behind the numerous neutral responses.

Results from the content analysis regarding the status of online infrastructure however, revealed that the online infrastructure has user support system, interactivity tools (Chat), collaboration tools (Wikis, Database, Glossary), Linkage to Open Educational Resources(OER) and Online Examination Proctoring software (Safe Exam Browser - SEB) However, collaboration tools, Linkage to OER and Online Examination Proctoring tool (SEB) were not used for the purpose of learning by both the faculty members and the students. Interactivity tools like chats, access to learning material, and user support tools were used by students only. (*see Appendix 8*).

4.7 Objective Two: Prospects of Online Pedagogical Infrastructure and its effect Learning.

The second objective was to determine the prospects of online pedagogical infrastructure and how they affect learning. A five-point Likert scale was used. The

mean, standard deviation (SD) and composite mean for student responses were computed and presented in Table 4.7.

The findings show that most students, 99(57.4%) disagreed that the use of online learning platform improved academic achievement contrary to Alhothli (2015) and Salmon (2018) whose findings affirmed that the use of MOODLE online infrastructure improved academic performance both at JKUAT and Montana University respectively.

Table 4.7: Prospects of use of online infrastructure for learning – Faculty Responses.

	POTENTIAL ITEMS	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std
1	The use of online learning platform improves academic performance.	22(12.7%)	77(44.7%)	54(31.1%)	13(7.5%)	7(4%)	2.46	0.949
2	Online learning is affordable than traditional face to face learning	20(11.4%)	60(34.8%)	67(36.2%)	17(9.8%)	9(5.2%)	2.77	0.877
3	Mobile learning will help solve the problems on online learning infrastructure.	__	66(38.2%)	31(17.9%)	76(43.9%)	__	3.06	0.907
4	It is better to work from home than from the university's physical environment.	4(2.3%)	44(25.4%)	84(48.6%)	34(19.7%)	7(4%)	2.98	0.842
5	Both theoretical and practical classes can be done online using the online infrastructures.	13(7.5%)	46(26.7%)	57(32.9%)	50(28.9%)	7(4%)	2.95	1.01
6	Gamification – the use of games to provide online learning can improve the perception of learners towards online learning.	9(5.2%)	38(22%)	65(37.5%)	43(24.9%)	18(10.4%)	3.13	1.04
7	The retention of knowledge can be enhanced through online learning	4(2.3%)	46(26.6%)	35(20.2%)	67(38.8%)	21(12.1%)	3.32	1.066
8	Online learning will change the perception of learners towards university education.	4(2.3%)	53(30.6%)	61(35.4%)	48(27.7%)	7(4%)	3.01	0.918
9	Online learning enables better understanding of content for the learners	9(5.2%)	40(23.1%)	73(42.1%)	51(29.5%)	___	2.96	0.858
10	Student cooperation, self-discipline and sense of responsibility can be promoted by online learning in public universities.	4(2.3%)	44(25.4%)	65(37.6%)	60(34.7%)	___	3.05	0.834
11	Online learning aids understanding of graphs, maps, and internet-based resources.	11(6.4%)	39(22.5%)	88(50.9%)	26(15%)	9(5.2%)	2.9	0.913
12	Online learning caters for Students different learning styles.	16(9.2%)	32(18.6%)	65(37.6%)	44(25.4%)	16(9.2%)	3.07	1.087
13	Lecturer's teaching efficiency is improved by online learning activities and processes	16(9.2%)	32(18.5%)	68(39.3%)	57(32.9%)	__	2.96	0.942
14	Online learning can aid the choice of technology related careers	18(10.4%)	25(14.5%)	54(31.2%)	62(35.8%)	14(8.1%)	3.17	1.015
15	Online learning infrastructure enables student collaboration and socialization	11(6.4%)	44(25.4%)	63(36.4%)	39(22.6%)	16(9.2%)	3.03	1.053
16	Online learning infrastructure allows customized learning experience	18(10.4%)	33(19.1%)	53(30.6%)	57(33.0%)	12(6.9%)	3.07	1.03
	Composite Mean and Std						**2.99**	**0.96**

From Table 4.7, it is also worth noting from the study that most students 80 (46.2%) disagreed that online learning is more affordable than traditional face-to-face learning. This is attributed to the fact that the students do not have access to reliable internet and the purchase of internet bundles is expensive. The students also indicated that the equipment for online learning was not easily accessible. Contrary to these findings, a study by Grand-Cayon (2021) indicated that students who studied via the online platform incured less tuition cost compared to regular classroom-based students. Furthermore, Snježana (2015) found out that the Open University of United Kingdom had reduced the cost of University Education by nearly half while it still offered quality education by adoption of effective online learning. Providing affordable and reliable internet and ensuring that the learners have necessary tools for online learning could change the perception of learners and make online learning cost effective as it should be based on previous studies.

On whether mobile learning will help solve the problems of online learning infrastructure, 76(43.9%) agreed, 31(17.9%) were neutral and 66(38.2%) disagreed. This implies that a large number preferred learning to be offered via smartphones given the fact that most students 230(64%) agreed they were more accessible to them (*see Table 4.4*). Mohammadi, Sarvestani & Nouroozi (2020) found out that 74% of the students investigated preferred smartphone-based learning application than desktop applications or face-to-face learning activities which closely relates to the findings in the present study. Furthermore Salmon & Joanne (2022) suggest that gaps in online learning can be bridged by adopting mobile-based applications for learning.

The majority, 88(50.9%), agreed that retention of knowledge could be enhanced through online learning. Furthermore, 76(43.9%) agreed that online learning enhances

career choice. These findings are supported by Drexel (2021) who postulated that students using online learning platforms have high retention of content and overcame various barriers to learning. Papia (2016) similarly agreed that cognitive load can be greatly reduced if properly designed instructional material were used for online learning leading to greater chances of content retention. Study at Walden University amongst the alumni indicated 73% of the career choices they made were related to their choice of online learning and certification they did online (Walden, 2019). This implies that the faculty members should be trained in instructional material design for online use so that students can easily consume and retain necessary content. Furthermore, students should be encouraged to use the online learning platforms to shape their careers.

On whether online learning infrastructure enables student collaboration and socialization, 55(31.8%) disagreed, 63(36.4%) were neutral and 55(31.8%) agreed. Most students were undecided whether socialization or collaboration could be enhanced by online infrastructure. Those that agreed or disagreed 55(31.8%) were of the same number. This finding contradicts the findings in other studies like Terry (2017); Mohamed (2018) and Lane (2021) who all found out that online collaboration and interaction is highly achievable in online learning where students interact and share knowledge irrespective of geographical locations. One respondent during an interview re-iterated that great interaction and collaboration is achievable through online learning;

> *"… When students' needs are met through online education, there is an increase in the amount of interaction and communication that takes place among them, as well as an improvement in their academic performance. In addition, using an online learning system helps save time and money while looking for materials, resources (such as*

paper and printer ink), and other expenditures. As a result, successful online education bestows more advantages in both the direct and indirect senses… **IDI 05"**.

This implies that the students were unaware of the collaborative tools available or had not been trained on their use. Observation made on how the system is used (*See appendix 7*) however, showed that there was medium (mid) use of online collaborative activities which corroborates the findings from the questionnaires. Content analysis of the infrastructure also showed that interactivity features of the Moodle platform were not user-friendly which explains the limited use of collaborative tools on the Moodle platform.

It is important to note that 69(39.9%) agreed that online learning infrastructure allows customized learning experience, 51(29.5%) of the respondents disagreed while 53(30.6%) were undecided. This showed that a good number of the respondents agreed that online learning infrastructure allows customized learning experience. This fact is supported by findings from one ODEL respondent who during an interview stated:

"……*most people want to study at their convenience and therefore if online learning is properly managed, the university will have the opportunity to offer many courses online and thereby becoming competitive. This will help solve the problem of those who are interested in learning while away from the university. This can only be achieved if the university prioritizes the activities of e-learning……."*

This finding, however, are contradicted by Nwankwo (2015) and Kooli, Zidi, and Jamrah (2019) who carried out studies on the student's learning experience, perceptions, perceptions of online course content and interaction respectively. They found out that there was a general negative perception towards the implementation of the online learning platforms. They concluded that hurried implementation of the

online systems without proper infrastructure in-place contributes to negative experiences for faculty members.

A large number of neutral responses was noted on Table 4.7 by faculty members regarding prospects of using online infrastructure at the university. This points to a confusion on whether the system was useful in improving learning or not. It tends to suggest a possible need for investigation regarding the indecision by faculty regarding prospects of online infrastructure.

4.8 Objective Three: Effects of using online pedagogical infrastructure on learning.

The third objective was to determine the effects of using online pedagogical infrastructure on learning. The study therefore sought to find out the effect of online infrastructure on learning. Both descriptive and inferential analysis were used to ascertain the effectiveness of the pedagogical infrastructure.

4.8.1 Descriptive Analysis of Student's Response on effects

To be able to determine the effects of online pedagogical infrastructure on learning, relevant questions were included in the students' questionnaires. A five-point Likert scale was used to get answers from the student respondents as presented in Table 4.8

Table 4.8: Students' response on effect of online pedagogical infrastructure on learning

S/NO	Potential Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
1	Am not comfortable with online discussions	42(11.7%)	144(40.0%)	-	152(42.2%)	22(6.1%)	3.09	1.237
2	Participating in online discussions requires a lot of time and effort.	-	163(45.3%)	-	102(28.3%)	95(26.4%)	2.64	1.291
3	The lecturer should facilitate online learning	66(18.3%)	158(43.9%)	-	109(30.3%)	27(7.5%)	3.35	1.287
4	Power outage affects online learning	-	165(45.8%)	24(6.7%)	49(13.6%)	122(33.9%)	2.64	1.352
5	Online learning is convenient to students	-	166(46.1%)	15(4.2%)	71(19.7%)	108(30%)	2.66	1.323
6	I am confident using online communication tools.	-	152(42.3)	25(6.9%)	102(28.3%)	81(22.5%)	2.69	1.230
7	It is necessary to have reward system or incentives to motivate students to continue using e-learning.	39(10.9%)	160(44.4%)	-	142(39.4%)	19(5.3%)	3.16	1.209
8	It is important to have an e-learning support service to provide online assistance.	-	170(47.2%)	20(5.6%)	88(24.4%)	82(22.8%)	2.77	1.257
	Composite Mean and Std						**2.875**	**1.116**

From Table 4.8, 186(51.7%) were not comfortable with online discussions at the university while 174(48.3%) were comfortable. The mean score of 3.09 with a standard deviation of 1.237 shows that most respondents agreed not being comfortable with online discussions at the university. The mean above the composite mean of 2.875 indicates a positive effect on the composite mean. This corroborates the observation made on the MOODLE platform in which there was low usage of online collaborative tools such as discussion forums and chats. This is further confirmed by 179(49.7%) respondents who noted that online discussions were not convenient to students while 166(46.1%) agreed that such discussions were convenient. This is however contradicted by Zozie (2020) and Aguti (2015) who asserted that most students were comfortable with online learning and using the online communication tools.

It is worth noting that 171(47.5%) students disagreed that power outage affected online discussions while 165(45.8%) agreed that they were affected. This can be explained by the fact that most students (*see Table 4.4*) have access to smartphones which could retain power for some time. However, it contradicts Zozie (2020) who found out that power outage greatly affects online discussions. Majority of the students 224(62.2%) pointed out the need for a lecturer to be present to guide online discussions.

It is worth noting that the same number of the respondents, 170(47.2%), agreed and disagreed that it is important to have an online learning support service. The mean score was 2.77 with a standard deviation of 1.257 which shows that there was a divided opinion and confusion on whether it is important to have an online learning support service. This implies that half of the students were comfortable with online

learning technology while the other half were not fully informed on online learing. This is supported by Teresa et. al (2019) who found out that students' skills in using technology were different and therefore there was a need for technical assistance from the faculty and the technical staff.

4.8.2 Descriptive Analysis of Faculty Response on Effects

To be able to determine the effects of online pedagogical infrastructure on learning, relevant questions were included in faculty questionnaires. A five-point Likert scale was used to get answers from the student respondents as presented in Table 4.9.

Table 4.9: Effect of Online Infrastructure – Faculty Response

SNO	Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std
1	E-learning system does not adequately keep up-to-date information via calendars.	32(18.6%)	80(46.2%)	45(26%)	12(6.9%)	4(2.3%)	2.28	0.225
2	I teach better in online	4(2.3%)	45(26%)	92(53.2%)	32(18.5%)	__	2.88	0.725
3	Using e-learning does not necessarily enhance a university's competitiveness in teaching and research.	9(5.2%)	42(24.3%)	55(31.6%)	56(32.5%)	11(6.4%)	3.1	1.012
4	I am less creative and innovative when using e-learning.	20(11.6%)	78(45.1%)	35(20.2%)	31(17.9%)	9(5.2%)	2.6	1.072
5	E-learning is very costly to the University.	23(13.3%)	49(28.3%)	64(37%)	37(21.4%)	__	2.66	0.96
6	E-learning helps Universities to increase their return on investment.	13(7.5%)	22(12.7%)	59(34.1%)	60(34.7%)	19(11%)	3.29	1.066
7	Using e-learning does not impact on the students' academic grades.	31(17.9%)	53(30.6%)	59(34.1%)	25(14.5%)	5(2.9%)	2.54	1.037
8	E-Learning has promoted access to education and learning.	22(12.7%)	54(31.2%)	42(24.3%)	41(23.7%)	14(8.1%)	2.83	1.167
9	I am open to participating in online discussions.	19(9%)	25(14.5%)	42(24.3%)	40(23.1%)	47(29.1%)	3.41	1.32
	Composite Mean and Std						**2.84**	**1.03**

The results show that the majority of the faculty 92(53.2%) were not sure whether they taught better online or not. It is no wonder 67(38.7%) could not tell whether students were satisfied with online learning or not (*see Table 4.6*). However, Jack (2022) indicated that 57% of the faculty members thought they taught better online. Inability of the faculty to tell whether students were satisfied is attributed unreliable internet at the university, insufficient equipment for online study, inadequate training and insufficient softwares (*See Table 4.6*). Results from interviews indicated that the faculty opted to use other methods to teach rather than the online learning platform (MOODLE). One respondent said that:

> "*…. We are the users of this system, but we do not know how it operates. Faculty members are not using the online learning platform for teaching, they are using Zoom, Google Meet, Skype and things like that to teach students online and call it online learning. Me included; I particularly use Google Meet. My view, very little is being done by faculty members on the e-learning platform…***ID8***."*

Furthermore, majority, 67(38.9%) noted that using online learning does not necessarily enhance the university's competitiveness in teaching and research despite David, Michael & Patterson, (2019) detecting a 45% increment of Stanford University competitive advantage because of using Massive Open Online Courses (MOOCs). Creativity and innovativeness went up when using online learning even though they were inadequately trained (*see Table 4.6*). This could have been as a result of self-aggressiveness of the staff to acquire new skills.

A large number of the faculty, (41.6%) indicated that online learning is cost effective contrary to the learners who indicated otherwise (*see Table 4.8*). It is however supported by Aguti (2015) and Zozie (2020) found out that online learning is cost effective for university education.

It is also notable that 84(48.5%) disagreed that using online learning platforms does not impact students' academic grades while 79(45.7%) agreed. This shows that many faculty members indicated that online learning has impact on students' academic grades. These findings are supported by Salmon (2018), Alhothli (2015) and Khaled (2022) who found out that online learning platforms improved students' academic performance. The students, however, opined that using online infrastructure does not affect their academic performance (*see Table 4.6*).

On whether E-learning promoted access to education and learning, a large number, 76(43.9%) disagreed, that E-learning promoted access to education and learning compared to 37(31.4%) who agreed. This implies that many had not successfully used online learning infrastructure to achieve their educational goals. This finding disagrees with studies done before covid-19 and post-covid 19. Snježana (2015) and Lane (2021) found out that Open University of the United Kingdom and Athabasca University had provided relatively cheap and quality education with 78% and 65% percent increment over a period of five years respectively.

Majority of the faculty members, 87(52.2%), were willing to participate in online discussions an idea that would improve students' confidence since they were of the opinion that faculty should be present during online discussions to guide the students and respond to their queries (*see Table 4.8*). To realize the potential of online teaching, there is need to monitor the discussion forums and even award marks for the discussion Michelle (2019). Observation made on the use of online learning platform indicated low participation in online discussion forums and chats by the faculty. From interviews, it emerged that students preferred discussions on other social platforms

like WhatsApp, Facebook and Short Messages (SMS) to the discussion forums embedded on MOODLE. One had this to say:

> "……*we are positive about online learning and since this is a university of science and technology, e-learning is a technology that we embrace. Regarding online discussions, students prefer other forums which are easy to use and easy to access, the forums on the MOODLE platform do not have interfaces that are user friendly in my opinion students don't feel comfortable using them....* **IDI 03.***"*

This implies low usage of collaboration tools and points to the design issues of communication forums built into the MOODLE learning platform which tend to be complex and not user friendly.

4.8.3 Analysis of the effect of online pedagogical infrastructure on learning in public universities.

To establish the effect of use of online pedagogical infrastructure on learning in public universities. Ordered Logistic Regression test was carried out to test the following null hypothesis at 0.05 level of significance.

> ***HO_3: Use of online pedagogical infrastructure has no effect on learning in MMUST.***

The results are shown in Table 4.10

Table 4.10: Frequency distribution of effect of online infrastructure

	N	%
[EFFECT= 1 (Strongly Disagree)	74	42.8%
[EFFECT= 2 (Disagree)	54	31.2%
[EFFECT= 3 (Neutral)	24	13.9%
[EFFECT= 4 (Agree)	21	12.1%

In Table 4.10, results show that overall 42.8% of faculty strongly disagree on the effect of online infrastructure on learning, 31.2% disagreed, 13.9% were neutral while 12.1% agreed.

Table 4.11: Model Fit

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	324.283			
Final	301.897	22.385	13	.040

Link function: Logit.

Table 4.11 presents the evaluation of the model's performance in relation to the data. The obtained findings reveal that the chi-square statistic is statistically significant ($p<.05$), suggesting that the final model exhibits a noteworthy enhancement compared to the baseline intercept-only model. This finding demonstrates that the model's predictive accuracy surpasses that of mere guesswork based on the marginal probabilities associated with the outcome categories.

To assess the degree of agreement between the observed data and the model that has been fitted. A goodness of fit test was performed. The present examination encompasses Pearson's chi-square statistic for the model, alongside an additional chi-square statistic derived from the deviance.

Table 4.12: Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	302.254	285	.231
Deviance	287.459	285	.448

Link function: Logit.

Based on the findings presented in Table 4.12, it can be concluded that the null hypothesis, which posits a good fit of the data, is supported. If the hypothesis is not rejected, specifically when the p-value is big, it can be inferred that the data aligns closely with the predictions of the model, indicating a strong model. However, in the event that the assumption of a satisfactory fit is disregarded, often shown by a p-value less than 0.05, it might be concluded that the model does not adequately capture the characteristics of the data. The findings of our research indicate that the model fits adequately, as the p-value is more than 0.05.

Table 4.13: Pseudo R-Square (R^2)

Cox and Snell	.121
Nagelkerke	.141
McFadden	.066

Link function: Logit.

In Table 4.13, the pseudo R^2 values (e.g. Nagelkerke = 14.1%) indicates that the effect of online Pedagogical Infrastructure explains 14.1% proportion of the variation in learning in public universities. The low R^2 indicates that a model containing only effects is likely to be a poor predictor of the learning in public universities. Note though that this does not negate the fact that there is a statistically significant and relatively large difference in the Online Pedagogical Infrastructure.

Table 4.14: Parameter Estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[LEARNING = 1]	-2.910	1.326	4.814	1	.028	-5.510	-.311
	[LEARNING = 2]	-.374	1.313	.081	1	.776	-2.948	2.200
Model 1	[OI-EFFECT=1]	.503	1.874	.072	1	.789	-3.171	4.177
	[OI-EFFECT =2]	-2.203	1.456	2.289	1	.130	-5.057	.651
	[OI-EFFECT =3]	-2.204	1.408	2.452	1	.117	-4.963	.555
	[OI-EFFECT =4]	0[a]	.	.	0	.	.	.
Model 2	[OI-EFFECT =1] * Pedagogical approaches * Instructional material design factors * Institutional Factors	-.075	.061	1.535	1	.215	-.194	.044
	[OI-EFFECT =2] * Pedagogical approaches * Instructional material design factors * Institutional Factors	-.023	.026	.797	1	.372	-.075	.028
	[OI-EFFECT =3] * Pedagogical approaches * Instructional material design factors * Institutional Factors	-.016	.020	.663	1	.415	-.054	.022
	[OI-EFFECT =4] * Pedagogical approaches * Instructional material design factors * Institutional Factors	-.136	.062	4.751	1	.029	-.257	-.014

Link function: Logit.

a. This parameter is set to zero because it is redundant.

b. OI-EFFECT: online infrastructure effect on learning

In Table 4.14, Model 1 shows the results without the effect of interaction (intervening variables). We take the exponent of the estimated coefficient to get OR i.e. exp (0.503) = 1.654, exp (-2.203) = 0.110, exp (-2.204) = 0.111, exp (-0.075) = 0.928, exp (-0.023) = 0.977, exp (-0.016) = 0.984, and exp (-0.136) = 0.873. The odds of faculty members response on strongly disagree OI-EFECT=1) on online pedagogical infrastructure has no effect on learning was 1.654 (95% CL, -3.171 – 4.177) times that of response of strongly agree, a statistically not significant effect, $(Wald = 0.072, \chi^2_{(1)} = 17.475, p = 4.177)$. Therefore at 0.05 level of significance, we accept the null hypothesis that, ***Use of online pedagogical infrastructure has no effect on learning in MMUST.***

An increase in strongly disagreeing on status of online pedagogical infrastructure was associated with a decrease in faculty members' response on strongly agreeing on the effect of online pedagogical infrastructure. Similar results can be explained for disagree neutral and agree.

Model 2 shows the results with the effect of interaction (intervening variables). The significant interaction terms indicates the slope of the assumed linear relationship between interaction variables (pedagogical approach factors, institutional material design factors and institutional factors) and status of online pedagogical infrastructure varies significantly between learning in public universities. The overall Wald for the status of online pedagogical infrastructure and interaction when the response was strongly disagree is not significant (Wald = 1.535, df = 1, p = 0.215). The OR value is 0.928(95% CL, -0.194 – 0.44) which indicates that the odds of strongly disagree on status of online pedagogical infrastructure decreases by 0.928 for each unit increase in

interaction score. Similar results can be explained for disagree and neutral with an exemption of the last response which has a significant effect.

Table 4.15: Test of parallel lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	314.523			
General	297.048	17.475	7	.015

Table 4.15 shows that there may be some explanatory variables for which the ORs are not stable across different cumulative thresholds in relation to the response of status of online pedagogical infrastructure ($\chi^2_{(1)} = 17.475, df = 7, p = 0.015$).

4.9 Objective Four: Challenges of use of online pedagogical infrastructure and how they affect learning.

The study sought to find out the challenges of using online infrastructure. A five-point Likert scale was used to get responses from the students and faculty members.

4.9.1 Descriptive Analysis of the Challenges to the Students

This section presents to opinion of the students on academic, technological, and administrative challenges that affect the use of online learning infrastructure at the university.

4.9.1.1 Academic challenges

Table 4.16: Academic challenges of online infrastructure experienced by students

Potential Items	SA	A	N	D	SD	Mean	STD. DEV
Interaction between Students and Faculty Members The faculty guide learners during active online learning sessions	51 (14.2%)	112 (31.1%)	36 (10.0%)	161 (44.7%)	-	3.15	1.143
Time Required to take online exams and Assignments. Sufficient time allocated to complete online tasks	-	66 (18.4%)	-	179 (49.7%)	115 (31.9%)	2.05	1.026
Reading Materials: The course learning materials can be accessed with a lot of ease and are simple to navigate	27 (7.5%)	236 (65.6%)	3 (0.8%)	94 (26.1%)	-	3.54	0.962
Composite Mean and Std						**2.913**	**1.0436**

The study sought to investigate the academic challenges of online infrastructure and their effects on learning. From Table 4.16, nearly same number of the students 163(45.3%), 161(44.7%) agreed and disagreed respectively that faculty members guided learners during active online learning sessions. This points to lack of clarity and confusion as to whether indeed the faculty guided the learners online. Faculty members however, indicated the willingness to participate in online discussions (*see Table 4.9*). It is also noticeable that the majority, 263(73.1%), indicated that course learning materials could be accessed and navigated with ease implying that faculty members had skills to design materials that can easily be navigated by the students. This disagrees with Sergey, Sviatlana, Kasiet, and Gulnara(2021) assert that students

could not make sense of the instructional materials used for online learning. Most students 294(81.6%) indicated that time allocated to complete online tasks was not sufficient. This explains the low completion rates of tasks. It however contradicts Mohammed (2020) who found that students had enough time to complete online tasks.

4.9.1.2 Technological challenges

Table 4.17: Technological challenges of online infrastructure experienced by students

TECHNOLOGY CHALLENGES FOR STUDENTS	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Availability of Technology at Home: I have a device to support online learning while at home.	-	141(39.2%)	-	129(35.8%)	90(25.0%)	2.53	1.24
Availability of Technology at School: There is available technology at the university to facilitate online learning	-	94(26.1%)	-	219(60.8%)	47(13.1%)	3.09	1.178
User management: The e-learning platform allows the student to manage his/ her personal information	68(18.9%)	175(48.6%)	-	94(26.1%)	23(6.4%)	3.48	1.24
Security of User Data: I am aware that my personal data are always protected while interacting via internet	-	103(28.6%)	-	173(48.1)	84(23.3)	2.34	1.125
Collaborative learning: The online learning platform provides opportunities for students to accomplish tasks collaboratively	-	173(48.1%)	30(8.3%)	82(22.8%)	75(20.8%)	2.84	1.232
Interactive learning: The platform allows students to locate students and people of similar interests outside of their module, course, and year of study or institution.	1(0.3%)	242(67.2%)	38(10.6%)	26(7.2%)	53(14.7%)	3.31	1.119
Bandwidth: the bandwidth provided by the university is sufficient for online learning.	-	82(22.8%)	99(27.5%)	70(19.4%)	109(30.3%)	2.43	1.145
Time Management: The platform allows students to plan, organize and manage the individual work according to their time and learning style	65(18.1%)	170(47.2%)	-	100(27.8%)	25(6.9%)	3.42	1.257
Learning tracking: The platform allows me to easily monitor my personal learning activities and gauge my level of achievements.	34(9.4%)	130(36.1%)	14(3.9%)	182(50.6%)	-	3.04	1.16
Use of e-portfolios: The system records student achievement using e-portfolios	-	152(42.2%)	49(13.6%)	69(19.2%)	90(25.0%)	2.73	1.243
Internet Connectivity: There is stable internet connectivity at home to facilitate online learning	26(7.0%)	183(50.8%)	-	151(41.2%)	-	3.23	1.08
Technology Background: I can easily navigate through the online learning platform using my device	22(6.1%)	156(43.3%)	11(3.1%)	145(40.3%)	26(7.2%)	3.01	1.172
Ease of Use: The e-learning platform is easy to use.	81(22.5%)	102(28.3%)	25(6.9%)	152(42.2%)	-	2.69	1.23
Composite Mean and Std						**2.92**	**1.51**

The study sought to establish the technological challenges that students face. From table 4.17, the results show that most respondents, 219(60.8%) and 266(73.9%) indicated that they lacked crucial devices to support online learning while at home and at the university respectively. This agrees with Hadullo, Oboko, & Omwenga (2017) and Mohammed (2020) who also found out that students lack sufficient technology for online learning. This implies a general inadequacy of online learning equipment for learners.

The results show that 243(67.5%) respondents agreed that e-learning platform allowed students to manage their personal information. However, most students, 257(71.4%) were unaware of the safety of their data online. On the other hand, 157 (43.6%) students were unaware that the online platform could allow them to accomplish tasks collaboratively. This corroborates the observation made on the infrastructure in which collaborative tools were available but were not being used.

The results further show that 243(67.5%) of the respondents agreed that the online learning platform allows students to locate students and people of similar interests outside of their module, course, and year of study or institution implying that the system could help students to collaboratively study and interact. A good number of students, 179(49.7%), indicated that they were not notified when they were inactive or had taken long to complete assigned tasks, implying that the online platform had no way of reminding the students on deadlines or they did not know how to activate such notifications. Salmon (2018) however confirmed that MOODLE had the capability of notifying students on the pending tasks and deadlines. It is therefore possible that the students in the current study did not know how to access the feature. The online platform enables students to plan, organize and manage individual work according to

their time and learning style as confirmed by 235(65.3%) students. However, a sizable number of students indicated that the system could not allow them to gauge their level of achievement as indicated by182(50.6%). This contradicts the findings by Aguti (2015) which showed that students could track their progress and were able to receive completion notification from MOODLE once they had completed a task. This could be attributed to insufficient training cited by the students. The results indicated that 178(49.4%) of the respondents agreed that they could easily navigate through the online learning platform using their devices while 171(48%) disagreed. On the contrary, the majority, 183(50.8%) indicated that the online learning platform was difficult to use.

It is therefore evident that even though the systems had various important components and tools that could allow students to learn and collaborate, the students were not able to use them appropriately. This shows a general inadequacy of skills and expertise in using the online learning platform which could be linked to insufficient induction on important features of the system.

The findings also showed that the bandwidth provided by the university was not adequate for online learning as shown by 179(49.7%) students. This is confirmed by the observation made during the study in which 1400 students were issued with two continuous assessment tests to observe performance of the system. It was noted that the system crashed when more than 1000 concurrent users were logged in. This was an indication that the system concurrency and bandwidth is not sufficient for multiple users exceeding certain limits.

4.9.1.3 Administrative challenges

Table 4.18: Students' view on administrative challenges of using online infrastructure.

ADMINISTRATIVE CHALLENGES FOR STUDENTS	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Std Dev
47: Adequate ICT and Learning Infrastructure The University has provided sufficient ICT devices to support online infrastructure. (Computers, Projectors, Tablets)	-	105 (29.2%)	-	183 (50.8%)	72 (20.0%)	2.38	1.106
48: University's Readiness to support Online Learning The university readily offers support for online learning activities	65 (18.1%)	164 (45.6%)	-	106 (29.4%)	25 (6.9%)	3.38	1.268
49: Policy The university has a policy regarding e-Learning that has been made available to all the learners	-	72 (20.0%)	-	188 (52.2%)	100 (27.8%)	2.12	1.032
Composite Mean and Std						2.63	1.135

The study investigated the administrative challenges of online infrastructure and how they affect students' learning. Majority, 255(70.8%), asserted that the university did not provide sufficient ICT devices like computers, projectors, tablets to support learning online. This relates to the results in *Table 4.4* and *Table 4.17*. Similarly, it is supported by Mohammed (2020) who found that there was inadequate support from management in ensuring there is sufficient equipment for online learning.

On university's readiness to support online learning, 229(63.7%), agreed that the university management readily offered support for online learning activities contrary to Stoffregen et al., (2016) and Al-Azawei et al. (2018) who established that 55% and

62% of the students respectively disagreed that the university readily offered support to online learning. However, these studies were conducted prior to covid-19 pandemic and the present study has been carried out in a post-covid 19 pandemic period in which the university management was committed to improving the status of online learning.

Of the respondents, 288(80%) disagreed that the university management had a policy regarding e-Learning that had been made available to all the learners. The sentiments of the faculty members (*see Table 4.6*) also indicated that the university had not circulated an online learning policy. George & Dorothy(2016) and Wamae(2020) share similar sentiments in their studies in which they observed that most universities had draft online learning policies which had not been approved by sanate and therefore not circulated for use.

These findings generally showed that the university was ready to support online learning but had not focused on important issues like online learning policy and equipment necessary to support online learning.

4.9.2 Descriptive Analysis of the Challenges to the Faculty

The data collected from the faculty on challenges faced while using online learning infrastructure are discussed below:

4.9.2.1 Academic challenges

The study sought to find out from faculty members' respondents the challenges of using online infrastructure. A five-point Likert scale was used to get answers from the respondents as shown in Table 4.19.

Table 4.19: Faculty response on Academic challenges of online infrastructure

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std
Time Required to develop e-Learning Content. Faculty members have enough time to develop online learning materials	40 (23.2%)	71 (41%)	31 (17.9%)	31 (17.9%)	___	2.31	1.019
Training Faculty members have been sufficiently trained to navigate the e-Learning platform and to handle online teaching and learning.	17 (9.8%)	70 (40.5%)	57 (32.9%)	24 (13.9%)	5 (2.9%)	2.6	0.945
Interaction with the Students There is adequate interaction with students while teaching online classes	17 (9.8%)	65 (37.6%)	57 (32.9%)	34 (19.7%)	___	2.62	0.910
Availability of Time for preparing and administering online exams There is sufficient time to prepare and administer online examination to the students	18 (10.4%)	63 (36.4%)	53 (30.3%)	39 (22.9%)	_____	2.65	0.944
Awareness on Integrating Learning software into teaching. I have knowledge of how to integrate e-learning software into teaching	23 (13.3%)	58 (33.5%)	51 (29.5%)	36 (20.8%)	5 (2.9%)	2.66	1.041
Provision of feedback There is the provision of teaching feedback from both the students and the administration.	17 (9.8%)	79 (45.7%)	48 (27.7%)	24 (13.9%)	5 (2.9%)	2.54	0.949
Composite Mean and Std						2.56	0.968

The study sought to find out from faculty members the challenges of online infrastructure and how they affect learning by the students. From Table 4.19, the data show that most faculty members, 111(64.2%), did not have enough time to develop online learning materials. Majority, 87(50.3%), indicated that they were not sufficiently trained to navigate the e-learning platform and handle online teaching and learning, while 82(47.4%) indicated that they did not have enough time to interact with the students while teaching online classes. Almost the same number, 81(46.8%), indicated that they did not have sufficient time to prepare and administer online examination. These findings support those of Marzilli et al. (2019) and Mohammed (2020) who found that inadequate training and insufficient time hinders faculty members from effectively using online learning platforms. Interview results also share similar opinions in which some respondents indicated that:

> *"……we do not have enough time to prepare the necessary materials and upload them online. Remember we have also the face-to-face classes that we have to attend to. There should therefore be faculty in ODEL who specifically handle online learning and not to put everyone on the same spot regarding online teaching.* **IDI 10"**.
>
> "…… *indeed, we have some computer skills, however, consider the age difference of members of faculty, some might find it difficult to learn the new technologies and use them on the online learning platform, such people need a lot of training and not the two hours that was used to train members of faculty....* ***IDI 08"***

On integrating learning software into teaching, a good number of faculty members, 81(46.8%) disagreed that they had knowledge of integrating e-learning softwares into teaching. This points to the fact that faculty members need training on instructional material design especially operation of online learning platform (MOODLE). This further explains why most faculty members opted to use other applications like zoom

and google meet to teach instead of using softwares like Big Blue Button (BBB) integrated in the official online learning platform, MOODLE.

Most faculty, 96(55.5%) showed that there was no provision for feedback from the students and management to ascertain whether actual teaching and learning was taking place. This explains why most faculty members indicated that they could not prove whether the students were satisfied with online learning or not (*see Table 4.6*). This is supported by the observation made by Hadullo, Oboko, & Omwenga (2017) in which 62% of the faculty members studied opined that students did not give feedback on effectiveness of the courses they were tought online. Salmon (2018), to the contrary found out JKUAT, School of Open and Distance Learning (SODEL) students provided feedback on learning that contributed to the improvement of online learning programs.

4.9.2.2 Technological challenges

Table 4.20: Faculty response on technological challenges of online infrastructure

TECHNOLOGY CHALLENGES FOR FACULTY MEMBERS	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std
17: Availability of Technology at Home: There is adequate technology available for use at home for online teaching.	32 (18.5%)	57 (32.9%)	47 (27.2%)	32 (18.5%)	5 (2.9%)	2.46	0.985
18. Availability of Technology at the University: There is sufficient technology at the university to facilitate online teaching	26 (15%)	72 (41.7%)	49 (28.3%)	21 (12.1%)	5 (2.9%)	2.83	0.788
20: Technical support: Faculty members are supported adequately by the ODEL technicians whenever they face technological challenges	15 (8.7%)	64 (37%)	64 (37%)	23 (13.3%)	7 (4%)	2.67	0.953
21: Interactive learning: The system provides opportunities for lecturer-student interactions.	25 (14.5%)	53 (30.6%)	47 (27.2%)	43 (24.9%)	5 (2.9%)	2.71	1.082
22: Technological Background: I have adequate technological background to enable me use online learning platform	11 (6.4%)	33 (19.1%)	82 (47.4%)	42 (24.2%)	5 (2.9%)	2.98	0.899
23: Student tracking: System is able to track the learners progress through their submission of learning tasks and assignments	7 (4%)	54 (31.2%)	70 (40.5%)	42 (24.3%)	__	2.85	0.836
24: Time Management: I am able to plan, organize and manage the individual students work according to their time and learning styles	19 (11%)	44 (25.4%)	64 (37%)	46 (26.6%)	__	2.79	0.96
25: Training by the university on online learning: The university provides constant training for faculty members on the usage of the online learning platform	29 (16.8%)	54 (31.2%)	47 (37.1%)	43 (24.9%)	__	2.6	1.038
26: Security of Online data: The system protects the online information uploaded by the members of faculty for private and public use	17 (9.8%)	53 (30.6%)	75 (43.4%)	28 (16.2%)	__	2.66	0.866
27: Internet Connectivity: There is stable internet connectivity at the university to facilitate online learning	30 (17.4%)	54 (31.2%)	54 (31.2%)	35 (20.2%)	__	2.54	1.003
29: Ease of Use: The e-learning platform is easy to use	12 (6.9%)	59 (34.1%)	49 (28.3%)	53 (30.7%)	__	2.83	0.949
Composite Mean and Std						**2.70**	**0.94**

The study sought to investigate the technological challenges that faculty members face while using the online infrastructure and how they affect learning. The results show that 89(51.4%) of the respondents disagreed that there was availability of technology at home to support online teaching. Majority, 98(56.7%), disagreed that technology was available at the university to support online teaching. Both students (*see Table 4.17*) and faculty members affirmed that they lacked necessary technology for supporting online learning both at home and at the university.

On technical support, 79(45.7%), disagreed that they were supported adequately by the ODEL technicians whenever they faced technological challenges, 64(37%) remained undecided and 30(17.3%) agreed. Even though students indicated that there was adequate support from the faculty members during online classes, (45.1%) indicated that the system provides limited opportunities for lecturer-student interaction. This is supported by interview responses in which one respondent stated that:

> " *… I get little support if any from the ODEL technicians, ODEL champion our school do not understand the system well. …I tend to think the champions should be well trained before they can be given roles at the schools to help other members of faculty otherwise the challenges of online learning will persist…* **IDI 03"**.

On technological background, 82(47.4%) faculty members were neutral to having adequate technological background that could enable them to use online learning platforms, 44(25.5%) disagreed and 47(27.1%) agreed. Findings by Al-Azawei & Dominic (2018) however showed that most faculty members lacked sufficient technological background to handle learning in the online infrastructure.

On whether the university offered training on online learning, 83(48%) disagreed, while 43(24.9%) agreed that the university provided constant training on the use of the online learning platform. This corroborates with the results of the interview in which one respondent said:

> "…… *indeed, we have some computer skills, however, consider the age difference of faculty members, some might find it difficult to learn the new technologies and use them on the online learning platform, such people need a lot of training and not the two hours that was used to train members of faculty....* ***IDI 08"***

ODEL technician, during an interview, cited inadequate technical staff to support online learning at the university:

> "……*we have a problem regarding resources allocated for the training of students and members of faculty. This is a new area, and we have few staff who are competent to handle the process, ODEL has only 5 employees employed at the directorate. We are literally surviving on limited allocations provided to ensure ODEL can carry out its activities…****IDI 11****."*

This implies that the number of staff manning the ODEL directorate then was not sufficient to oversee all the activities of online learning. Nwabufo (2013) shared similar suggestions in his findings where 65% of the interviewed faculty members stated that they could not use online learning citing inadequate training by the university.

The results on security of online data show that 75(43.4%) were neutral on whether the system protected the online information uploaded by the faculty members for private and public use while 70(40.4%) disagreed. On internet connectivity, the results showed that 84(48.6%) disagreed that there is stable internet connectivity at the university to facilitate online learning, 54(31.2%) remained undecided and

35(20.2%) agreed. This implies that a large number disagreed that there is stable internet connectivity at the university to facilitate online learning. The student respondents also agreed that the internet at the university was not stable (*see Table 4.4*). Hadullo, Oboko, and Omwenga (2017) also found that unreliable internet affects online learning adoption in universities. Even though findings in this study show that faculty members were neutral on online security, Mohammed (2020) found that faculty members declined to upload personal materials or even lecture notes citing insecurity of the online platform.

The study investigated whether the online learning platform was easy to use. The result showed that 71(41.0%) disagreed with the statement, 49(28.3%) remained undecided and 53(30.7%) agreed that the e-Learning platform is easy to use. This implies difficulty in using online learning. It further implies that the system could be complicated for the faculty members, and this could be one main factor that hinders its use. This finding confirms the finding by Aguti (2015) in which faculty members indicated that the online learning platform was complicated to use and required much time to navigate and get access to resources.

4.9.2.3 Administrative challenges

Table 4.21: Faculty response on administrative challenges of online Infrastructure

ADMINISTRATIVE CHALLENGES FOR THE FACULTY	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std
30: Administrative Support There is enough administrative support to faculty members by the university management.	27 (15.6%)	83 (48%)	46 (26.6%)	12 (6.9%)	5 (2.9%)	2.34	0.923
31: School Role The faculty / School have been given a role to help improve the process of online learning {ROLE}	20 (11.6%)	90 (52%)	50 (28.9%)	13 (7.5%)	___	2.32	0.777
32: Administrative encouragement The faculty get encouragement from the administration through rewards.	16 (9.2%)	96 (55.5%)	46 (26.6%)	15 (8.7%)	___	2.35	0.767
33: Adequate provision of Resources The management keeps upgrading online learning resources like computers and internet connectivity	50 (28.9%)	48 (27.7%)	51 (29.5%)	24 (13.9%)	___	2.28	1.032
Composite Mean and Std						**2.32**	**0.87**

The study sought to find out from the faculty members the administrative challenges of the online infrastructure and their effects on e-learning. Most of them, 110(63.6%), disagreed that there was enough administrative support to faculty members by the university management. This disagrees with the opinion of the students in which 229(63.7%) agreed that the university management offers sufficient administrative

support for online learning (*see Table 4.18*). The result of the interview with management staff, however, indicates that the management provided enough support for online learning. A respondent stated that:

> "……*if at all the university was not supportive of the online infrastructures for learning then we would not be where we are today. But because we have launched the program and students and other faculty members are positively using it, this is a good indication that we just need to improve our support for the directorate of ODEL by employing the appropriate staff and providing on necessary equipment.* **IDI 04.***"*

Another respondent from management stated:

> *"…… because, as we all know, students pay their fees towards the end of the semester when examinations are just around the corner, and during the semester, they are required to be learning. It is the fee paid that fund necessary equipment and resources needed for online learning like the purchasing of computers, other gadgets and even internet connectivity. So, poor fee payment is one of those challenges that the management faces. Technology use is also a challenge to some of the faculty who are aged, this also affects successful implementation.* **IDI 10***".*

This finding implies that the students, faculty, and management had divergent opinions regarding whether online infrastructure is properly supported by the university or not.

It is worth noting that most of the faculty 110(63.6%) disagreed that they had been given a role to help improve the process of online learning. This implied that online learning programs were only managed by ODEL. Furthermore, the majority of the respondents, 112(64.7%) indicated that there were no rewards given by the administration as encouragement. On adequate provision of resources, results show that 98(56.6%) disagreed that the management keeps upgrading online learning resources like computers and internet connectivity. These findings agree with those findings by Wamae (2020) in which faculty members suggested that there were no

motivational rewards given to them for using online infrastructure for teaching. Interview results, however, showed that the management did not have the intention of availing such rewards and considered the idea inconceivable. One respondent stated:

> "*...I do not believe that the administration is capable of conceiving of a rewarding plan or a motivating strategy for either the faculty members or the students. The institution is incurring a lot of costs from acquiring, installing, and educating faculty members. ...* **IDI 02**.*"*

However, Mohammed (2020) found out that there was need for the university management to motivate online platform users who are committed for its success.

4.9.3 Analysis on challenges of use of online pedagogical Infrastructure its effect on learning in public universities.

To establish whether the challenges of using online infrastructure affect learning in MMUST. Ordered Logistic Regression test was carried out to test the null hypothesis at 0.05 level of significance.

> ***HO_4: Challenges of use of online pedagogical infrastructure have no effect on learning in MMUST.***

The results are shown in Table 4.22

Table 4.22: Frequency distribution of challenges of online infrastructure

	Frequency	Percent
CHALLENGES = 1(Strongly agree)	172	47.8
CHALLENGES = 2(agree)	159	44.2
CHALLENGES = 3(Neutral)	16	4.4
CHALLENGES = 4(Disagree)	12	3.6

In Table 4.22, results shows that overall 3.6% of respondents strongly agree that there are challenges with online infrastructure, 44.2% agreed, 4.4% were neutral while 3.6% disagreed.

Table 4.23: Model Fit

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	700.368			
Final	694.328	6.040	7	.035

Link function: Logit.

Table 4.23 presents the outcomes of the model's fit to the data. The statistically significant chi-square statistic ($p<.05$) derived from the findings suggests that the final model exhibits a noteworthy enhancement compared to the baseline intercept-only model. This finding demonstrates that the model's predictive accuracy surpasses that of mere guesswork based on the marginal probabilities associated with the outcome categories.

To assess the degree of agreement between the observed data and the model that has been fitted. A goodness of fit test was conducted. The present examination encompasses Pearson's chi-square statistic for the model, together with an additional chi-square statistic derived from the deviance.

Table 4.24: Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	698.505	685	.352
Deviance	683.238	685	.512

Link function: Logit.

The results presented in Table 4.24 support the null hypothesis that the data suit well. If the hypothesis is not rejected, specifically when the p-value is big, it can be inferred that the data aligns closely with the predictions of the model, indicating a strong model fit. However, in the event that the assumption of a satisfactory fit is not accepted, often shown by a significance level of $p<.05$, it might be concluded that the

model does not adequately capture the characteristics of the data. The findings from our research indicate that the model fits adequately, as the p-value is more than 0.05.

Table 4.25: Pseudo R-Square (R2)

Cox and Snell	.017
Nagelkerke	.019
McFadden	.008

Link function: Logit.

According to the findings presented in Table 4.25, the pseudo R2 values, such as Nagelkerke (1.7%), suggest that the effect of online Pedagogical Infrastructure problems on learning outcomes in public universities is quite limited. The low coefficient of determination (R2) suggests that a model comprising solely of difficulties is unlikely to serve as an effective predictor of the learning outcome for individual students. It is important to acknowledge that despite this, there exists a statistically significant and notably substantial disparity in the online Pedagogical Infrastructure.

Table 4.26: Parameter Estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[LEARNING = 1]	-.537	.313	2.946	1	.038	-1.151	.076
	[LEARNING = 2]	1.771	.331	28.618	1	.000	1.122	2.420
Model 1	[CHALLENGES=1]	1.426	1.738	.673	1	.041	-1.981	4.833
	[CHALLENGES=2]	-.591	.481	1.509	1	.023	-1.534	.352
	[CHALLENGES=3]	-1.088	1.272	.732	1	.039	-3.581	1.405
	[CHALLENGES=4]	0[a]	.	.	0	.	.	.
Model 2	[CHALLENGES=1] * pedagogical approaches * Institutional factors * Instructional Material design factors	-.043	0.005	.822	1	.0365	.000	0.004
	[CHALLENGES=2] * pedagogical approaches * Institutional factors * Instructional Material design factors	.015	0.001	1.942	1	.0163	-5.910E-6	0.003
	[CHALLENGES=3] * pedagogical approaches * Institutional factors * Instructional Material design factors	.085	.007	1.445	1	.0229	-0.005	.000
	[CHALLENGES=4] * pedagogical approaches * Institutional factors * Instructional Material design factors	-.068	.008	.622	1	.0430	-0.002	0.001

Link function: Logit.

a. This parameter is set to zero because it is redundant.

In Table 4.26, Model 1 shows the results without the effect of interaction (intervening variables). We take the exponent of the estimated coefficient to get OR i.e. exp (1.426) = 4.162, exp (-0.591) = 0.554, exp (-1.088) = 0.337, exp (-0.043) = 0.958, exp (0.015) = 1.015, exp (0.085) = 1.089, and exp (-0.068) = 0.934. The odds of

respondents on strongly agree (CHALLENGES=1) on online pedagogical infrastructure has no effect on learning was 4.162 (95% CL, -1.151 – 0.076) times that of disagree, a statistically significant effect, (Wald = 0.673,$\chi^2_{(1)} = 2.767, p = 0.041$). An increase on strongly agreeing in challenges of online pedagogical infrastructure was associated with a decrease in response on strongly disagreeing on the effect of online pedagogical infrastructure. Similar results can be explained for disagree, neutral and agree. Therefore at 0.05 level of significance, we reject the null hypothesis that, ***Challenges of use of online pedagogical infrastructure have no effect on learning in MMUST.*** This implies that indeed challenges of online pedagogical infrastructure affect learning in public universities.

Model 2 shows the results with the effect of interaction (intervening variables). The significant interaction terms indicates the slope of the assumed linear relationship between interaction variables (pedagogical approach factors, institutional material design factors and institutional factors) and challenges of online pedagogical infrastructure varies significantly between learning in public universities. The overall Wald for the challenges of online pedagogical infrastructure and interaction when the response was strongly agreeing is not significant (Wald = 0.822, df = 1, p = 0.365). The OR value is 0.958(95% CL, 0.00 – 0.004) which indicates that the odds of strongly agree on challenges of online pedagogical infrastructure decreases by 0.958 for each unit increase in interaction score. Similar results can be explained for disagree, neutral and agree.

Table 4.27: Test of parallel lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	694.328			
General	691.561	2.767	7	.906

Table 4.27 indicates that there may be some explanatory variables for which the ORs are not stable across different cumulative thresholds in relation to the response of challenges of online pedagogical infrastructure $(\chi^2_{(1)} = 2.767, df = 7, p = 0.906)$.

4.10 Objective Five: To establish the perception of users towards application of online pedagogical infrastructure in facilitating learning.

The perception of faculty members and students towards the use of online pedagogical infrastructure was investigated. The findings were documented as shown below.

4.10.1 Descriptive Analysis of the Student Perception

The study sought to find out student perceptions towards using online infrastructure. A five-point Likert scale was used to get answers from the respondents as shown in Table 4.28

Table 4.28: Students Perception on using Online Pedagogical Infrastructure

Potential Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
I am comfortable with online discussions.	-	172(47.9%)	25 (6.9%)	97 (26.9%)	66 (18.3%)	2.84	1.208
Participating in online discussions requires a lot of time and effort.	35(9.7%)	165(46.8%)	-	141 (39.2%)	19 (5.3%)	3.16	1.196
I spend a lot of time on an online course	-	252(70%)	49 (13.6%)	59 (16.4%)	-	3.54	0.76
Interruptions interfere with the seamless process of online discussions.	-	117(32.5%)	49 (13.6%)	148 (41.1%)	46 (12.8%)	2.66	1.065
I find using online discussions convenient.	10(2.8%)	170(47.2%)	41 (11.4%)	139 (38.6%)	-	3.14	0.976
I am comfortable using online communication tools.	10(2.8%)	170(47.2%)	41 (11.4%)	139 (38.6%)	-	3.14	0.976
I understand what am doing in an online course	10(2.8%)	163 (45.2%)	33 (9.2%)	154 (42.8%)	-	3.08	0.994
I learn and understand better while using online than face to face	-	172 (47.8%)	21 (5.8%)	45 (12.5%)	122 (33.9%)	2.68	1.363
Online courses are more beneficials than face-to-face classes.	-	212 (58.9%)	-	90 (25.0%)	58 (16.1%)	3.02	1.22
I have difficulty in typing activities in online infrastructure courses	-	66 (18.4%)	-	179 (49.7%)	115 (31.9%)	2.05	1.026
I have difficulty listening to audio in online platform	-	95 (26.4%)	-	165 (45.8%)	100 (27.8%)	2.25	1.129
I have Difficult vocabularies are used in online learning platforms	-	91 (25.2%)	-	168 (46.7%)	101 (28.1%)	2.23	1.116
I enjoy interactions with materials in online courses	42 (11.7%)	185 (51.4%)	-	93 (25.8%)	40 (11.1%)	3.27	1.272
Online instruction uses variety of media	37 (10.3%)	151 (41.9%)	-	137 (38.1%)	35 (9.7%)	3.05	1.266
Composite Mean and Std						**2.87**	**1.117**

The study sought to find out from students their perceptions towards using online pedagogical infrastructure. From table 4.28, the results show that 172(47.9%) students were comfortable with online discussions, while 163(45.2%) were not. Furthermore 200(56.5%) students said that online discussions required a lot of time and effort contrary to Winahyu (2020) who indicated that online discussions were comfortable and did not consume time. However, he cited distractions as a hindrance to effective online discussions. Despite the challenges, majority, 180(50%), indicated that online discussions were convenient compared to face-to-face discussions.

The data shows that most students, 252(70%) spent a lot of time in an online course. Most students, 196(53.9%) also agreed that interruptions interfere with seamless online learning process. This is attributed to lack of adequate equipment, inconsistent electricity supply and unreliable internet connectivity making online courses to even take longer time as indicated by (Rimba, Izlan, & Sakka, 2020).

Furthermore, 180(50%) students were comfortable using online communications tools, while 139(38.6%) were not comfortable. A larger portion of the students, 173(48.0%) agreed that they understood what they did in an online course while 154(42.8%) of the students did not understand. This implies confusion among students since the number of those who didn't understand what they were doing was almost the same as those who understood what they were doing. Students however indicated that they did not have any difficulty in typing activities, listening to audio files and with the vocabulary used in an online course as shown by 294(81.7%), 265(73.6%) and 269(74.8%) students who disagreed respectively. The findings also showed that online courses are more beneficial than face-to-face courses since majority of the learners 212(58.9%), agreed or strongly agreed with this statement. This implies that there has been effort to use a variety of media in the online learning platform thus making online learning more appealing and interesting. This agrees with the findings by Zozie (2020) in which 63% of the studied population agreed that using a variety of media improves the perception of learners towards using the platform.

Online infrastructure at the university uses a variety of media. This is supported by 188(52.2%) who agreed or strongly agreed with the statement and the majority of the student respondents, 225(63.1%), also indicated that they enjoy interactions with these materials used for learning.

These findings show a general positive perception of the students towards using online infrastructure for learning despite the challenges that they face. This is confirmed by the results from the interview in which ODEL technicians witnessed a positive surge on the number of students who use the online learning platform.

4.10.2 Descriptive Analysis of the Faculty Perception

The study sought to find out from faculty members, their perception towards using online infrastructure. A five-point Likert scale was used to get answers from the respondents as shown in table 4.29.

Table 4.29: Members of Faculty Perception of online infrastructure

	Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std
1	Online teaching is the most preferred teaching approach.	53(30.6%)	67(38.7%)	34(19.7%)	4(2.3%)	15(8.7%)	2.2	1.16
2	I do not need training on the use of online infrastructure for teaching.	27(15.6%)	65(37.6%)	48(27.8%)	21(12.1%)	12(6.9%)	2.57	1.106
3	The current practice of online teaching is satisfactory, and the university should continue using it.	25(14.5%)	37(21.4%)	42(24.3%)	62(35.8%)	7(4%)	2.94	1.147
4	The university e-learning system does not support online consultations for learners.	19(11%)	48(27.7%)	45(26%)	43(24.9%)	18(10.4%)	2.96	1.178
5	Students need to be trained on the use of online learning infrastructure to enable participation in online classes.	13(7.5%)	35(20.2%)	45(26%)	44(25.5%)	36(20.8)	3.32	1.224
6	Online learning is not a viable alternative for learning compared to face-to-face environments.	33(19.1%)	49(28.3%)	28(16.2%)	38(22%)	25(14.4%)	2.84	1.353
7	Teacher-student interaction is limited in online learning environments.	28(16.2%)	40(23.1%)	44(25.4%)	43(24.9%)	18(10.4%)	2.9	1.242
8	There is no way of knowing if my students did the reading in the online infrastructure.	32(18.5%)	39(22.5%)	29(16.8%)	69(39.9%)	4(2.3%)	2.85	1.201
9	Online Interpersonal communication interaction is limited.	29(16.8%)	41(23.7%)	45(26%)	54(31.2%)	4(2.3%)	2.79	1.129
10	There is highly impersonal communication among students and faculty members in online education	23(13.3%)	51(29.5%)	47(27.2%)	41(23.7%)	11(6.3%)	2.8	1.134
11	Teaching online lacks impact on my face-to-face courses and instructions	26(15%)	68(39.3%)	28(16.2%)	40(23.1%)	11(6.4%)	2.66	1.173
12	Best teaching practices are transferable from traditional face-to-face to online learning classes.	48(27.7%)	42(24.3%)	24(13.9%)	59(31.1%)		2.54	1.22

13	Students can learn less in e-Learning class.	47(27.2%)	39(22.5%)	49(28.3%)	27(15.6%)	11(6.4%)	2.51	1.223
14	There is more academic dishonesty (cheating, plagiarism) in online classes	25(14.5%)	52(30.1%)	63(36.4%)	29(16.8%)	4(2.2%)	2.62	1.002
15	I lack experience in preparing online content (i.e., presentations) and modules	13(7.5%)	68(39.3%)	36(20.8%)	49(28.3%)	7(4%)	2.82	1.055
16	Faculty cannot be replaced by technological tools	13(7.5%)	64(37.1%)	57(32.9%)	32(18.5%)	7(4%)	2.79	0.979
17	Time commitment for developing online class is comparable to that in face-to-face classes	34(19.7%)	47(27.2%)	40(23.1%)	52(30%)	__	2.64	1.11
18	I am less creative and innovative when using e-learning.	31(17.9)	58(33.5)	34(19.7)	50(28.9)	__	2.6	1.088
19	Using e-learning is very costly to the University.	20(11.5%)	70(40.5%)	42(24.3%)	34(19.7%)	7(4%)	2.64	1.05
20	E-learning does not affect students' academic grades.	29(16.8%)	44(25.4%)	47(27.2%)	46(26.6%)	7(4%)	2.76	1.141
21	University administrators do not support online learning	21(12.1%)	24(13.9%)	87(50.3%)	41(33.7%)	__	2.86	0.919
22	I prefer using google meet or zoom or Microsoft teams to the online learning platform used by the university.	9(5.2%)	45(26%)	29(16.8%)	67(38.7%)	23(13.3%)	3.29	1.145
	Composite Mean and Std						**2.77**	**1.09**

The study sought to establish faculty members' perceptions towards application online infrastructure in facilitating learning. From table 4.29, majority of the faculty, 120(69.3%) disagreed that online teaching is the most preferred teaching approach. Most faculty members, 92(53.2%), also disagreed that they do not need training on the use of online infrastructure for teaching. This is confirmed by the findings from the interviews which show that faculty members indeed need training. This is further supported by Zozie (2020), Mohammed (2020) and Salmon (2018) who all found out that faculty members need training to be able to use the online learning platform effectively.

The results show that 69(39.8%) agreed that the current practice of online teaching is satisfactory, and the university should continue using it, while 62(35.9%) disagreed and the rest were neutral. On the other hand, 67(38.7%) disagreed that university e-learning system does not support online consultations for learners, 61(35.3%) agreed and 45(26.0%) of the respondents were undecided.

On whether the students needed to be trained on the use of online learning infrastructure to enable participation in online classes, many respondents 80(46.3%) agreed that indeed training was necessary for students. The results further show that 82(47.4%) indicated that online learning is a viable alternative for learning while 63(36.4%) indicated that online learning is not a viable alternative for learning and the rest were neutral. This implied that both faculty members and students need training for successful online learning. The results show that 68(39.2%) of the respondents disagree that teacher-student interaction was limited in online learning environments, 44(25.4%) were neutral while 61(35.3%) agreed that teacher-student interaction is limited in online learning environments.

Most faculty members indicated that best teaching practices are not transferable from traditional face-to-face classes to online classes. This is observable from 90(52.0%) of the faculty who disagreed with the statement that these practices are transferable. This agrees with the lecturer's opinion during the interview that there is need for training of faculty members on designing online instructional materials that will not increase the cognitive load in the learners. Papia (2016) similarly agrees that cognitive load can be greatly reduced if properly designed instructional material is used for online learning leading to greater chances of content retention. The results of the study further indicate that many faculty members, 86(49.7%), indicated that students can learn more in an online learning class while 49(28.3%) indicated that students can learn less. This points to a positive perception and implies that online learning should be encouraged by providing necessary resources. These findings are in agreement with those of Hart and Laher (2015), who in their study, majority of the respondents (68.2%) indicated that they learn better in the online platform.

The study also intended to assess if there is more academic dishonesty (cheating, plagiarism) in online classes. From the table the results indicate that 77(44.6%) disagreed that there is more academic dishonesty (cheating, plagiarism) in online classes, while 63(36.4%) were neutral and 33(19%) of the respondents agreed. This implies that little academic dishonesty is experienced in online learning platform. However, most students 306(85%) indicated that they have never taken exams online (*see Table 4.1*). Furthermore, 81(46.3%) of the faculty disagreed that faculty members lack experience in preparing online content (i.e., presentations) and modules, 36(20.8%) were neutral while 56(32.4%) agreed.

The data show that 77(44.6%) of the respondents disagree that faculty members cannot be replaced by technological tools, 57(32.9%) remained undecided while 39(22.5%) agreed they can be replaced.

The study sought to investigate whether time commitment for developing online classes is comparable to that in face-to-face classes. (The amount of time needed for course preparation is the same in both modes) and the result from the table show that a large number 81(46.9%) disagreed with the statement while 52(30.0%) agreed and the rest were undecided whether the time commitment is comparable.

The data also indicates that most of the respondents, 89(51.4%), disagreed that faculty members are less creative and innovative when using e-learning, 50(28.9%) agreed and the rest were undecided. The mean score was 2.6 with a standard deviation of 1.088. This implies that the majority of the respondents accepted that faculty members were creative and innovative when using e-learning.

Furthermore, the data show that majority of respondents, 90(52.1%), disagreed that using e-learning is very costly to the university. This implies that if online learning is implemented properly, it can be cost effective compared to face-to-face classroom learning. This contradicts the student's opinion which indicated that online learning is very costly to the university. Zozie (2020) agrees with this finding that indeed online learning is cost effective.

The study sought to find out whether E-learning does not affect students' academic grades and the results show that 73(42.2%) disagreed, 47(27.2%) were neutral while 53(30.6%) agreed that indeed it does not affect students' academic performance. The mean score was 2.76 with a standard deviation of 1.41. This shows that a notable number disagreed that E-learning does not affect students' academic grades. The

mean score of the item was below the composite mean of 2.77 indicating a negative affect on the composite mean. The standard deviation was above the composite standard deviation of 1.09 indicating a wider spread in response for the item than the variable.

Lastly, most respondents 90(52.0%) agreed that faculty members prefer using Google Meet or Zoom or Microsoft teams to the online learning platform used by the university, while 54(31.2%) disagreed and 29(16.8%) were undecided. This points to the fact that MOODLE is not easy to use and therefore faculty members opt to use applications that they understand better. This is confirmed by the interview results in which one lecturer said:

> "*.... I prefer using simple applications like google meet and zoom, students also understand these applications much better, however if both faculty members and students can properly be inducted on how the platform operates, we have no problem using the likes of Big Blue Button(BBB)...***ID9***."*

On whether university administrators do not support online learning most faculty members, 87(50.3%), were neutral that university administrators do not support online learning. This implies that the faculty were not sure whether the university administrators indeed support online learning. Generally, there is a notable indecision from the faculty regarding various items. This points to a possible need for investigation as to why the members of faculty are neither agreeing nor disagreeing on various items regarding the use of online infrastructure for learning.

4.10.3 Analysis on the effect of perception of users using online pedagogical infrastructure on learning in MMUST.

From the data collected, ordinal logistic regression test was used to find out whether the perception of users of the online pedagogical infrastructure has effect on learning in MMUST. The study utilized the following null hypothesis which was tested at 0.05 level of significance.

$H0_5$: Perception of users of Online Pedagogical Infrastructure has no effect on Learning in MMUST.

The results are shown in Table 4.30

Table 4.30: Frequency distribution of Perceptions towards of online infrastructure

	Frequency	Percent
PERCEPTION = 1(Strongly agree)	64	17.8
PERCEPTION = 2 (agree)	193	53.6
PERCEPTION = 3 (Disagree)	60	16.7
PERCEPTION = 4 (Strongly disagree)	43	11.9

In Table 4.30, results show that overall 17.8% of respondents strongly agree that they have positive perception towards online pedagogical infrastructure, 53.6% agreed, 16.7% disagreed while 11.9% strongly disagreed.

Table 4.31: Model Fit

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	704.526			
Final	694.455	10.071	7	.015

Link function: Logit.

Table 4.31 presents the evaluation of the model's performance in relation to the data. The obtained findings reveal that the chi-square statistic is statistically significant ($p<.05$), suggesting that the final model exhibits a substantial enhancement compared to the baseline intercept-only model. This finding demonstrates that the model's predictive accuracy surpasses that of mere guesswork based on the marginal probabilities associated with the outcome categories.

To assess the degree of agreement between the observed data and the model that has been fitted. A Goodness of Fit test was conducted. The test includes Pearson's chi-square statistic for the model, as well as an additional chi-square statistic derived from the deviation.

Table 4.32: Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	686.725	687	.496
Deviance	687.524	687	.487

Link function: Logit.

The null hypothesis that the data fitted well is supported by the findings in Table 4.32. If the hypothesis is not rejected, specifically when the p-value is big, it can be inferred that the data aligns closely with the predictions of the model, indicating a strong model. However, in the event that the assumption of a satisfactory fit is negated, often indicated by a p-value less than .05, it might be concluded that the model does not adequately capture the characteristics of the data. The findings of our analysis indicate that the model exhibits a strong fit, as evidenced by a p-value greater than 0.05.

Table 4.33: Pseudo R-Square (R2)

Cox and Snell	.028
Nagelkerke	.032
McFadden	.014

Link function: Logit.

According to the findings presented in Table 4.33, the pseudo R2 values, such as Nagelkerke (3.2%), suggest that the effect of users' perception towards Online Pedagogical Infrastructure on learning outcomes in public universities is relatively limited, accounting for just a small percentage of the observed variation. The relatively low value of R^2 suggests that a model comprising solely of perception is unlikely to serve as an effective predictor of the learning outcome for individual respondents. However, it is important to acknowledge that there exists a statistically significant and substantial disparity in the Online Pedagogical Infrastructure.

Table 4.34: Parameter Estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[LEARNING = 1]	.126	.650	.038	1	.846	-1.148	1.401
	[LEARNING = 2]	2.457	.668	13.524	1	.000	1.148	3.767
Model 1	[PERCEPTION=1]	1.071	.840	1.627	1	.025	-.575	2.717
	[PERCEPTION=2]	.111	.732	.023	1	.034	-1.325	1.546
	[PERCEPTION=4]	.555	.876	.401	1	.048	-1.161	2.271
	[PERCEPTION=5]	0[a]	.	.	0	.	.	.
Model 2	[PERCEPTION=1] * Pedagogical Approaches * Instructional material design factors * Institutional Factors	-.002	0.001	1.667	1	.020	-.004	.008
	[PERCEPTION=2] * Pedagogical Approaches * Instructional material design factors * Institutional Factors	.009	.001	.865	1	.032	-.001.	.003
	[PERCEPTION=4] * Pedagogical Approaches * Instructional material design factors * Institutional Factors	.003	.002	.054	1	.038	-.002	.004
	[PERCEPTION=5] * Pedagogical Approaches * Instructional material design factors * Institutional Factors	.005	.003	3.159	1	.046	-.005	.000

Link function: Logit.

a. This parameter is set to zero because it is redundant.

In Table 4.34, Model 1 shows the results without the effect of interaction (intervening variables). We take the exponent of the estimated coefficient to get OR i.e. exp

(1.071) = 2.918, exp (0.111) = 1.117, exp (0.555) = 1.742, exp (-0.002) = 0.998, exp (0.009) = 1.009, exp (0.003) = 1.003, and exp (0.005) = 1.005. The odds of respondents on strongly agree (PERCEPTION=1) on online pedagogical infrastructure has no effect on learning was 2.918 (95% CL, -0.575 – 2.717) times that of strongly disagree, a statistically significant effect, (Wald = 1.627,$\chi^2_{(1)} = 10.285, p = 0.025$). An increase on strongly agreeing in perception response of online pedagogical infrastructure was associated with a decrease in response on strongly disagreeing on the effect of online pedagogical infrastructure. Similar results can be explained for disagree, neutral and agree. Therefore, at 0.005 level of significance we reject the null hypothesis that ***Perception of users of Online Pedagogical Infrastructure has no effect on Learning in MMUST.*** This implies that the perception of users indeed affect learning in public universities.

Model 2 shows the results with the effect of interaction (intervening variables). The significant interaction terms indicates the slope of the assumed linear relationship between interaction variables (pedagogical approach factors, institutional material design factors and institutional factors) and perceptions of respondents towards online pedagogical infrastructure varies significantly between learning in public universities. The overall Wald for the perceptions towards online pedagogical infrastructure and interaction when the response was strongly agreeing is not significant (Wald = 1.667, df = 1, p = 0.197). The OR value is 0.998(95% CL, 0.04 – 0.008) which indicates that the odds of strongly agree response on perceptions towards online pedagogical infrastructure decreases by 0.958 for each unit increase in interaction score. Similar results can be explained for disagree, neutral and agree.

Table 4.35: Test of parallel lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	684.455			
General	684.170	10.285	7	.173

Table 4.35 indicates that there may be some explanatory variables for which the ORs are not stable across different cumulative thresholds in relation to the response of perception of users of online pedagogical infrastructure $(\chi^2_{(1)} = 10.285, df = 7, p = 0.173)$.

4.11 Basic Tests of Statistical Assumption for students and faculty questionnaires

Diagnostic tests were performed to check the fitness of data in meeting the basic tests of statistical assumptions.

4.11.1 Multicollinearity Tests

Multicollinearity is a phenomenon that occurs when there is a high degree of correlation between or among predictor variables. This connection leads to an increase in the standard errors associated with the beta coefficients, which in turn limits the value of the coefficient of determination (R-squared) and complicates the assessment of the individual importance of each predictor variable within the model. The evaluation of multicollinearity was conducted by employing the tolerance value and Variance Inflation Factor (VIF). The tolerance value is a numerical measure that falls within the range of 0 to 1. A tolerance number below 0.1 is indicative of a significant issue known as Multicollinearity. The Variance Inflation Factor (VIF) is the reciprocal of the tolerance value and does not have a predetermined threshold. However, it is generally accepted that if the VIF value falls within the range of 1 to 10, then there is no presence of Multicollinearity. Multicollinearity is present when

the Variance Inflation Factor (VIF) value is below 1 or exceeds 10. The outcomes of the Multicollinearity test conducted on the student and faculty populations are displayed in Tables 4.36 and 4.37, respectively.

Table 4.36: Multicollinearity Tests for students' data

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Software factors	.853	2.836
	Internet connectivity	.834	1.805
	Hardware Factors	.754	3.941
	Online infrastructure	.732	1.705
	Learning in Public Universities	.786	1.782

Table 4.37: Multicollinearity Tests for Faculty Data

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Software factors	.853	1.116
	Internet connectivity	.834	2.116
	Online infrastructure	.754	1.211
	Hardware factors	.729	1.938
	Learning in public universities	.567	2.178

The findings presented in Table 4.36 and 4.37 demonstrate that all tolerance values exceed 0.5 and are closer to the upper limit of 1 rather than the lower limit of 0. This suggests the lack of Multicollinearity. In contrast, the Variance Inflation Factor (VIF) values exhibit a proximity to 1 rather than 10, suggesting the lack of collinearity and bias within the regression model.

4.11.2 Linear Relationship between Independent and Outcome Variables

The bivariate correlation, which quantifies the relationship between two variables, was calculated for the observed data using the Pearson product-moment correlation coefficient (r). The variable r represents the correlation coefficient, which measures the strength and direction of the linear link between two variables. It varies between -1 and +1, with values closer to -1 suggesting a strong negative correlation, values closer to +1 showing a strong positive correlation, and a value of 0 indicating no linear relationship between the variables. The findings of the correlation study are displayed in Table 4.38.

Table 4.38: Correlation analysis for students' questionnaire

Correlations					
		Hardware Factors	Software Factors	Internet Connectivity	Online Infrastructure
Hardware Factors	Pearson Correlation	1	.470**	.492**	.893**
	Sig. (2-tailed)		.000	.000	.000
	N	360	360	360	360
Software Factors	Pearson Correlation	.470**	1	.463**	.800**
	Sig. (2-tailed)	.000		.000	.000
	N	360	360	360	360
Internet Connectivity	Pearson Correlation	.492**	.463**	1	.659**
	Sig. (2-tailed)	.000	.000		.000
	N	360	360	360	360
Online Infrastructure	Pearson Correlation	.893**	.800**	.659**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	360	360	360	360

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.38 and 4.39, shows a strong positive correlation between the study variables and the outcome variable are significant at 0.01 level of significance for the faculty questionnaire.

Table 4.39: Correlation analysis for students' questionnaire

Correlations

		Hardware factors	Software factors	Internet connectivity	Online infrastructure
Hardware factors	Pearson Correlation	1	.573**	.612**	.780**
	Sig. (2-tailed)		.000	.000	.000
	N	173	173	173	173
Software factors	Pearson Correlation	.573**	1	.671**	.921**
	Sig. (2-tailed)	.000		.000	.000
	N	173	173	173	173
Internet connectivity	Pearson Correlation	.612**	.671**	1	.761**
	Sig. (2-tailed)	.000	.000		.000
	N	173	173	173	173
Online infrastructure	Pearson Correlation	.780**	.921**	.761**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	173	173	173	173

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.39, shows a strong positive correlation between the study variables at 0.01 level of significance.

4.11.3 No Extreme Outliers

Ordered Logistic regression assumes that the data used do not possess influential observations or extreme outliers. In the present study, this assumption was tested using Cook's distance for each observation. The following formula was used to calculate Cook's distance.

The formula for Cook's distance is:

$$\mathbf{D_i} = (r_i^2 / p*MSE) * (h_{ii} / (1-h_{ii})^2)$$

where:

- **ri** is the i^{th} residual.
- **p** is the number of coefficients in the regression model.
- **MSE** the mean squared error.
- $\mathbf{h_{ii}}$ is the i^{th} leverage value.

When plotted, the result showed that there were no outliers or influential points that would course variations in the observations.

4.11.4 The sample size is sufficiently large.

Ordered logistic linear regression further assumes that the sample size used in a study is sufficiently large enough that can aid drawing of conclusions from the fitted logistic regression model. In the present study, this was ensured by using Yamane's formula to ensure that the sample size from the population is sufficient to enable running of logistic regression analysis.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter highlights the key findings from the study " Online Infrastructure and its effect on learning in public universities: The case of MMUST." The chapter presents a summary of findings, conclusions, recommendations.

5.2 Summary of the Research Process

Permission to conduct this study was sought from the university and National Commission for Science, Technology, and Innovation (NACOSTI). Instruments of data collection were developed in consultation with the supervisors and reviewed by experts for correctness and validity. Sampling was done on members of the faculty, students, ODEL staff and the university management. A pilot study was then conducted in three schools within the university to ensure that the instruments measure what they were intended to measure and that they measure it correctly. Adjustment on the research instruments was done based on the outcome of the pilot study. The researcher then, in conjunction with the university appointed supervisors and identified research assistants conducted data collection from eleven (11) schools within the university. The data collected was recorded, cleaned, and organized into tables in readiness for analysis. The data were then analyzed, and the findings reported.

5.3 Summary of the Findings

The findings of this study were grouped and summarized based on the study's objectives. The objectives were as follows: Establish the status of online pedagogical infrastructure used by the university; To determine the effects of online pedagogical

infrastructure use on learning; To determine the prospects of online pedagogical infrastructure and how they affect learning; To investigate the challenges of use of online pedagogical infrastructure and how they affect learning; To establish the perception of users towards application online pedagogical infrastructure in facilitating learning.

5.3.1 The status of online pedagogical infrastructure used by MMUST.

This study sought to establish the status of online infrastructure used by the university. After investigating the university's online infrastructure status, the findings showed that there is a general inadequacy of necessary technologies like computers, tablets, printers, and reliable internet at the university to support online learning. However, many students indicated that they have access to smartphones. They also showed confidence in using all these devices if made available to them for successful online learning. The findings further indicated that faculty members have not been adequately trained and they have never been issued with an online learning policy to guide them on online infrastructure use. The findings also show that faculty members have received little support from the technical staff and are not sure whether there is any full online learning taking place at the university. However, the faculty members indicated that blended learning is being used at the university to facilitate learning. More so, they were not sure whether the students were satisfied or contented with the online learning at the university and not sure whether hardware devices used by the university have been adequately upgraded to the latest state-of-the art. Finally, the findings showed that faculty members prefer to use other applications like Zoom and Google meet for online teaching instead of applications like Big Blue Button (BBB) integrated within MOODLE used by the university for online learning.

5.3.2 The prospects of online pedagogical infrastructure and how they affect learning.

This study sought to determine the prospects of online infrastructure and how they affect learning. According to the results, even though use of online learning reduces the cost of education, respondents indicated that it is not affordable. Findings show that its use does not improve academic performance of students. On the other hand, use of online learning infrastructure leads to customized learning experience and furthermore enhances retention of knowledge. It also shows that online learning infrastructure makes it easy for faculty members to teach and manage their schedules. Mobile learning has the capability of solving problems of online learning and gamification can improve the attitude and perception of online infrastructure users. The future of online learning at the university is therefore bright and can bring forth many benefits. But there is confusion that must be dealt with regarding whether it enhances socialization and collaboration, whether it caters for individual learners' differences and learning styles and whether it improves faculty teaching and efficiency.

5.3.3 The effects of online pedagogical infrastructure use on learning.

The study also sought to investigate the effects of online infrastructure in facilitating learning processes at Masinde Muliro University of Science and Technology. Most respondents were not comfortable with online discussions citing interruptions and distractions as issues affecting online discussions. It was found that power outage does not affect interactions and collaborations within online infrastructure and majority of the students agreed that there is need for faculty members to guide the processes of online learning. According to the study findings, online infrastructure

affects learning. A significant positive association was found between online infrastructure and learning. Most faculty members were undecided whether teaching online is a better option than face-to-face teaching. It was not clear from the findings whether online learning enhances university's competitiveness. However, faculty members were creative and innovative in using online learning infrastructure to facilitate learning. They further stated that online learning is cost-effective and increases the universities' return on investment.

Using students and faculty questionnaires, the null hypothesis ($H0_3$), use of online infrastructure has no effect on learning in public universities was tested at 0.05 level of significance. The results showed that use of online pedagogical infrastructure does not affect learning ***(Wald =0.07, $X^2_{(1)}$ =17.475, p=4.177)*** since the value of ***p>0.05*** Based on the findings, the null hypothesis was accepted implying that indeed use of online infrastructure has no effects on learning in public universities.

5.3.4 The challenges of online pedagogical infrastructure and how they affect learning.

The study also had an objective to determine the challenges of online infrastructure and how they affect learning. According to the study findings, academic challenges, administrative challenges, and technological challenges affect online learning. First, academic challenges such as limited time, limited interaction between faculty members and students, lack of feedback and inadequate training were cited as the academic challenges affecting both faculty members and students.

For technological challenges, we found there was inadequacy of necessary equipment like laptops, iPad and desktop computers, unreliable internet, inadequate technological background, and difficulty of use (for students) affected online learning

at the university. Furthermore, inadequate technical support from ODEL staff also affected the effective use of online infrastructure for learning.

For administrative challenges, the data showed that there is limited administrative encouragement and motivation to the online learning champions, limited involvement of schools in improving online learning, inadequate provision of learning, unclear online learning policy for both the students and faculty members.

At a personal level, not all students have access to the required resources for online learning, such as smartphones, laptops, and internet connection. The university has also not yet established enough resources for faculty members and students to use during online learning.

The null hypothesis ($H0_4$) that challenges of using online pedagogical infrastructure has no effect on learning was tested at 0.05 level of significance. Using both the faculty and student questionnaire, the study ***Wald*** statistic ***(Wald =0.673, X^2 (1) =2.767, p=0.041)*** showed that indeed challenges currently faced by the university in implementing online pedagogical infrastructure significantly affect learning leading to rejection of this null hypothesis. This implied that the challenges of online infrastructure affect learning in public universities.

5.3.5 The perception of users towards the application of Online Pedagogical Infrastructure in facilitating learning.

This study sought to determine the perception of users towards application online infrastructure in facilitating learning. According to the research findings, the perception towards online infrastructure had no effect on learning in public universities. It was found that online discussions were time consuming on the side of students. Despite being time consuming, most students agreed that online discussions

are convenient compared to face to face discussions. These findings show a general positive attitude of the students towards using online infrastructure for learning. This is confirmed by the results from the interview in which ODEL technicians witnessed an increase in the number of students accessing the online learning platform.

Faculty members indicated that despite the possibility of making learning more learner-centered, use of online infrastructure does not affect the students' academic performance. Faculty members were not satisfied whether the management sufficiently supports online learning and its related infrastructure since those were satisfied were only 33.7% while the rest were neutral or disagreed. Most faculty members furthermore indicated that they prefer Google Meet, Zoom or Microsoft teams for teaching despite the university having MOODLE as their online learning platform.

The following null hypothesis was tested at 0.05 level of significance. $H0_5$: Online infrastructure user's perception has no effect on learning. Based on the analysis of the data collected from both faculty and students, Wald Statistics ***(Wald =1.627, X^2 (1) =10.285, p=0.025)*** produced value of ***p<0.05*** which indicated significant effect of perception on online pedagogical infrastructure leading to the rejection of the null hypothesis, implying that there is significant effect of online pedagogical infrastructure users' perception on learning in public universities.

5.4 Evaluation of Results and Findings

The current study's findings were consistent with most of the results from previous studies. First, this study's findings are supported by (Raymond, Angela, & Emily; 2018; Helen, 2007; Yong, Que, & Xiaoli, 2021; Ding et al., 2019), who all found that online infrastructure facilitates learning in universities through various ways. E-

learning platforms create a suitable learning environment for students and tutors, facilitating the learning process. Also, the findings by Arun and Vrishali (2021), Abdullah and Azzedine (2011), Jaiswal (2013), and Felix (2021), who found an increased literacy among students due to the integration of e-learning platforms in learning, supports the the findings of the current study. Since online learning infrastructure facilitates learning, it is more likely that if applied appropriately, students will get a better understanding of what they are being taught, which increases their literacy level.

The current study's findings were also consistent with most studies regarding the status of online learning infrastructure in various Kenyan universities. Most of the previous authors concluded that Kenyan universities have tried implementing online infrastructure, but they are far from establishing working online learning platforms (CUE, 2017; Kennedy, 2018; Ssekakubo, Suleman, & Marsden, 2011; Tarus, Gichoya, & Muumbo, 2015; Makokha & Mutisya, 2016; Muuro, Wagacha, Kihoro, & Oboko, 2014). This study revealed that Masinde Muliro University of Science and Technology is similar to most Kenyan and African universities as it has also yet to establish a working online learning infrastructure. However, unlike other studies who concluded that very little progress has been made in implementing online learning infrastructure in universities, the current study reveals that average work has been done in enhancing online learning in the public universities. The difference between the finding of this research and most previous studies could be explained by the fact that most previous studies were conducted before the emergence of Covid-19 when most people did not see the need for e-learning. On the other hand, this study was

conducted after Covid-19, when online learning became a necessity, and some effort has been put in place to facilitate it.

Regarding the perception towards the use of online infrastructure in learning, the findings of this study were inconsistent with the findings from most previous studies. Several previous studies on online learning found faculty members and students have a negative perception towards using online pedagogical infrastructure (Fard, Rostamy, & Taghiloo, 2009; Hart & Laher, 2015; Winahyu, 2020; Rimba, Izlan, & Sakka, 2020). However, the current study found that faculty and students have positive perception towards online learning platforms. The difference between the findings of this research and most previous studies on the research topic could be the effect of time since most of the previous studies were conducted before covid-19 when people did not see the need for e-learning. Faculty members' and students' perception toward e-learning could have changed because of emergence of covid-19 pandemic. This explains why the current study identified that faculty and students have a relatively more favorable perception toward e-learning when compared to the same cases in previous studies.

This study helped identify the essential tools and technologies a university should have to support the implementation of online learning infrastructure. The findings of this study are of great importance to the Universities adopting e-learning platforms and Instructional Material Designers tasked with designing online learning resources. These findings are also helpful to Institution Policy makers in laying down required standards for online infrastructure as they can use it to better understand how to improve e-Learning in schools. The findings of the current study are also helpful to universities as they will help them determine the perception of the faculty members

and learners in adopting online infrastructure. Such knowledge will help facilitate positive faculty members' and learners' perceptions toward e-learning, which is critical for success at any level of study. The findings of this study are also helpful to the higher institutions of learning as they can use it to identify the challenges that affect the proper implementation of online infrastructure, which is critical in determining how to resolve or avoid the challenges and enhance e-learning. Lastly, the findings of this study is adopted and will be helpful to scholars who wish to conduct related studies as it provides valuable insights to online learning implementation.

5.5 Conclusions

5.5.1 Establish the status of online pedagogical infrastructure used by MMUST.

Online learning has been embraced at MMUST; however, both faculty and students are not aware of some of the online pedagogical infrastructure used in the university; MOODLE. Inadequate training on online infrastructure use for both students and faculty was evident. Furthermore, scarcity of equipment and unreliable internet affects effective utilization of the online platform. The hardware and software have not been upgraded to meet the current technological advancement.

5.5.2 To determine prospects of online pedagogical infrastructure and how they affect learning.

The future of online learning is bright for public universities with several foreseen benefits. Students and faculty members are using the available platform in the university. Faculty and students felt that certain issues like collaboration on the

online platform, catering for individual differences, learning resources and the efficiency of learning online affected learning. There is need to address the uncertainties surrounding online learning for it to be embraced by all stakeholders.

5.5.3 To determine the effects of online pedagogical infrastructure use on learning.

Online infrastructure use affects learning in various ways. Availability of power enables operations of electronic devices, and its outage does not affect online learning. However, students mostly use smartphones whose power storage lasts a little longer. Students' satisfaction while learning online could not be quantified and faculty members were unsure on whether they teach better face-to-face than online. The learners expect faculty members to facilitate online learning through making creative and innovative content. Despite the management being supportive of online learning, they are skeptical about the return on investment in online infrastructure which they deem costly. Therefore, most hardware and software are outdated leading to ineffective online learning. Inferential analysis showed that online pedagogical infrastructure had no effect on learning in MMUST for both the students and the faculty.

5.5.4 To investigate the challenges of online infrastructure and how they affect learning.

Despite having numerous benefits and prospects, there are also several challenges hindering its effective use. These include inadequate equipment like laptops, desktops, iPad and tablets for students to use. However, smartphones stand a better opportunity to solve most problems of online learning. Inadequate training and time constraints led to limited interaction and poor feedback between faculty members and

students on the online platform. Unclear and uncirculated online learning policy has led to limited involvement of schools within the university on issues concerning online learning. This hands-off characteristic of schools has been caused by the administration that does not encourage and motivate the users. It was evident that indeed challenges of online infrastructure use affect learning in public universities.

5.5.5 To establish the perception of users towards application online infrastructure in facilitating learning.

The study confirmed that perception indeed affects the use of online pedagogical infrastructure. From the descriptive and inferential, there was disparity between faculty and students on their perception on online learning. While students showed positive attitude, faculty members had a negative attitude on the application of online pedagogical infrastructure, and both significantly affected learning in public universities.

The effect of online pedagogical infrastructure on learning in public universities, the case of Masinde Muliro University of Science and Technology seems to suggest that in its current setting, there is minimal learning taking place. However, if the current challenges and negative attitude of users affecting their use are overcome then the prospects of online learning are infinite.

5.6 Suggestions for Further Research

This study recommends that a similar study be conducted in the future, using comparative data from public and private universities to establish the key differences in handling online learning infrastructure in public and private universities. This will yield more conclusive results and increase researchers' ability to generalize the results

to represent all the universities. A study should be conducted on the level of satisfaction in using online learning among students in public universities.

A study should be conducted to determine why most of the faculty are indecisive regarding issues that might affect online pedagogical infrastructure based on the significant number of neutral responses.

Financial constraints were highlighted in the present study, a comparative study should be done in a private institution to help in making more concrete conclusions.

5.7 Recommendations

Considering the study's findings, the following recommendations were made:

1. To improve the status of online pedagogical infrastructure, public universities should upgrade ICT infrastructure (hardware, software, and internet connectivity), integrate necessary technologies that support online learning, and standardize the online learning programs. They should focus on learning platforms supported by smart mobile phones easily accessible to the students.
2. For prospects of online pedagogical infrastructure to be achieved, relevant training should be provided to faculty members and students to ensure they can use the available online resources effectively and efficiently. They should also train the staff in the dynamic learning technologies that are emerging so that they are updated.
3. The study recommends that for positive effect of the pedagogical infrastructure on learning to be realized, public university managements should increase fundings channeled towards online learning to ensure latest state-of-the-art technologies are availed. The management should also work hand in hand with lectures and students to ensure their suggestions are factored during implementation of the online learning platforms.
4. Public universities should employ skilled technical staff to solve challenges facing online learning at the university. University Policy makers should also formulate policies that promote online learning across universities locally and globally.
5. Universities should look into ways of motivating students and faculty who use technology in teaching and learning. This will appeal to the skeptics to also

embrace technology in education and will help solve the perception problem that is affecting both the students and faculty.

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APPENDICES

Appendix 1: Ethics Statement

1. Researcher Details

Investigator: Owidi Salmon Oliech. Contact numbers: Office: +254792396545

Supervisors:

a) Prof. John O. Shiundu.
b) Prof. Mukasa A. Simiyu
c) Dr. Erick W. Wangila

2. Statement of invitation

You are invited to take part in a research study. Before participating in this study, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask the undersigned if there is anything that needs clarification. Thereafter decide on whether to participate in the study or not.

Thank you.

3. What is the purpose of the study?

The purpose of this study is to investigate online pedagogical infrastructure and their effect on learning in public universities. The case of Masinde Muliro University of Science and Technology (MMUST).

4. Why have I been chosen to take part or participate in this study?

You have been chosen because you are either a student or lecturer or ODEL Staff who have had an opportunity to interact with the online learning system that is being used by MMUST to facilitate eLearning.

5. How will I benefit if I take part in this study?

Taking part in this study will enable you participate in improving the status of online learning at Masinde Muliro University of Science and Technology (MMUST) and consequently to other universities who may experience similar prospect and challenges as MMUST. This study will also help in enhancing the approaches to education as new educational technologies emerge.

6. Will my taking part in this study be kept confidential?

Information which is collected about you during the research will be kept strictly confidential. You will be identified by a unique ID number and any information about you will have your name and address removed so that you cannot be recognized from it. All data will be destroyed when the study is over.

7. Anonymity

Every effort will be made to hide your identity in any written work resulting from this study. All

8. What will happen to the results of the research study?

The data will be used for academic purposes only.

9. I agree to take part in the study.

a YES { } NO { }

CONSENT FORM

Title of Project: Online pedagogical infrastructure and their effects on learning in public universities: The Case of Masinde Muliro University of Science and Technology.

Name of Researcher: Salmon Oliech Owidi

1. I confirm that I have read and understood Statement for this study and have had the opportunity to ask questions.

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

3. The interview was recorded with my consent. The information was referred to by a unique ID number at any given point during reference.

4. I agree / do not agree (tick as applicable) to take part in the above study.

a Agree { } b Disagree { }

_____

_____ _____

Name of Participant **Date** **Signature**

_____ _____ _____

Researcher **Date** **Signature**

Appendix 2: Student Questionnaire

Introduction:

Dear participant,

I am a student conducting research on the ***Online Pedagogical Infrastructure and their effect on learning. The Case of Masinde Muliro University of Science and Technology.*** The purpose of this questionnaire is to collect your views and opinions on the research problem. Kindly respond to it by filling in the blank spaces or ticking [√] where appropriate. All the information will be treated with utmost confidentiality during and after the study. Do not write your name anywhere in the questionnaire.

B01 - Demographic Information

1. What is your current level of study?

- { }Doctoral Degree
- { }Master's Degree
- { }Postgraduate Diploma
- { }Bachelor's Degree
- { } Diploma
- { } Certificate

2. What School do you belong to?

- { }School of Agriculture, Veterinary Sciences and Technology (SAVET)
- { }School of Arts and Social Sciences (SASS)
- { }School of Business and Economics (SOBE)
- { }School of Computing and Informatics (SCIT)
- { }School of Disaster Management and Humanitarian Assistance (SDMHA)
- { }School of Education (SEDU)
- { }School of Engineering and Built Environment (SEBE)
- { }School of Medicine (SM)
- { } School of Natural Sciences (SONAS)
- { }School of Nursing Midwifery and Paramedics (SNMP)
- { }School of Public Health, Biomedical Sciences and Technology (SPHBST)

3. How long have you used MOODLE e-learning platform used for e-learning at MMUST?

- { }1 Semester
- { } 2 Semesters
- { } 3 Trimesters
- { } 1 Academic Year
- { } Over 2 Academic years

4. What is your gender ⦿ { } Male { } Female
5. Select your age bracket? ⦿{ }15 - 20 Years ⦿{ } 21 - 29 Years ⦿ { } 30 – 39 Years { } Over 40 Years
6. Have you ever taken examination online using MOODLE online learning Infrastructure used by the University? ⦿ { }Yes ⦿ { } No ⦿ { } Not Sure
7. Do you feel confident enough to study on your own in e-learning? ⦿ { }Yes ⦿ { } No { } Not Sure

Instructions

Please rate each item on an importance scale of Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree shown at the top of each page.

B02: STATUS OF ONLINE INFRASTRUCTURE **The following items are easily accessible to me at home?**					
Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
1: INTERNET					
2: LAPTOPS					
4: PRINTER					
6: SMARTPHONE					
7: IPAD					
8: TABLET					
9: RADIO					
10: TELEVISION					

11: DESKTOP COMPUTER					
I am confident enough to use the following items					
Potential Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
12: INTERNET					
13: COMPUTERS / LAPTOPS					
14: PRINTERS					
15: SMARTPHONES					
16: IPAD					
17: TABLET					
Read the following statements and tick your opinion on the scale provided					

Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
18: E-learning induction training I have been trained on how study and participate in learning activities online					
19: Response to requests Technicians are prompt in responding to request and challenges raised by students					
20: On-demand support I can get technical support while interacting with the e-learning system					
21: Staff capacity development Faculty members demonstrate capacity to use the online learning platform while teaching.					
22: E-learning Student webinars Faculty members, technicians, and students frequently interact in webinars to promote knowledge sharing and discussions on e-Learning					
23: ICT training support Students are offered basic ICT literacy trainings to enable them to use the e-learning systems					
24: Adaptability of Course Platform The course platform allows me to easily access content, activities, and assessments					
25: Ease of Navigation The course is easy is to navigate thus allows me to easily move between the sections of the course					
26: Consistency of course outlook on the platform The sections of the course are marked with specific colors, graphics, icons, and text styles are consistent throughout the course.					

27: User-friendliness The e-learning platform is user friendly and easy to navigate.					
28: Accessibility of course content The course makes use of a variety of content media resources such that content is available in numerous formats such as video, CDs, podcasts available online and can be accessed anywhere at any time or on any gadget					
29: Event management The e-learning system offers up-to-date calendars and time schedules for each of the courses for which students are enrolled					
B04: CHALLENGES OF ONLINE INFRASTRUCTURE ON LEARNING					
Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
ACADEMIC CHALLENGES FOR STUDENTS					
31: Interaction between Students and Faculty members. The Faculty members provide online support to the learners during active online session and					
32: Time Required to take online exams / Assignments There is sufficient time allocated to complete online tasks and assignments by the course Faculty members					
33: Course Notes / Materials: The course materials can be accessed with a lot of ease and are simple to navigate					
TECHNOLOGY CHALLENGES FOR STUDENTS					
34: Availability of Technology at Home Technology is available to facilitate online learning while at home.					
35. Availability of Technology at School There is available technology at the university to facilitate online learning					
36: User management The system allows the student to manage his/ her profile and to put personal information/ data in the system					
37: Security of User Data I am aware that my credentials are protected and always encrypted while interacting via internet					
38: Collaborative learning The system provides opportunities for interactions to enable mastery of course content through emails, discussion forums, synchronous chats, webinars, lab activities and other group projects by use web 3.0 tools					

49: Interactive learning The system allows students to locate students and people of similar interests outside of their module, course, and year of study or institution.					
40: Bandwidth The bandwidth is sufficient to support online learning.					
41: Time Management The system allows students to plan, organize and manage the individual work according to their time and learning style					
42: Learning tracking I can easily monitor my personal learning activities and gauge my level of achievements					
43: Use of e-portfolios The system records student achievement using e-portfolios					
44: Internet Connectivity There is stable internet connectivity both at home and at school to facilitate online learning					
45: Technology Background I have enough knowledge about technology that allows me to easily navigate the online learning platform					
46: Ease of Use The e-learning platform is easy to use.					
ADMINISTRATIVE CHALLENGES FOR STUDENTS					
47: Inadequate ICT and Learning Infrastructure The University has provided sufficient ICT resources to support online infrastructure. (Computers, Projectors, Tablets)					
48: University's Readiness to support Online Learning The university is ready to offer support for online learning activities.					
49: Policy The university has a policy regarding e-Learning that has been made available to all the learners					
B05: EFFECTS OF ONLINE INFRASTRUCTURE ON LEARNING					
Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
50: I do not feel comfortable with online discussions.					
51: Participating in online discussions requires a lot of time and effort.					
52: It's important to have a lecturer to facilitate online discussions.					
53: External interferences affects our online discussions (e.g., power outage)					

54: Using online discussions is convenient.					
55: I am confident using online communication tools.					
56: It is necessary to have reward system/incentives to motivate students to continue using e-learning.					
57: It is important to have an e-learning support service to provide online assistance.					
B06: ATTITUDE OF STUDENTS TOWARDS ONLINE INFRASTRUCTURE FOR LEARNING					
Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
58: I am comfortable with online discussions.					
59: Participating in online discussions requires a lot of time and effort.					
60: I spend a lot of time in an online course					
61: Interruptions interferes with the seamless process of online discussions.					
62: I find using online discussions convenient.					
63: I am confident in using online communication tools.					
64: I understand the work am doing in an online course					
65: Online courses are more productive for me than face to face					
66: Online courses are more beneficials than face-to-face classes.					
67: I have difficulty in writing activities in online infrastructure courses					
68: I have difficulty in listening activities in online courses					
69: I have difficulty with vocabulary used in online courses.					
70: I enjoy interactions with materials in online courses					
71: The variety of instructional media used in online course enhances my understanding					

Appendix 3: Interview Schedule for Faculty Members

Introduction:

Thank you so much for taking time to complete the questionnaire. Otherwise, I would really appreciate following up with an interview as this would give an opportunity to clarify some of the items included in the questionnaire. Given your current position and valuable experiences in e-learning, I would also like to get insights into the current state-of-affairs of e-learning implementation in the University. Several questions are listed below that form the basis of our discussion during the interview. Kindly, do examine these beforehand. All responses will be treated anonymously, and in no case will the individual giving information be identified.

Effectiveness of e-learning platform used by MMUST.

1. Have you experienced any problems while delivering e-learning?
    a If YES, what are some of the challenges that you faced?
    b Were these challenges related to online learning system and how?
    c If NO, explain how beneficial it is.
2. Have you identified any long-term e-learning support challenges and requirements?
    a If YES, what are some of the appropriate measures that have been put in place to ensure that the support challenges are resolved?
    b If NO, what general challenges have you identified.
3. How is learning effectiveness ascertained with the use of online learning?
4. What e-learning management system is being used by the University?
    a What do you know about the system?
    b What are some design problems related to the online system in {4} above?
    c Is the learning management system easy to use? {IF YES, explain; if NO, explain}
5. How would you describe the e-learning system; student-centered or teacher-centered {EXPLAIN}?
6. What are your views on Modular Object-Oriented Learning Environment (MOODLE) learning Platform regarding promoting the effectiveness of online learning?

7. Based on the online system and non-system statistics, what is the overall student satisfaction with the current e-learning management systems in place relative to e-learning content, e-delivery methods?
8. Does online learning have an impact on the student academic achievement?
    a If YES, how do you compare student achievement in face-to-face classroom and online learning environment?
    b If NO, explain.
9. How does the online learning platform support students from diverse backgrounds such as;
    a Academic
    b Socio-Cultural
    c Economic

Appendix 4: Faculty Members' Questionnaire

Introduction:
Dear participant,
I am a student conducting research on the ***Online Pedagogical Infrastructure and their effect on learning in Public Universities. The Case of Masinde Muliro University of Science and Technology.*** The purpose of this questionnaire is to collect your views and opinions on the research problem. Kindly respond to it by filling in the blank spaces or ticking [√] where appropriate. All the information will be treated with utmost confidentiality during and after the study. Do not write your name anywhere in the questionnaire.

D01 - Demographic Information

1. What is your Gender?

- ☐ Male
- ☐ Female

2. What is your age?

- ☐ 21 – 30
- ☐ 31 – 40
- ☐ 41 – 50
- ☐ 51 or older

3. What is your highest academic qualification?

- ☐ Doctorate Degree
- ☐ Master's Degree
- ☐ Postgraduate Diploma
- ☐ Bachelor's Degree
- ☐ Other…….

4. What is your current designation?

- ☐ Teaching Assistant
- ☐ Assistant Lecturer
- ☐ E-Learning Educationist
- ☐ E-Learning Technologist

{ }Lecturer

{ }Senior Lecturer

{ }Associate Professor

{ } Professor

5. What School do you belong?

{ }School of Agriculture, Veterinary Sciences and Technology (SAVET)

{ }School of Arts and Social Sciences (SASS)

{ }School of Business and Economics (SOBE)

{ }School of Computing and Informatics (SCI)

{ }School of Disaster Management and Humanitarian Assistance (SDMHA)

{ }School of Education (SEDU)

{ }School of Engineering and Built Environment (SEBE)

{ }School of Medicine (SM)

{ }School of Natural Sciences (SNS)

{ }School of Nursing Midwifery and Paramedics(SNMP)

{ }School of Public Health, Biomedical Sciences and Technology (SPHBST)

6. How do you rate your experience with e-learning?

{ }Novice

{ }Intermediate

{ }Experienced

7. How long have you been using ICTs in education?

{ }1 to 5 years

{ }6 to 10 years

{ }11 to 20 years

{ }21 years or more

8. How frequently do you access the internet from the following places?

	Daily	Weekly	Monthly	Never
From home				
From the University				
From a public terminal (e.g., library)				
From a Mobile Hotspot				

D02: STATUS OF ONLINE INFRASTRUCTURE AT MMUST

Instructions:

Based on your valuable experience in using e-learning, read the following statements about e-learning and its use within the University and indicate how much you agree/disagree.

D02: STATUS OF ONLINE INFRASTRUCTURE AT MMUST						
	Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	1: Availability of Online Platform I am aware of online learning platforms at the University					
	2: The university has circulated the policy guiding online learning implementation to both Faculty members and students.					
	3: Network / Internet The university provides reliable internet to support online learning for both the students and the Faculty members by ensuring adequate network hardware.					
	4: Training The university has trained its Faculty members on use of online learning infrastructure.					
	5: There is sufficient upgraded state-of-the art hardware for online learning provided to the Faculty members.					
	6: There are sufficient updated softwares for document conversions and document editing provided by the university to support online learning					
	7: The university has mounted academic programs that are purely online with no physical learning					
	8: The university have ICT equipment used to complement online learning activities					
	9: Both blended learning and online learning are used by the university to facilitate online learning.					
	10: Students are comfortable using online learning platform used by the university					

D03: CHALLENGES OF USING ONLINE INFRASTRUCTURE						
	Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	ACADEMIC CHALLENGES					
	11: **Time Required to develop e-Learning Content.** Faculty members have enough time to develop online learning materials					
	12: **Training** Faculty members have been sufficiently trained to navigate the e-Learning platform and to handle online teaching and learning.					
	13: Interaction with the Students There is adequate interaction with students while teaching online classes					
	14: Availability of Time for preparing and administering online exams There is sufficient time to prepare and administer online examination to the students					
	15: Awareness on Integrating Learning software into teaching I have knowledge of how to integrate e-learning softwares into teaching					
	16: Provision of feedback There is the provision of teaching feedback from both the students and the administration.					
	TECHNOLOGY CHALLENGES FOR MEMBERS OF FACULTY					
	17: Availability of Technology at Home There is adequate technology available for use at home.					
	18. Availability of Technology at the University There is sufficient technology at the university to facilitate online teaching					
	19: Adaptive technology The technology used for online learning by the university is easily adaptable for online learning					

	20: Technical support Faculty members are supported adequately by the ODEL technicians whenever they face technological challenges					
	21: Interactive learning The system provides opportunities for lecturer-student interactions to enable interaction in course content through emails, discussion forums, synchronous chats, webinars, lab activities and other group projects by use of web 3.0 tools					
	22: Technological Background I have adequate technological background to enable me use online learning platform					
	23: Student tracking System can track the learners progress through their submission of learning tasks and assignments					
	24: Time Management I can plan, organize, and manage the individual students work according to their time and learning styles					
	25: Training by the university on online learning The university provides constant training for Faculty members on the usage of the online learning platform					
	26: Security of Online data The system protects the online information uploaded by the Faculty members for private and public use					
	27: Internet Connectivity There is stable internet connectivity at the university to facilitate online learning					
	28: Bandwidth There is sufficient bandwidth to support online learning					
	28: Ease of Use The e-learning platform is easy to use					
	ADMINISTRATIVE CHALLENGES FOR FACULTY MEMBERS					
	29: Administrative Support There is enough administrative support to Faculty members by the university management					

	30: Faculty Role The faculty have been given a role to help improve the process of online learning {ROLE}					
	31: Administrative encouragement Faculty get encouragement from the administration through rewards.					
	32: Adequate provision of Resources The management keeps upgrading online learning resources like computers and internet connectivity					

D04: PROSPECTS OF ONLINE INFRASTRUCTURE

	Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	33: The use of online learning platform improves academic performance.					
	34: Online learning is economically cheaper than traditional face to face learning					
	35: Mobile learning will help solve the problems on online learning infrastructure					
	36: It is better work from home than from the university's physical environment.					
	37: Both theoretical and practical classes can be done online using the online infrastructures.					
	38: Gamification – the use of games to provide online learning can improve the attitude of learners towards online learning.					
	39: The satisfaction and retention knowledge can be enhanced through online learning					
	40: Online learning will change the perspective of learners towards university education					
	41: Online learning enhances better understanding of content to learners					
	42: Student cooperation, self-discipline and sense of responsibility can be promoted by online learning in public universities.					
	43: Online learning aids understanding of graphs, maps, and internet-based resources.					
	44: Online learning caters for Students different learning styles.					
	45: Faculty teaching effectiveness is improved by online learning activities and processes					

	46: Different learning styles are effectively catered for through online learning					
	47: Online learning can aid the advancement of technology related career choices.					
	48: Online learning infrastructure enables student collaboration and socialization					
	49: Online learning infrastructure allows customized learning experience					
D05: FACULTY MEMBERS ATTITUDE						
	Potential Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	50: Online teaching is the most preferred teaching approach.					
	51: I do not need training on the use of online infrastructure for teaching.					
	52: The current practice of online teaching is satisfactory, and the university should continue using it.					
	53: The university e-learning system does not support online consultations for learners.					
	54: Students need to be trained on the use of online learning infrastructure to enable participation in online classes.					
	55: Online learning is not a viable alternative for learning compared to face-to-face environments					
	56: Teacher-student interaction is limited in online learning environments					
	57: There is no way for me to know if my students did the reading in the online infrastructure					
	58: Online Interpersonal communication interaction lacks feeling compared to the traditional face-to-face classes.					
	59: There is highly impersonal communication among students and Faculty members in online education					
	60: Teaching online has no impact on my face-to-face courses and instructions					
	61: Best teaching practices are transferable from traditional face-to-face to online learning classes.					

	62: Students can learn less in e-Learning class.					
	63: There is more academic dishonesty (cheating, plagiarism) in online classes					
	64: I lack experience in preparing online content (i.e., presentations) and modules					
	65: My lectures cannot be replaced by technological tools					
	66: Time commitment for developing online class is comparable to that in face-to-face classes. (The amount of time needed for course preparation is the same in both modes)					
	67: I am less creative and innovative when using e-learning.					
	68: Using e-learning is very costly to the University.					
	69: E-learning does not affect students' academic grades.					
	70: University administrators do not support online learning					
	71: I prefer using google meet or zoom or Microsoft teams to the online learning platform used by the university.					

D06: EFFECTS OF ONLINE INFRASTRUCTURE ON LEARNING

	Items	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	72: E-learning system does not adequately keep up-to-date information via calendars.					
	72: My Job performance improves tremendously due to using online infrastructure for teaching					
	73: Using e-learning does not necessarily enhance a university's competitiveness in teaching and research.					
	74: I am less creative and innovative when using e-learning.					

	75: E-learning is very costly to the University.					
	76: E-learning helps Universities to increase their return on investment.					
	77: I think using e-learning does not impact on the students' academic grades.					
	78: E-Learning has promoted access to education and learning.					
	79: I am open to participating in online discussions.					

Appendix 5: Interview Schedule for ODEL Technicians

Introduction:

Given your current position and valuable experiences in e-learning in the ODEL directorate, I would also like to get insights into the current state-of-affairs of e-learning implementation in the University. Several questions are listed below that form the basis of our discussion during the interview. Kindly, do examine these beforehand. All responses were treated as anonymous, and in no case will the individual information be identified.

Effectiveness of e-learning platform used by MMUST.

1. Explain the role you play as an e-learning technician in MMUST. What challenges do you face and how do you handle them?
2. Does the university provide incentives for using e-learning?
    a. If YES, do you feel the university is doing enough to ensure there is effective uptake of online learning by its staff?
    b. How do these incentives increase the urge of using online infrastructure to facilitate learning?
    c. {CONSIDER NO}
3. How often have you been trained by the university on the use of LMS infrastructure?
4. What are some of the areas that the university has trained you on about e-learning?
5. How does LMS training improve your skills in using e-learning??
6. Do you have skills in instructional material development?

    a) If YES, how can you ensure that face-to-face instructional materials are made effective for online infrastructure use?
7. As an ODEL technician, what are your responsibilities regarding Online instructional materials?
8. Do you receive complains from the following areas:
    a Internet connectivity
    b E-learning system speed
    c Availability of Computers at the university
    d Ease of Use
    e Infrastructure Security }

9. Has the university provided you with the required technologies to support e-learning implementation?
10. What are some of the challenges regarding Internet Speed, Storage capacity and the MOODLE software that you face?
11. Is the bandwidth acquired by the university sufficient for online learning?

Appendix 6: Interview Schedule for the University Management.

Introduction:

Given your current position and experience at the management level at the university. I would like to get insights into the current state-of-affairs of e-learning implementation in the University and the support that the management offers to ensure the success of the process. Several questions are listed below that form the basis of our discussion during the interview. All the information gathered was confidential and was used for this study and not for any other purpose.

Effectiveness of e-learning platform used by MMUST.

1.) What measures has the university put in place to ensure the success of online learning?
2.) Is the university willing to incur cost of e-learning system implementation and upgrade?
3.) Is the university able to cover the cost of developing e-learning instructional materials?
4.) Is it necessary to have reward system/incentives to motivate staff and students to continue using e-learning?
5.) How does the use of e-learning enhance a university's competitiveness currently?
6.) How does E-learning help Universities to increase their return on investment?
7.) Does the University have a clear vision and commitment to integrate e-learning? How?
8.) Do you think the University's culture readily supports e-learning? How?

Appendix 7: Observation Schedule

The use of Online Infrastructure by Students at the University (MMUST)

School: _____

Course: _____

Date: _____

This schedule is intended to capture the student's ability to use the online infrastructure to facilitate learning. Against each item are the words ***Low, Mid, High*** *which were a representation of the values 1, 2, and 3 respectively.* The researcher to tick the most appropriate column.

	Low	Mid	High
Tasks and assignments completion			
Technology Challenges			
Participation in Online discussion forums			
Student – Teacher Interaction/ engagement			
Student – Material Interaction			
System Ease of Use			
Frequency in of using the online infrastructure			
Ability to handle multiple concurrent users			
Activity completion as per course instructional objectives			
Learner motivation			

Online Collaborative Activities			
Online Interactivity Projects and Activities			

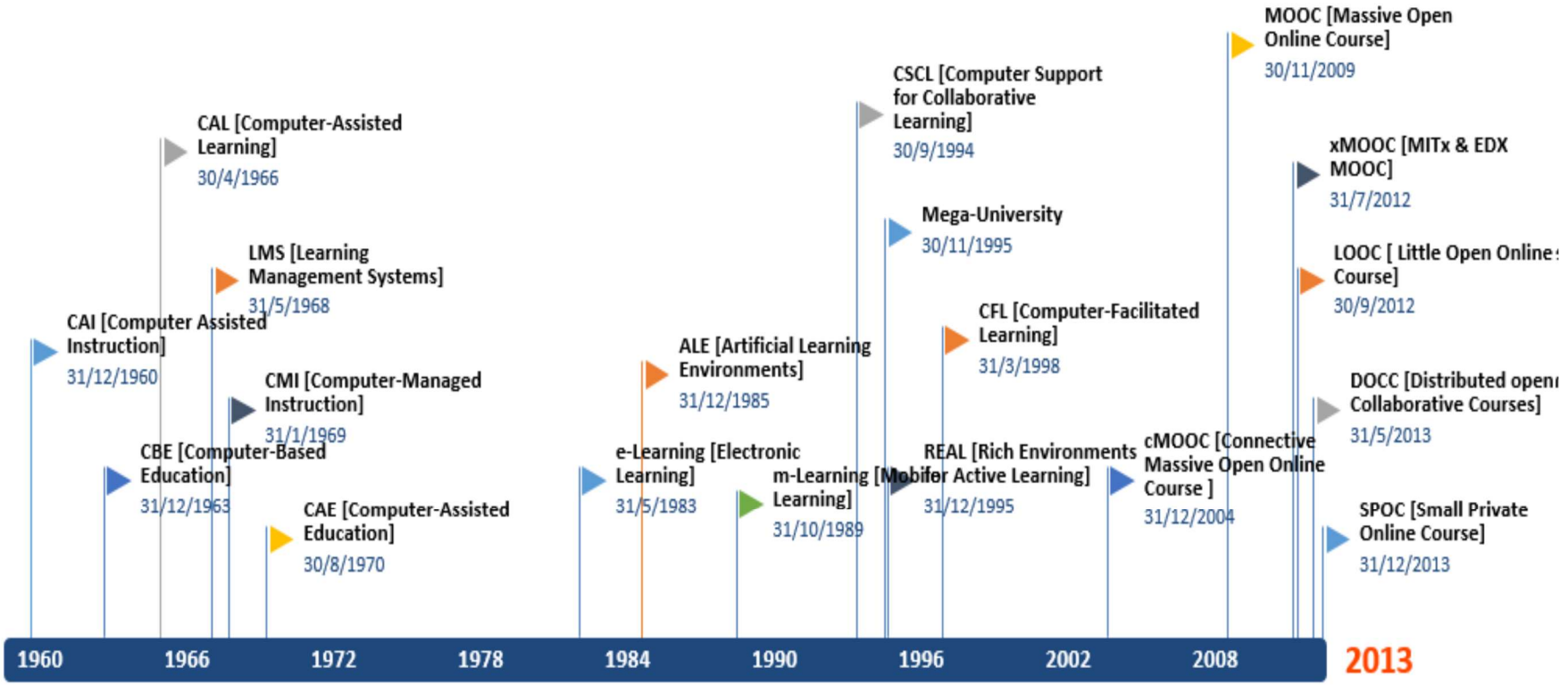
Appendix 8: Content Analysis for Online Infrastructure

MOODLE E-LEARNING SYSTEM AND OTHER ONLINE LEARNING PLATFORMS USED BY MMUST	AVAILABILITY		ADEQUACY		USAGE		
	Available	**Not Available**	**Adequate**	**Inadequate**	**Used**	**Partially Used**	**Not Used**
User Support	✓			✓ Tickets/ response		✓	
Data Security & User Privacy	✓			✓		✓	
Interactivity Tools	✓			✓		✓	
Collaboration Tools	✓		✓				✓
System User Manual (For Faculty members and students)		✓		✓ Modules explained/available modules			✓
System Reporting Ability: Student report section and Lecturer report section	✓		✓			✓	
Linkage To Other Open Educational Resources (OER)	✓			✓			✓
Online Examination Proctoring Software. (For monitoring online exams)	✓		✓				✓
Linkages to the University Digital Library	✓			✓		✓	
Relevant Course Content		✓		✓	✓		
Tracking activity completion as per instructional objectives	✓			✓		✓	

Appendix 9: Results for Observation Schedule

The use of Online Infrastructure by Students at the University (MMUST)			
	Low (1)	**Mid (2)**	**High (3)**
Tasks and assignments completion	8	6	6
Technology Challenges	12	6	2
Participation in Online discussion forums	5	11	4
Student – Teacher Interaction	13	3	4
Student – Material Interaction	5	13	2
System Ease of Use	10	6	4
Frequency in of using the online infrastructure	9	8	3
Ability to handle multiple concurrent users	14	4	2
Online Collaborative Activities	3	5	4

Appendix 10: Chart of the History of Technology in Education



The Timeline of e-learning related concepts: (Source: (Aparicio, Bacao, & Oliveira, 2015))

Appendix 11: The Map of MMUST

Appendix 12: University Research Permit

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

Tel: 056-30870
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E-mail: directordps@mmust.ac.ke
Website: www.mmust.ac.ke

P.O Box 190
Kakamega – 50100
Kenya

Directorate of Postgraduate Studies

Ref: MMU/COR: 509099

16th December 2022

Salmon Oliech Owidi
ECI/H/01-70211/2020,
P.O. Box 190-50100,
KAKAMEGA.

Dear Mr. Owidi,,

RE: APPROVAL OF PROPOSAL

I am pleased to inform you that the Directorate of Postgraduate Studies has considered and approved your PhD proposal entitled: ***"Online Infrastructure and their Effects on Learning in Public Universities: The Case of Masinde Muliro University of Science and Technology ."*** and appointed the following as supervisors:

1. Dr. Wangila Erick — SEDU MMUST
2. Prof. Mukasa A. Simiyu — SEDU MMUST
3. Prof. John O. Shiundu — SEDU MMUST

You are required to submit through your supervisor(s) progress reports every three months to the Director Postgraduate Studies. Such reports should be copied to the following: Chairman, School of Education Graduate Studies Committee and Chairman, Department of Curriculum and Institutional Technology. Kindly adhere to research ethics consideration in conducting research.

It is the policy and regulations of the University that you observe a deadline of two years from the date of registration to complete your PhD thesis. Do not hesitate to consult this office in case of any problem encountered in the course of your work.

We wish you the best in your research and hope the study will make original contribution to knowledge.

Yours sincerely,

Prof. Stephen O. Odebero, PhD, FIEEP
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

Appendix 13: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **230999**

Date of Issue: **22/December/2022**

RESEARCH LICENSE

This is to Certify that Mr.. Salmon Oliech Owidi of Masinde Muliro University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kakamega on the topic: ONLINE INFRASTRUCTURE AND THEIR EFFECTS ON LEARNING IN PUBLIC UNIVERSITIES: THE CASE OF MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY for the period ending : 22/December/2023.

License No: **NACOSTI/P/22/22863**

230999

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Director General
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Verification QR Code

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See overleaf for conditions

Appendix 14: Publications

a) Owidi, S., Wangila, W. E., Shiundu, J. O., & Simiyu, A. M. (2023). Post COVID-19 Analysis of the Status of online Infrastructure use by Public Universities in Kenya: The Case of Masinde Muliro University of Science and Technology. *African Journal of Empirical Research*, 4(2), 76–87. https://doi.org/10.51867/ajernet.4.2.11

b) Owidi, S., Wangila, W. E., Shiundu, J. O., & Simiyu, A. M. (2023). University Students' and Lecturers' Attitude towards Online Pedagogical Infrastructure in the Post-Covid 19 Pandemic Period. The Case of Masinde Muliro University of Science and Technology, Kenya. *International Journal of Innovative Science & Research Technology (IJISR),* 8(8), 1334-1340