UNIVERSITY OF NAIROBI

DEPARTMENT OF COMPUTING AND INFORMATICS

ASSESSMENT OF ADVANCED DIGITAL SKILLS GAP IN KENYA USING THE DESIGN REALITY GAP RESEARCH FRAMEWORK

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A research project report submitted in partial fulfilment of the requirements for the award of Master of Science of Information Technology Management of the University of Nairobi

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Declaration

This research project report is my original work and has not been presented to any other university for the award of a degree.

Signed *Barke Said* Date 2nd August, 2021

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P54/32756/2019

This research project report has been submitted for examination towards fulfilment for the award of Master of Science in Information Technology Management with my approval as the university supervisor.

Signed  Date *August 6,2021*

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Abstract

The new technological landscape brings new opportunities and challenges that require skills to manage and operate. Digital skill is a prerequisite for benefiting from technology, and advanced digital skills are crucial because they allow people to use technology in a transformative way. Local universities, training and vocational institutions continue to develop an ICT workforce that is neither guided by policy nor well aligned to the industry needs, especially at the high end. The graduates are underprepared to meet the demand of the modern workplace and are unable to create effective solutions leading to a shortage of competent and skilled workforce required for the national digital transformation. The study aimed to assess the advanced digital skills development process in higher learning institutions, the reality of the process and identify possible challenges leading to the digital skills gap. The study used an archival research strategy and applied the design reality gap framework with its 'OPTIMISM' checklist of dimensions to assess student enrollment, graduation, curriculum, staff, laboratory and equipment at the higher learning institutions in Kenya that teach ICT programmes. The research findings reveal that there is a low student enrolment in ICT programmes resulting in a low number of graduates joining the industry. The demand for ICT skills continues to increase while the industry complains that graduates are not well prepared to undertake projects from the industry forcing the country to rely on foreign expertise. The curriculum used in the learning institutions is mismatched leading to inappropriate competencies to be developed among the graduates. Despite the existence of standards and guidelines from the university regulator, they are not actively enforced due to challenges faced by the regulator and the institutions. A proposed implementation strategy was developed which provides for bridging the digital skills gap in Kenya among the government agencies, educators/trainers, and employers. The study focused on skills development in higher learning institutions excluding the technology hubs and complementary programmes offering training programmes for advanced digital skills. The study confirmed that inappropriate competencies are being developed among the graduates which makes them unqualified for meeting the demand of the industry and the country. The study responds to the policies related to ICT workforce development in the country. The study will trigger the development of new thinking and interactions among the government agencies, learning institutions, academic staff/trainers, and employers to bridge the skills gap leading to an empowered country capable of leapfrogging the economic growth.

Table of Contents

LIST OF FIGURES AND TABLES

ABBREVIATIONS AND ACRONYMS

AI…….....Artificial intelligence

CBC…….Competency-Based Curriculum

CUE…….Commission for University Education

FKE…….Federation of Kenya Employers

GoK…….Government of Kenya

HR…….....Human Resource Development

ICT……..Information and Communications Technology

ICTA…….....Information and Communications Technology Authority

IFC……..International Finance Corporation

IoT……..Internet of Things

KAM…….....Kenya Association of Manufacturers

KEPSA…….....Kenya Private Sector Alliance

MoE…….....Ministry of Education

MoEST…….....Ministry of Education, Science and Technology

MoICT……Ministry of Information, Communications and Technology

ML……..Machine Learning

ODEL……..Online, Distance and E-learning

OOP……Object-Oriented Programming

PGD……Post Graduate Diploma

PhD…….Doctor of Philosophy

STI…….....Science, Technology and Innovation

TIVET…….Technical and Vocational Education and Training

TIVETA…….....Technical and Vocational Education and Training Authority

DEFINITION OF TERMS

Accreditation - the procedure by which CUE recognizes an institution as a University and as having fulfilled the prescribed criteria for mounting its academic programmes

A chartered university - a university that has been accredited and awarded a charter by CUE

Curriculum/Academic programme - course offerings at an educational institution which includes the design of learning content, the structure of content, delivery modes, academic resource

Higher education - consists of undergraduate and postgraduate education from universities and TVET institutions

Digital Skills - they are skills most needed by ICT professionals which include a range of abilities that enable access to digital technology, having literacy and know-how to use technology, and being able to participate in and create with technology.

ICT Skills - a range of skills about understanding and applying a range of computer programmes, software and other applications

Skills mismatches - occur when employees are trained/educated in skills that are not relevant or do not coincide with those that are being demanded by employers

Skills shortage - occur when there is a lack of training and education in certain skills amongst the working population which increases the cost of hiring and adopting new technology

Skills Gap - occurs when there are skill mismatches and skill shortages

CHAPTER ONE
INTRODUCTION

1.1 Background

Digital Economy Blueprint was launched at the African Tech summit in Kigali, Rwanda in May 2019. The Blueprint is a flagship project by Kenya and the country's contribution to the Smart Africa Alliance initiative which is working to digitize the economies and the trade of members (21 countries) across the African continent. The Blueprint has five key pillars for achieving a vibrant digital economy: digital government, digital business, infrastructure, innovation-driven entrepreneurship, and digital skills and values, which is involved in the development of a digitally skilled human workforce to ensure that citizens have the digital know-how and literacy to participate in the digital economy.The Digital Skills pillar is focused on developing digital human capital to achieve the digital economy which can only be realized if the human capital uses technology with the proper level of competency and expertise. They are key in the implementation of the country's digitized projects in the private and public sectors. There are various digital skills, that range from Basic Skills (skills for performing basic tasks), to Intermediate Skills (skills enabling the use of digital technologies in a more meaningful and beneficial way), to Advanced Skills (high-level skills needed by specialists in ICT professionals to deliver world-class products and services) (ITU, 2020a; the Republic of Kenya, 2019). The purpose of the pillar is to increase the number of graduates trained in Advanced Digital skills (the Republic of Kenya, 2019). Advanced Digital skills are a critical element in building a digital economy and society (ITU, 2019). They are skills that allow people to use technology in a transformative way (IFC, 2019) and includes skills like AI, ML, Big data, Programming, and Coding in tools such as R, Cybersecurity, IoT, and Mobile app development (ITU, 2020a, 2019; Republic of Kenya, 2019; TVETA, 2020; YIL, 2019). While the study focuses on Advanced Digital skills, all forms of digital skills are essential to the future workforce in Africa with the basic skills being most critical (IFC, 2019). A dearth of competent and skilled human capacity (Hossain, 2018; Ministry of ICT, 2019) exists among the youth and it is the primary barrier to their employment (Gropello et al., 2011; Republic of Kenya, 2019) in the digital jobs sector (ACS, 2008). The youth

unemployment rate in Kenya is 19.2% (https://labour.go.ke/wp-content/uploads/2019/09/MLSP-Strategic-Plan-2018-2022_17.09.2019.pdf) and it is estimated that the world will have 71.9M unemployed youth by the year 2022(ITU, 2019). Digital skills are important to ensure that the youth contribute to the economic performance of the country now and in the future. This is more crucial in Kenya and Africa as a continent that is facing a demographic explosion that is expected to double the youth population by 2050 without enough jobs to cater for this growing youth population(YIL, 2019). Almost 60% of the world population lacks digital skills and only 5% know how to write a computer programme (ITU, 2019). Higher education in Kenya has expanded in the number of institutions and student enrolments in the last two decades (Oanda & Jowi, 2012) because it is conceived as an agent of economic development. After all, it plays an important role in producing a trained workforce for the economy. Additionally, digital skills are directly linked to higher earning potential(ITU, 2018). As a result of the greater automation of internal processes by national and county governments and enterprises to deliver e-services, Kenya is seeing an increase in demand for skilled ICT workers. In addition, significant multinational firms and ICT companies that are establishing Africa headquarters in Nairobi, such as Airtel Africa, IBM, and Microsoft, are increasing their demand for ICT workers(https://icta.go.ke/pdf/THE%20NATIONAL%20ICT%20MASTERPLAN%202017.pdf). However, the higher education system has been criticized for producing ill-equipped graduates for the world of work forcing employers to invest in time-consuming and expensive exercises to overcome that. Graduates are ill-equipped to fulfil the skills demands of today's job and are unable to devise effective solutions to the most pressing socio-economic issues (C. Mbogo, 2019). The situation has been the same in the UK, where businesses have regularly expressed their unhappiness with graduates' abilities (Taylor-Smith et al., 2019). Additionally, a sense of under-preparedness is experienced in Indonesia where young graduates are underqualified for their jobs and professional life in general (Gropello et al., 2011). The ramifications of a digital skills shortage are serious, and it could have a negative influence on IT operations in businesses as well as business success. Furthermore, it may limit the ability of local IT enterprises to satisfy the demands of a quickly increasing industry, resulting in lower economic performance(ACS, 2008) at the company and country levels. The availability

of a reliable national pool of skilled IT professionals is critical to the building of sustainable IT industries (Alsafadi & Abunafesa, 2012) and a sustainable country. Despite the recognition of the existence of the digital skills gap, local universities, training and vocational institutions continue to generate ICT human capital and workforce that is neither guided by a human resource development policy nor properly connected to business needs.(Authority, 2014). Learning institutions are rapidly expanding and face significant challenges in providing high-quality, relevant education, training, and learning(Wanzala, 2013).

1.2 Higher Learning Institutions and ICT Programmes

Higher learning institutions in Kenya consist of TVET institutions and universities (https://www.knqa.go.ke/wp-content/uploads/2018/10/sessional-paper-sept.-2005-final.pdf). Due to employment market demands, many institutions have been established to meet the expanding need for higher education. There are 74 institutions in the country's higher education system that offer at least one ICT degree programme. These programmes can be classified as Electrical Engineering and its equivalents (e.g. computer engineering), Computer Science and its equivalent (e.g. Applied computer science) and Information Technology and its equivalent (e.g. Information systems). Kenya has 1,825 accredited TVET institutions (https://www.tveta.go.ke/wp-content/uploads/2020/04/TVETA-NEWSLETTER-APRIL-2020-min.pdf) which offer Diploma in Information Technology, Diploma in Computer Engineering, Certificate in Computer Engineering. Graduates of any of the above programmes can work as high-end ICT experts in the ICT industry, building, deploying, and maintaining sophisticated systems and networks. The Engineers Act, 2011, which took effect on September 14, 2012, governs the quality of engineering education in Kenya. There is no legal or professional body that provides professional accreditation for computer science or information systems degree programmes, unlike engineering degree programmes. This indicates that the quality of computer science, information systems, or IT graduates is solely dependent on an institution's own quality assurance methods(Authority, 2014).

1.3 Problem Statement

While the market for ICT skilled experts continues to grow, the Kenyan ICT industry considers fresh ICT graduates to be of low quality, resulting in a small pool of high-end ICT professionals. This situation is worsening, and it is exacerbated by the lack of an approved structure for ICT professional training in Kenya's learning institutions, which currently provide organization-specific training that is neither guided by a human resource development policy nor well aligned to the industry, particularly at the high end. This leads to the development of inappropriate competencies, resulting in ICT graduates remaining unemployed for long periods of time despite companies' demand for graduates. Some graduates attempt to start their own enterprises but fail as a result of limited training (Berger & Frey, 2015). Consequently, most graduates are left to learn the advanced skills that businesses require on their own (Authority, 2014). To say the least, a range of stakeholders, including government agencies, schools and trainers, and businesses, are paying close attention to the current shortage and its expected worsening(Lotriet et al., 2010).

1.4 Research Objectives

1. Review the current policy specifications that exist for the digital skills
2. Analyse the student enrolment and graduation for the ICT programmes
3. Determine the market needs for digital skills
4. Evaluate the alignment of curriculum implementation with the technical needs
5. Develop an implementation strategy that will serve as a road map for developing digital skills and minimizing the digital skills gap

1.4 Research Questions

1. What measures have been put in place for digital skills development in the country?
2. Does the enrollment and graduation for the ICT programmes meet the demand of the industry?
3. What is the market demand for digital skills now and in the future?

4. Does the curriculum implementation process align with the technical needs of the industry and the country?
5. How does an implementation strategy plan address the digital skills development in the country?

1.5 Justification

The research will guide the GoK and the rest of the Smart Alliance Africa on the steps they would take to realize the Digital Skills pillar and leapfrog the economic growth.

1.5 Scope

The study was directed by the research objectives in evaluating the advanced digital skills development process in higher learning institutions, particularly in public and private chartered universities, which are currently delivering education that largely fits labour market needs (Ketamo & Passi-Rauste, 2019). The study focused on the development process, the reality of the process and the design-reality gaps.

1.6 Report Structure

The report is organised as follows: Chapter one provides the Introduction, Chapter two the Literature Review, Chapter three covers the proposed Research Methodology, Chapter Four the Results and an in-depth Discussion of the Results and finally Chapter provides a Summary, Conclusion and Recommendations.

CHAPTER TWO
LITERATURE REVIEW

2.1 ICT Skills Development Policies

National policies, strategies, standards and programmes are critical in the development of digital skills. The main issue of concern for policymakers should be the gap between the digital skills of current and future IT workers and those sought in the market (Gok, 2013). ICT policies guide workforce development to meet the industry demand for high-end talent. The study reviewed various policies developed by diverse stakeholders in digital skills development, ranging from the national government, regulators, standards bodies, and the private sector. The MoE (https://www.education.go.ke/index.php) is responsible for providing access to relevant education and training and access to employment while the Ministry of ICT (https://ict.go.ke/) is mandated to develop and administer ICT standards. The National ICT Masterplan 2014-2017 aligned key documents such as the Constitution, and new laws such as STI Act 2013, TIVET Act 2013 and Universities Act 2012. This Masterplan (https://icta.go.ke/pdf/THE%20NATIONAL%20ICT%20MASTERPLAN%202017.pdf) is built around three pillars and foundations. The Masterplan's first foundation is ICT human capital and workforce development, which aims to build high-quality ICT human resources as a precondition for the growth of a successful ICT industry. Integrated ICT infrastructure and Integrated information infrastructure are the other two foundations. E-Government services, ICT as a Driver of Industry, and Developing ICT Businesses are among the Masterplan's pillars. This plan identifies digital skills development as one of the main focus areas that need to be developed to support the country's transformation and adoption of technology. It acknowledges that the new technological landscape brings new opportunities and challenges that will need citizenry skills to manage, operate, and understand at scale. Since the skills needed are new, our training and manpower development processes need to become responsive to these needs. The Digital Economy Blueprint (Republic of Kenya, 2019) intends to develop Kenya such that every citizen, business, and organization has digital access and the ability to participate in and prosper in the digital economy. Digital Government, Digital Business,

Infrastructure, Innovation-Driven Entrepreneurship, and Digital Skills and Values are proposed as foundations for the establishment of a digital economy in this crucial policy document. The digital skills and values initiative, in particular, strives to produce a digitally trained workforce based on strong ethical standards and socio-cultural values. This pillar focuses on digital skills training, ensuring that it is incorporated into educational institutions, inclusive, and supports the other pillars of the blueprint for achieving a digital economy. The Draft Digital Economy Strategy 2020 (https://ncs.go.ke/wp-content/uploads/2021/02/DRAFT-DIGITAL-ECONOMY-STRATEGY.pdf) aims to set the tone for Kenya to unlock new economic opportunities in order to boost labour productivity, diversify the economy, and position the country as a source of stable economic growth with high-skilled talent.Digital Skills and Values is one of the strategy's pillars, with the goal of enabling people to utilize ICT to access information, equipping people with digital skills to use digital goods and services, and increasing Kenya's competitive advantage.The pillar emphasizes the value of digital skills as well as the need for more responsible and productive ICT professionals. The Ministry of Education's 2006 ICT Strategy (https://www.nepadkenya.org/documents/MOE-ICT%20in%20Education.pdf) intends to make ICT more accessible as a universal tool for education and training. It understands that ICT provides the talents and skills required in a knowledge-based economy. ICT in education policy, digital equipment, connection and network infrastructure, access and equity, harnessing emerging technologies, capacity building, professional development, collaborations, and resource mobilization are some of the components of the plan pertinent to this study.These strategies aim to provide exposure to ICTs through a reliable infrastructure to allow for training and development through collaborative efforts and partnerships. The Ministry of Labour and Social Protection Strategic Plan for 2018-2022 covers Manpower Planning, Development, Employment and Productivity Promotion which addresses skills mismatch through an industrial placement to allow graduates to gain hands-on experience in the world of work. CUE has developed several policy documents to regulate higher education in Kenya. CUE's goals and challenges in maintaining standards, quality, and relevance in all elements of university education and training are presented in the Strategic Plan 2014-2018(https://www.cue.or.ke/images/docs/CUE_strategic_Plan.pdf). Academic

programme conception, implementation, quality assurance, and review are all covered by the Standards and Guidelines for University Academic Programmes.The Guidelines for Designing Curriculum for University Academic programme indicates the basic information that should be included in a curriculum for academic programmes.Universities Standards and Guidelines 2014 contains schedules that cover all aspects of university education, including Academic programme Standards. Through licensing, registration, and accreditation of programmes, institutions, and trainers, TVETA (https://www.tveta.go.ke/) is responsible for regulating and coordinating training in Kenya.The National TVET Standards Report 2020 (https://www.tveta.go.ke/wp-content/uploads/2021/02/National-TVET-Standards-Kenya-Report-2020-5.12.-2020-2.pdf) was created to provide a clear roadmap for the development of TVET standards in Kenya and to assist the country in achieving its competitive human capital goals.The implementation of the report will identify sector gaps and regulatory standards that are required in the Kenyan TVET sector. This will serve as a guide to ensuring that the standards set will improve the delivery of appropriate training that contributes to job creation and economic growth. The ICTA.6.002:2019 ICT Human Capital and Workforce Development Standard (http://icta.go.ke/standards/ict-human-capital-workforce-devpt-std/) aims to establish standards for technical ICT professionals in the public sector, ICT end-users, and Kenyan citizens' ICT training. ICT Professionals in the Public Sector; Capacity Development for End Users; Capacity Development for Citizen Competency; Accreditation of ICT Institutions/Training Providers; Accreditation of IT Professionals are among the standards for this strategy.These standards are relevant to our research since they all attempt to help ICT professionals improve their skills. Kenya's Development Vision 2030 aims to develop the country into a newly industrialized middle-income country that provides a high-quality life to all of its residents by 2030. STI (Foundation 6) and HR Development are two foundations of the Vision that are pertinent to this study (Foundation 8).These foundations aim to provide citizens with globally competitive quality education and training, improve/raise education quality and relevance, revise university curricula to include more science and technology subjects, and increase school enrolment and student transition to technical institutions and universities.Because of their vital role in developing human resources with appropriate

innovative and competitive skills, universities were identified as one of the critical stakeholders in accomplishing the vision in the Vision (CUE, 2014b). In 2019, the IFC conducted a high-level analysis of the demand for digital skills in Africa, which included Côte d'Ivoire, Kenya, Mozambique, Nigeria, and Rwanda(https://www.ifc.org/wps/wcm/connect/b5ad161e-a2e2-4010-86f2-54717e68b239/Demand+for+Digital+Skills+in+Sub-Saharan+Africa_web.pdf?MOD=AJPERES&CVID=nEldzv7). The five nations have a huge unmet demand for digital skills.In the future decade, there will be a boom in demand for digital skills training. The COVID pandemic has accelerated the rate of change in these countries, and by 2030, all professions in Kenya will require some level of digital skills. The bulk of demand for digital skills will come from occupations other than ICT, and the majority of training possibilities will come from public-private partnerships. The Survey on the Development of IT Skills and Jobs in Kenya and Uganda (https://www.mercycorps.org/sites/default/files/2020-01/Publication_IT_Skill_Gap_Report_April1_VF.pdf) looked into the source, nature, and magnitude of the skills gap, as well as the likely demand from local and international companies. The poll looked at the availability of skills in Kenya and the demand for them as a result of changes in the technological landscape, which indicate the need for digital skills development, particularly in advanced IT. The function of Andela in fostering IT talent in Africa to give technology companies with access to a high-skilled resource pool was examined in a case study conducted by the IFC(https://www.ifc.org/wps/wcm/connect/1f44c711-c6ed-42c9-9590-9ea53013f927/Digital+Skills_Final_WEB_Andela.pdf?MOD=AJPERES&CVID=mGk7cgt). By investing in people and ensuring that participants are job-ready, Andela is solving the worldwide digital skills deficit that employers face. The LinkedIn survey, titled "The Top Skills Companies Needs Most in 2020" (https://www.linkedin.com/business/learning/blog/top-skills-and-courses/the-skills-companies-need-most-in-2020and-how-to-learn-them) looked at the skills that are in high demand by businesses vs their supply from educational institutions. The lack of digital skills can have a severe impact on national productivity and the ability to innovate and adopt new technologies. The policies, standards, and recommendations examined are aimed at addressing the country's skill shortages and skill mismatch. Both

the public and private sectors must make far-reaching decisions about how to address the digital skills gap. Higher learning institutions have a key role in developing skills as highlighted by Vision 2030; however, their quality is slipping and has accelerated in the past 20 years (Munene, 2016). A detailed analysis of the various policies, standards and guidelines is provided in the findings and discussion sections of this report.

2.2 National Digital Skills Development Initiatives

ICT personnel must have digital skills in order to perform their jobs effectively (Llorens et al., 2010). The government has emphasized skills development among the citizenry because "human capacity remains the biggest strength that a country can harness in its development" (Gok, 2013). It has been argued the best approach to satisfy future digital skills demand is through the domestic supply (ACS, 2008) and that is why the government started a few initiatives to provide skills and knowledge for operationalization within the government. Some of the initiatives include:

2.2.1 Ajira Digital Project

The project is implemented by KEPSA in partnership with the GoK through MoICT. It aims to "bridge the gap between skills demand and the lack of jobs in the country". By 2022, the project's main goal is to make Kenya a freelance centre and a global destination for online work. The project will teach basic soft skills, online work skills, digital marketing skills, and basic financial management skills to young people who have never worked online before. Furthermore, the project aims to teach experienced online work freelancers so that they can grow their firms into agencies and find more work to share with new online workers. The project has managed to train a total of 7,168 youths. 75% of the trainees have managed to successfully sign up on the different online platforms and have their work profile accounts approved. 67% have started bidding for online work, 49% have won bids and started earning from online work. The cumulative earnings from the bids have surpassed $100,000. However, the changing dynamics of education and skills have affected the jobs offered to the trainees. The jobs are always changing and they require more skills and better education qualifications which the trainees do not have.

2.2.2 Presidential Digital Talent programme (PDTP)

PDPT or DigiTalent is an internship programme for fresh ICT graduates designed to build their ICT capabilities through a rigorous training process preparing them for the ICT market. The initiative is led by a partnership between government, public, and private sector players and is implemented by the MoICT through the ICTA. The interns are placed both in government ministries and the private sector for 10 months and 2 months respectively. During their placement, they are given a holistic understanding of how ICT works in both sectors. This exposure helps them to acquire and apply digital skills for effective service delivery and efficient implementation of projects. This programme has assisted in the digitization of government records such as in the Ministry of Land. The challenges of this initiative have been the limited number of interns that are taken every year. The programme currently takes 100 fresh graduates every year, which is a small number compared to the number of graduates from the ICT programmes in higher learning institutions.

2.2.3 Digital Inclusion (Pasha Centres/Digital Villages)

According to the ICTA (http://icta.go.ke/pdf/Pasha%20Project%20Handbook.pdf), this initiative was rolled out in 2010 to promote access to technology, digital skills, and knowledge to the rural areas to ensure digital inclusion to all citizens through a network of information facilities across the country. The project has had several benefits such as employing young people in the rural areas and helping improve business skills and knowledge. Lack of business and entrepreneurial capacity and capability, quality and expense of Internet bandwidth in remote locations, lack of technical support, and inadequate marketing techniques have been some of the obstacles for Digital Villages. Due to these challenges and past performance, the project was put on hold and it has not been active since 2012.

2.3 Challenges of COVID-19

The COVID-19 epidemic has posed a serious danger to education. However, those shocks can be mitigated and crises can be turned into opportunities. Countries should use their universities and other post-secondary institutions to provide technical support for

remote learning, rapid training, and global knowledge access (Dreeseni et al., 2020; World Bank, 2020). The COVID-19 pandemic has forced universities to shift from traditional classrooms to virtual learning environments, requiring academics, support personnel, and students to retrain in the necessary knowledge, competencies, abilities, and attitudes. Many colleges have used ODEL platforms to continue their education, and some have even held virtual graduations (R. W. Mbogo, 2020). The University of Nairobi has trained its teaching and support personnel, as well as students, in the use of synchronous and asynchronous learning tools for curriculum delivery (https://ict.uonbi.ac.ke/latest-news/virtual-working-teaching-and-learning-training). Kenyatta University, for example, has reported advancements such as the production of ventilators and modified Covid-19 testing swabs. Pete & Soko (2020) found that there was a very low degree of satisfaction with the internet connection, cost, and reliability in their study on teacher and student preparedness for online learning in Sub-Saharan Africa. They suggested that because the majority of students own smartphones and laptop computers, universities should make the most of mobile technologies to teach and enhance online learning. Rather than depending on campus ICT, universities should change their focus from centralized ICT investment to off-campus empowering the learner and instructor. Furthermore, colleges should fight for subsidized internet bundles from internet providers, and governments should lower tax levies on internet service providers so that learners and instructors off-campus may access reasonable and dependable internet connections.

2.4 Digital Skills Gap

The Government of Kenya (2013) categorises the skills gap as the limited supply of adequately trained personnel for ICT firms. According to the findings of Desjardins & Rubenson (2011), skills mismatch is often ascribed to shortcomings in the education and training system. A report by the Kenya ICT Board (2011) established that various digital skills are lacking within the country which has forced the country to rely on foreign expertise to deliver on ICT projects. The situation is similar in countries such as Ghana and Australia which do not have sufficient skilled ICT practitioners and are dealing with the digital skills shortage through the use of temporary Visa migrants but

they foresee that not being sufficient for their future ICT demands (ACS, 2008; IFC, 2019). A study by Morrison & Rooney (2017) found that a lack of technical specialist's skills is responsible for digital skills shortage in the technology sector resulting in employers struggling to find workers with digital skills, and concerns are growing over graduates leaving "the learning institutions without up-to-date technical skills to be effective in the workplace".

2.5 Employer Efforts to Bridge Skills Gap

Skills are a critical component of a company's competitiveness and success. Employers find the education system, technical training and vocational institutions produce graduates without the required skills which is a business constraint. Employers are investing in a variety of initiatives to overcome the skills gap. They have modified their expectations of graduates and are now focusing on ways to promote employee learning, skill acquisition, and skill adaptation (Kolding et al., 2018). In Kenya, only around a third of firms provide training to their employees, either on-the-job or through external training possibilities (Laura Sanchez Puerta et al., 2018). Most businesses have unrealistic job requirements and are unwilling to pay for training for individuals they hire, preferring instead to hire people who have worked before(Cappelli, 2012; YIL, 2019). Larger companies expect hiring to be difficult due to fierce competition for talent and prefer to upskill and retrain their workforces rather than employ (Kolding et al., 2018). Berger & Frey (2015) agreed, emphasizing the importance of focusing efforts on improving the digital skills of a broad portion of the workforce in order to ensure that the advantages of technological breakthroughs benefit ordinary workers. According to Morrison & Rooney (2017), most businesses want to upskill their existing employees to assist them to adapt to current and emerging technologies in their industry. Many ICT businesses have established academies to help employees get skills and certifications in their technologies, while the education industry has been working on building curricula to boost graduate employability.

2.6 Dimensions of the Design Reality Gap

The design reality gap framework and its 'OPTIMISM' checklist of factors were employed in the study, which has been used in similar studies. Bass & Heeks (2011) used the framework to examine the implementation of international computing curricula in Ethiopian higher education and discovered that, despite significant progress, significant gaps between design and reality existed, necessitating specific actions along specific dimensions such as technology to close design-reality gaps and ensure greater implementation. To encourage success, Dasuki et al., (2015) used the OPTIMISM concepts of the design reality gap framework to assess the mismatch of implementing British computing degree programmes in a private university setting in Nigeria. They discovered that there is a need to shift beyond the direct implementation of such curricula to adapting them to the local cultural, institutional, social, and political context. The framework will be used in the study to identify significant gaps between the design and reality of digital skills development in the country, as well as specific steps to close such gaps. The OPTIMISM mnemonic can be used to summarize the extended aspects of the design reality gap (Figure 1): Objectives and values, Processes, Technology, Information, Management structures and systems, financial Investment, Staffing and skills, Milieu. The framework has been interpreted in this study, as shown in Table 1.

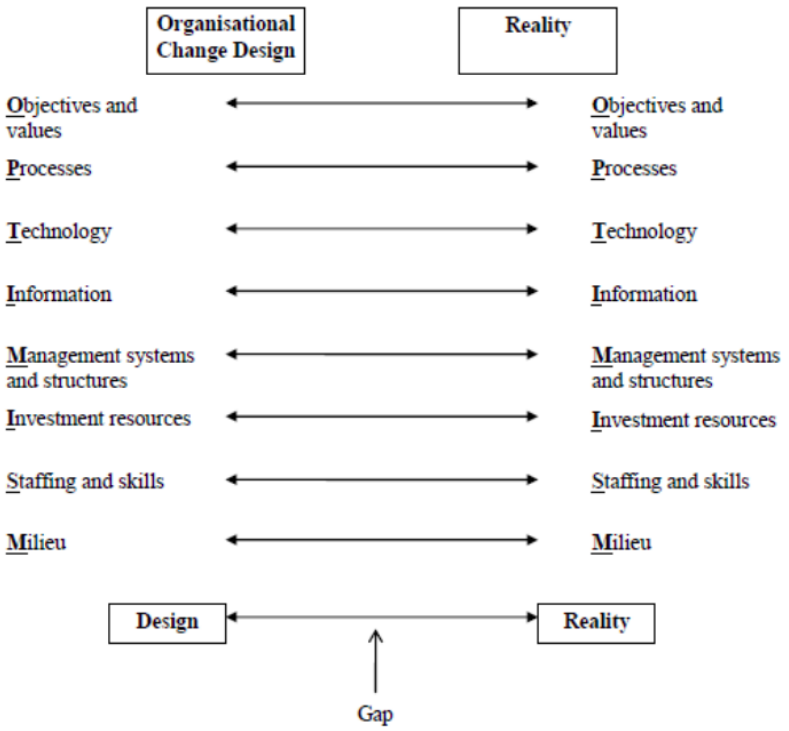

Figure 1 The Design Reality Gap Model

Source: Evaluating the implementation of international computing curricular in African universities: A design-reality gap approach (Dasuki et al., 2015)

Table 1 Interpretation of the framework to the study

Elements of the framework	Interpretation of the framework to the study
Objectives and values	What are the objectives of the ICT programmes? How do they meet the expectations of the stakeholders affected by the ICT programmes? What are the enrolments and graduation in STEM programmes? Do the enrolment and graduation satisfy the market needs of the digital skills
Processes	How are the curriculums developed for the ICT programmes? Do the curriculums meet the expectations of the stakeholders? Does the curriculum affect the quality of graduates?

Technology	What technologies are available to the students to support their learning processes? Are there enough computer laboratories and equipment for the students? Do the students get the necessary exposure to technology?
Information	Are there any policy specifications for digital skills? What information is there to support the implementation of the ICT programmes in the institutions?
Management Structures and Systems	Are there standards and regulations for the ICT programmes? Who is enforcing them?
Financial Investment	What investment has been made to support digital skills development in the country?
Staffing and skills	What level of staffing is required to support the ICT programmes? Is there enough personnel to support ICT-related programmes?
Milieu	What legal and political conditions must be met in order for ICT programmes to be implemented successfully? What impact do they have on the success of these degree programmes? (Dasuki et al., 2015)

CHAPTER THREE
RESEARCH METHODOLOGY

This chapter describes the research design, the data collection methods and analysis to determine the attributes contributing to the advanced digital skills gap in the country.

3.1 Research Design

An interpretivism research approach was adopted for the study to explore and understand the digital skills development environment. The purpose of the study was descriptive and problem-solving. The study used the design reality gap framework and its 'OPTIMISM' checklist of dimensions (Bass & Heeks, 2011). In the context of this study, the framework helped understand the design expectations of the digital skills development process, the reality and possible design reality gaps.

3.2 Target Sources

The research strategy was archival research which involved the study of secondary data with a focus on the internet and document-based research (Oates, 2006) such as journal articles, policy documents and reports. Literature and data related to the research key stakeholders such as the employers, educators, government and professional bodies (ACS, 2008) were collected. The literature and data that were chosen were based on the research objectives and findings.

3.3 Sampling Technique

Purposive sampling was used in this study, which allowed for the purposeful selection of secondary data. It is a low-cost, convenient (Taherdoost, 2016), and time-saving method that is likely to yield valuable data to meet the research's objectives (Oates, 2006). For this investigation, a minimum of 30 distinct secondary resources was gathered.

3.4 Data Collection And Analysis

Data relevant to the study was gathered. With a focus on qualitative and quantitative data, a deductive method was adopted.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter describes the findings of the research and is organized based on the OPTIMISM checklist of the research design.

4.1 Objectives and Values

Design Expectations

Higher education plays an important role in Kenya's Vision 2030, which calls for "Globally Competitive Quality Education, Training, and Research for Sustainable Development." Higher education is expected to contribute to national development by providing high-level relevant manpower training (Mukhwana, Oure, Kiptoo, et al., 2016) as well as a more hands-on technical and industry-related curriculum (Koppi et al., 2010), allowing individuals to become self-reliant and useful members of society.

Reality

University programmes are classified into four major levels: Bachelor, PGD, Master and Doctorate. Bachelor's level has the highest proportion of programmes followed by Master and Doctorate and PGD.

Table 2 Programmes offered in Chartered Universities (Public and Private)

Number of Universities	PhD	Master	PGD	Bachelors	Grand Total
74	813	1,554	93	2,114	4,574

Table 3 Proportion of the ICT cluster in Chartered Universities(Public and Private)

University Type	Bachelor	PGD	Master	PhD	Grand Total	Proportion
Public	99	3	31	20	153	3.77%
Total	**1,614**	**80**	**1,319**	**749**	**4,061**	**100%**
Private	37	0	16	4	57	7.53%
Total	**366**	**12**	**197**	**55**	**757**	**100%**

From programmes in public universities, ICT related courses are 153 which is 3.77% of the proportion of all courses offered while the private universities offer 57 courses which are 7.53% of the proportion of all courses offered in private chartered universities(CUE, 2019). TVETA approved 269 courses for the institutions with less than ten courses in ICT.

Table 4 ICT Enrolment in Chartered Universities (Public and Private)

University Type	Bachelor	PGD	Master	PhD	Grand Total	Proportion
Public	21,897	0	1,943	245	25,134	5.5%
Private	9,591	0	739	16	11,318	10.47%

Table 5 ICT programmes offered to Student Ratio (programme: Student)

Number of programmes	Number of Students	programme: Students
210	36,452	1:174

While the universities enrol more than 500,000 students, ICT clusters enrol 5.5% and 10.47% in the public and private chartered universities respectively (Table 4). Clusters with the highest number of enrolled students are non ICT programmes such as Arts. The minimum ICT programmes offered to students leads to a high programme to student ratio (Table 5). Similarly, while computing courses have a low enrolment rate, enrolment in applied sciences and business-oriented courses is rapidly increasing. It is evident that higher learning institutions are negligibly contributing towards Vision 2030 because they are negligibly playing a leading role in promoting innovation and technology interventions indicated by the minimal ICT programmes and low student enrollment.

Table 6 Graduation trends for ICT cluster in Public and Private universities

University Type	Grand Total	Proportion
Public	1,939	3.2%
Private	1,275	5.7%
Total	**3,214**	**8.9%**

Looking at the actual supply of digital skills, the learning institutions in Kenya produce over 300,000 graduates but only 3,214 from the ICT cluster (Table 6). This is a low percentage, and it demonstrates the institutions' inability to develop future human resources with the specialized knowledge and skills that the industry and country require. TVET institutes have a low enrolment rate as a result of a negative perception that TVET is just for people who have failed academically. There is a huge disparity between the enrolment and graduation for ICT programmes implying that skills demand significantly exceeds the skills supply. The disparity between enrolment and graduation can be attributed to student dropout due to minimal mentorship opportunities. A survey by Moringa School projected the graduates in ICT will grow to 17,671 by 2022 and that the industry will require 95,000 IT professionals by the end of the same year as a result of increasing demand for advanced skills (YIL, 2019) in the technology sector. By 2030, 50-55% of all jobs in Kenya will require digital skills, driven by a thriving ICT sector and start-up ecosystem(IFC, 2021). Furthermore, there is a concern of the ICT graduates being absorbed in non-IT professions after graduation which contributes further to the skills supply gap.

Design-Reality Gap

Student enrolment and graduations are highly skewed towards Arts, Humanities and Social Sciences as opposed to ICT. A focus on the arts at the expense of science-based programmes has disadvantaged key national development sectors that demand advanced digital capabilities. Low enrolment in ICT programmes is attributed to the negative perceptions of students about ICT such as ICT professions are difficult, boring, not respected, involve no interaction with people, unemployment concerns and long hours of work. Graduation to enrollment ratios in ICT is low, which can be attributed to student dropout as a result of minimal mentorship opportunities. Despite the projected growth of the graduates, their number is still very low and would not meet the projected demand of the industry by 2022. The regulators predict an increased enrollment by 2022. General enrolment in TVET and universities seems to have improved with 122,831 candidates being placed in universities and 88,724 in TVET institutions based on the 2020/2021 Placement Report. Higher learning institutions need to find means of offering more ICT programmes, increasing enrolments in ICT and retaining students after enrolment to align with the development needs of the country.

4.2 Processes

Design Expectations

A proper curriculum ensures that the graduates have extensive laboratory exercises and student projects to develop the right hands-on experience. The curriculum change process is expected to be conducted in all subject areas for higher education (Dasuki et al., 2015) to ensure that emerging technologies are included in the curriculum. A university shall constantly monitor its established programmes through various internal evaluation processes to examine the relevance of the programmes(UoN, 2020).

Reality

The National Broadband Strategy recognizes the existence of a skills gap caused by higher learning institutions failing to appropriately address present and future ICT needs, resulting in a shortfall in the country's high-end talent pool of IT trained workers. There is a lack of a standard ICT curriculum across the universities. The existing curriculum is misaligned with the technical needs of the country. As a result of obsolete courses taught at colleges, the Kenya ICT Board (2011) determined that the existing supply of digital skills does not fulfil the needs of the company. Universities offer curricula that are out of sync with the needs of the industry and they have been slow to catch up with the evolving demand for IT skills (YIL, 2019). In addition to that, most universities in Kenya have failed to provide programmes tailored to emerging technologies (Odhiambo, 2011). Individual departments and schools determine university curriculum, meaning that the quality of computer science, information systems, and IT graduates is solely dependent on the institution's internal quality assurance methods (Authority, 2014). The curriculum has not been regularly reviewed to introduce modern technologies such as network engineering and mobile computing. With changing technology, the high-end skills required are continuously expanding, necessitating a rapidly evolving curriculum to ensure that they are integrated into educational institutions, are inclusive, and relevant. Inappropriate competencies are created as a result of a mismatched computer curriculum, and the necessary skills and information are not taught (Bass & Heeks, 2011). Employers have made various claims that graduates lack critical skills(McGill et al., 2015). Taking an example of the academic

programme for Computer Science offered at the University of Nairobi (UoN), none of the modern technologies identified by the LinkedIn survey and Digital Economy Blueprint such as CyberSecurity, Big Data, and Robotics is being taught. That is similar to the equivalent programmes offered at the Jomo Kenyatta University of Agriculture and Technology(JKUAT), Kenyatta University(KU), Kenya Methodist University (KeMU) and the United States International University-Africa(USIU). Some universities teach programming languages like C++ in some of their courses like OOP when companies are looking for graduates with in-depth knowledge of Python and Scala programming languages. Programmes offered by these institutions teach very basic and/or general knowledge regarding computing, mathematics and business concepts. While their curricula offer courses on security, networking, mobile computing and AI, they are only introductory courses into those crucial concepts with minimal lab activities. Similarly, due to the lack of a relationship between the institutions and the sectors, TVET institutions offer a curriculum that is primarily theory-based and unrelated to market needs. The current TVET curriculum is inadequate and inflexible in light of technological advancements. It is based on a rigid supply-driven structure with little, if any, linkage or relevance to labour market needs, as a result of which graduates lack the necessary skills, knowledge, and competencies (Anindo et al., 2016). While CBC is becoming more popular across the country, higher education institutions continue to prioritize Content-Based Curriculum, which emphasizes knowing rather than doing (Amimo, 2021). Learning institutions' curricula are nearly entirely focused on course material and information rather than skills training, resulting in graduates lacking the abilities required to fulfil the expectations of future employers. Despite this, universities continue to generate ICT human capital and workforce that is neither guided by an HR development policy nor properly connected to industry needs. They continue to provide organization-specific training and professional development programmes that are neither responsive nor adaptive to new technology or industry demands. Higher education, particularly STI, is intended to contribute to national development and the achievement of Vision 2030; as a result, programmes must be tailored to the country's development needs and developed in collaboration with stakeholders in charge of labour market data from both the private and public sectors. Furthermore, universities should assist educational systems in the use of digital/online learning. In response to

the COVID-19 epidemic, the World Bank report (World Bank, 2020) notes that universities can conduct focused applied research and foster local innovation. Some universities may have the connections needed to quickly disseminate and use the knowledge on how to deal with the situation from around the world. Furthermore, the report suggests that TVET colleges provide focused online training for high-demand professions in pandemic coping and recovery to their students. They can also provide short-term training in skills for expedited digital transformation in other industries, which are in high demand right now.

Design-Reality Gap

The rising demand for higher education has resulted in the creation of a slew of new institutions and delivery methods, some of which are of questionable quality. Academic programmes on offer are highly skewed towards Arts and Humanities instead of ICT. The current ICT programmes offered in educational institutions do not meet the demands of a scientific and technology-driven economy. The curriculum taught in the institutions is not up to date and does not provide the graduates with the relevant skills needed in the IT market. There is a need to update, strengthen and grow ICT academic programmes that support the national priority and strategic areas. Many aspects of the courses are out of sync, including technology, industry changes, and teacher knowledge. Because of the misaligned curriculum, graduates from formal educational institutions lack the necessary skills for the industry. The learning institutions should continually undertake programme reviews to determine their currency and effectiveness. Moreover, they need to continuously identify programmes that address the changing workforce needs to keep pace with the technological changes and trends. Regular programme review will ensure graduates have the requisite skills and industry knowledge to guarantee market responsiveness. In terms of curriculum development and knowledge exchange, employers indicate that they do not have regular and relevant connections with general education and technical training institutes(Laura Sanchez Puerta et al., 2018). Interactions between them are about giving internships, arranging training for current employees, or recruiting new employees. These exchanges do not address issues about educational quality. The learning institutions need to establish more meaningful interactions with the industry to acquire labour market information to address quality concerns such as guiding the curriculum development. The industry will provide the

necessary interventions to ensure the relevance of skills developed which will not only improve the delivery of training to the graduates but will guarantee the relevance of their skills and a hence better chance at employability. When establishing digital skills courses, institutions should focus on graduate employability. To guarantee that graduates get the skills necessary for the business, they must ensure that the courses are aligned with market demand and employer expectations. Because of the ever-changing nature of IT, the curriculum should be revised on a regular basis to ensure that it is aligned with current and future market demands while also ensuring quality delivery.

4.3 Technology

Design Expectations

Learning institutions should have learning tools and equipment to mimic business activities and give graduates hands-on experience to help them comprehend business applications and assure the marketability of their talents (IFC, 2019).

Reality

Universities have placed a greater emphasis on theoretical learning, with minimal emphasis on practice and hands-on experience (Dasuki et al., 2015). They have ill-equipped laboratories and insufficient ICT surroundings, which impede students' ability to learn practical skills. Due to the difficulty of limited digital equipment, a restricted variety of ICT has been employed in the delivery of education, with the access rate in Kenya being around one computer per 150 learners (https://www.infodev.org/infodev-files/resource/InfodevDocuments_409.pdf). Other challenges such as frequent power disruptions, high costs of Internet provision and digital equipment, and inadequate infrastructure hinder access to ICT facilities. Inadequate connectivity and network infrastructure are experienced across the country in the different institutions especially those in the rural and low-income areas. Furthermore, most institutions are using systems that are nearly obsolete, preventing them from fully exploiting the potential of emerging technology. Similarly, TVET institutes have outdated technology and insufficient learning material (Kigwilu & Akala, 2017). They lack sophisticated training equipment in their workshops, which has an

impact on the employability of graduates. Due to a lack of access to computers, graduates have been forced to share computers, resulting in minimal exposure and hands-on experience with technologies, resulting in poor quality. Lack of modern equipment in schools has affected the exposure of graduates to the practical knowledge required by the industry, making employers invest time and money in employee training. Graduates in Kenya are experiencing challenges with access to laboratories. A graduate from JKUAT remarked that his school did not teach him even basic skills and he had to learn the course OOP by writing code on paper due to lack of facilities(YIL, 2019).

Design-Reality Gap

The relevance of skills required by industry has been undermined by inadequate training materials and the usage of inadequate technology in higher learning institutions. Higher education institutions have limited access to technology-based learning resources, which limits the skills graduates can master, making them "unsuitable" candidates for employment. Acquiring skills is possible when educational institutions have adequate resources to provide graduates with practical knowledge and hands-on experience. Institutions, on the other hand, have been criticized for underutilizing learning resources. Despite the availability of learning devices, some teachers spend more time teaching theoretical than practical content.

4.4 Information

Design Expectations

CUE and TVETA have provided guidelines and standards to guide institutions for the development, implementation and quality assurance of education. The study will focus on the guidelines indicated in table 7.

Table 7 Standards and guidelines from the learning institutions regulators

Standard/ Guideline	CUE	TVETA
Financial Resources	Institutions are expected to have adequate financial resources	
Quality of Teaching	Through a range of delivery modalities and methodologies, each institution shall promote the highest levels of teaching and learning. Internal quality assurance procedures must be institutionalized at a	Institutions will provide high-quality training programmes and delivery, up-to-date facilities, and the inclusion of new technology with clear linkages with the job market. Institutions must have

	university with suitable quality assurance policies, institutions, and funding requirements.	quality assurance management systems to ensure constant training quality.
Academic Staff	Academic personnel must stay up to date on current trends in their fields as well as new technologies. An academic programme must be backed up by enough full-time staff with the necessary academic qualifications and led by a qualified academic leader. For ICT courses, the recommended full-time staff: student ratio is 1:10	Institutions will have skilled trainers and should conduct Continuous Professional Development (CPD) for trainers to ensure upskilling and career opportunities.
Laboratory	A university must have laboratories with sufficient space for digital and analogue communication, control, and fibre optics, as well as state-of-the-art facilities for wireless sensor networks, network security, mobile networking, data packet routers, and voice over IP gears, including a software switch, media server, trunk gateway, and IP phone. All facilities and equipment must be current, appropriate, and sufficient to support the curriculum(CUE, 2014b)	Institutions shall have up-to-date laboratories with modern technologies
Academic Programme	A specific academic programme's content must be relevant and consistent with institutional, national, and global aims and trends. The curriculum of a specific programme should be examined on a regular basis to keep up with current trends in the domain. The substance of an academic programme should support the institution's vision and mission, as well as national goals.	Institutions will design and develop high-quality programmes which will have strong links to the industry, leading to better employability of graduates
Programme Review and Audit	At regular times, a university must conduct a self-assessment of its programmes. An institution must put in place structures to examine the quality and efficiency of its academic programmes on a regular basis.	programmes shall be regularly reviewed to guarantee linkages with the job market to enhance employability

Reality

Table 8 Reality of adoption of the standards and guidelines

Standard	CUE	TVETA
Financial Resources (Further discussed in Financial Investment)	Universities are experiencing inadequate funding. CUE has limited funding which limits policy development and implementation. The regulator is hindered from carrying out its functions.	TVETA complains of inadequate funding. It currently relies on three sources of funding but despite these sources of funding, TVETA reports that the allocated resources are inadequate even for the expenditures.

Quality of Teaching	Individual departments and schools determine university curriculum, meaning that the quality of computer science, information systems, or IT graduates is solely dependent on the institution's internal quality assurance methods.	Limited research on skill needs and the labour market information system has limited curriculum creation and resulted in few industry connections to TVET programmes.
Academic Staff (Further discussed in Staffing and skills)	In public and private chartered universities, there are 1,437 academic staff for ICT, accounting for 7% of all academic staff teaching ICT programmes, resulting in a high staff-to-student ratio.	Institutions have insufficient trainers. The available staff are unqualified resulting in inadequate delivery of training curriculum.
Laboratory (Further discussed in Technology)	In public universities, the computer to student ratio is poor, with around one computer per 150 students in Kenya. Students are forced to share computers, which results in limited exposure to and hands-on expertise with the technologies, resulting in poor quality.	TVETA acknowledges to have an operational ICT infrastructure, however, there is a need for continuous infrastructure improvements to include modern technologies. Further, there is a need for use of ICT in education and training.
Academic programmes (Further discussed in Processes)	There is a misalignment between courses and market requirements. To ensure market responsiveness, universities must adapt their computer programmes to accommodate developing technology and reflect industry and country demands.	Due to the lack of a relationship between the institutions and the industries, TVET institutions offer a curriculum that is primarily theory-based and irrelevant to market needs. The establishment of effective skills development programmes is hindered by the lack of labour market research and information.
Programme Review and Audit (Further discussed in Processes)	Many developing country computer curricula are outdated, resulting in graduates who lack the skills that industries seeking to utilise ICTs require (Dasuki et al., 2015).	Lack of occupational training standards limits the curriculum review process for aligning the TVET programmes with the industry.

Design-Reality Gap

Learning institutions are experiencing challenges in adopting the policies. Inadequate funding has hindered policy adoption and there is a need for the regulators and the government to assist in providing funds to support the adoption of these standards. Learning institutions are encouraged to establish strong partnerships with the industry to make use of their resources to facilitate the adoption of the policies. Additionally, strong partnerships between the institutions, industry and regulators will enable the development of further policies to guarantee a match between the skills demand and skills supply (ITU, 2020a). The regulators are encouraged to improve the collaboration

between the industry and the institutions to assist in the implementation of these standards.

4.5 Management Structures And Systems

Design Expectations

CUE was established to improve measures for the promotion of high-quality university education in the country. Its mission is to ensure that standards, quality, and relevance are maintained in all aspects of university education. (CUE, 2014a). TVETA's mission is to regulate and organize the TVET sector by accrediting institutions, programmes, and trainers, as well as ensuring access, quality, equity, and relevance in education and training (TVETA, 2018).

Reality

CUE has worked to increase access to higher education by assisting in the creation and establishment of new public universities, campuses, improving existing middle-level institutions, and building new private universities since its inception. CUE has been unable to carry out its tasks, such as conducting university education research, enforcing existing standards, or even maintaining an acceptable flow of information between the Ministry of Education and the universities, due to financial restrictions (CUE, 2014a). In addition to that, CUE has been unable to perform its duties due to 'politicisation of decision-making' which has reduced its powers and effectiveness to carry out its functions of planning, development and maintenance of the quality of university education (Sifuna, 2006). Professional bodies have attempted to fill the void left by the CUE's deficiencies, but they have been sued for doing so due to a lack of statutory authority (Munene, 2016). Similarly, TVETA has devised a road map for achieving competitive human capital that takes into account both the changing operating environment and the government's strategic aims. However, the regulator faces difficulties in carrying out its duty due to a lack of human resource capability and a lack of institutional understanding of TVETA and its mandate. In addition, the regulator has limited engagement with the private sector, lacks a framework to guide engagement with other government organizations, and publishes insufficient information on TVET.

Design-Reality Gap

Because of a lack of corporate visibility and inadequate enforcement mechanisms, regulators believe there is no law or professional body that provides professional accreditation of ICT programmes. Additionally, the regulators are facing challenges with communication and inadequate publication which further affects their role and functions. The challenges faced by CUE have led to a lack of standard quality among the different IT degree curriculums in the different higher learning institutions. The quality of IT degree programmes is now determined by each university's own quality assurance systems. School administrators and teachers typically make decisions regarding what institutions educate, and these decisions are overly theoretical and outdated.

4.6 Financial Investment

Design Expectations

Higher education is critical to the development of national digital skills. It is expected that a recurring budgetary allocation will be made, with increased government and private sector investment in higher education.

Reality

Government capitation, student fees, research grants, and other incomes are the four sources of income for universities, while personnel costs, capital development, maintenance, and other expenses are the four sources of expenditure (Mukhwana et al., 2016).

Table 9 Income and Income Streams at Public and Private Universities

Income and Income Streams (Ksh. Millions) 2010-2014 Academic Years					
University Category	Government Capitation	Student Fees	Research Grants	Other Incomes	Grand Total
Public Universities	133,398.26	117,922.89	14,495.33	13,801.49	279,617.98
Private Universities	0	53,804.88	1,480.64	11,009.70	66,295.22
Total	**133,398.26**	**171,727.78**	**15,975.97**	**24,811.19**	**345,913.20**

Source: State of university education in Kenya (Mukhwana, Oure, Kiptoo, et al., 2016)

Table 10 Public and Private Universities' Expenditure and Expenditure Items

University Category	Expenditure and Expenditure Items (Ksh. Millions) 2010-2014 Academic Years				Total Expenditure
	Staff Costs	Building Costs	Maintenance Costs	Other Expenditure	
Public Universities	165,881.92	33,486.86	21,375.42	60,743.34	281,487.54
Private Universities	31,643.10	9,115.82	10,354.62	22,304.46	73,418.00
Total	**197,525.02**	**42,602.67**	**31,730.05**	**83,047.79**	**354,905.54**

Source: State of university education in Kenya (Mukhwana, Oure, Kiptoo, et al., 2016)

Universities can no longer rely on the cash they currently receive from diverse sources to stay afloat. Their expenditure exceeds income. Furthermore, universities receive limited donor funding due to their inhibited partnerships with top international universities as a result of their poor quality (Nganga, 2011). Similarly, TVETA complains of inadequate funding. It currently relies on three sources of funding: government funding, funding from development partners and services (mainly enrollment) for its operations(TVETA, 2018).

Table 11 TVETA funding for the Financial year 2017/2018

Source	Amount (Ksh. Millions)
Government funding	111.0
Development partners	34.0

TVETA relies on government funding to implement its programmes, projects and activities. The regulator foresees a threat of possible reduced funding due to changes in government priorities. They're collaborating closely with development partners to get external funds for policy support, research, development, and creative projects, as well as publications and events. Enrollment fees are one of the other sources of income; however, decreasing enrolment at TVET institutions is impacting this source of funding. Despite these sources of support, TVETA claims that the provided resources are insufficient to meet their needs. As the expanding number of students puts strain on the limited resources available to serve the growing number of students, inadequate funding has contributed to the delivery of poor quality services by higher learning institutions. Limited funding had affected the efforts of the institutions to install ICT infrastructure, purchase learning materials and equipment as well as manage its operations such as curriculum review and updating processes. In order to survive with

limited resources, institutions have shifted their focus to developing only appealing programmes in order to attract more students and thus generate more revenue, while ignoring the development of ICT programmes, which are considered more expensive despite being critical to the country's long-term development agenda. Unfortunately, this underinvestment cannot be undone easily. There is a need to lobby for increased annual funding by the government. TVET institutions experience inadequate financing which limits their efforts for procuring up-to-date learning equipment such as computers and developing training materials which adversely affects curriculum implementation. Most graduates do not pursue professional certifications such as CISCO certification because most of these programmes are too expensive. While most households can afford training for foundational skills, affordability decreases for higher skills, with just over 3% of households on average expected to be able to afford training for advanced and highly specialized skills by 2030 (IFC, 2021). Inadequate funding is affecting the development of the learning institutions. Additionally, the functions and capabilities of the regulator are affected such as policy development and implementation. Aside from funding, the government is supporting a few initiatives for digital skills development. The PDPT programme is fully funded by MoICT from the training, placement and benefits that the interns receive. Digital Village is another initiative supported by the government. Since its launch, the government has allocated over KES 70M to facilitate the initiative. For Round 1 of the initiative, the government approved KES 47,899,147 for the selected individuals in different constituencies in Kenya and Round 2, the government approved KES 27,995,000.

Design-Reality Gap

Government funding is a major source of money for higher education institutions, while private colleges rely on student fees. With the resources they currently receive from their different income streams, the institutions may not be able to sustain themselves. This has led them to explore alternatives, such as developing more business and art-related programmes at the expense of critical ICT programmes for the country's development. Due to financial constraints, both the CUE and the institutions have underinvested in critical infrastructure and capacity building. Higher education plays an important role in Vision 2030 hence more focus and funding should be directed towards them. The government should increase funding allocation to the higher

education sub-sector to enable the sub-sector to play its role in the training, research, innovation and technology interventions needed in the country. However, the learning institutions should rethink sustainability strategies that will support them now and in future. In addition to that, they need to simplify to improve efficiency and effectiveness while avoiding excessive resource waste.

4.7 Staffing and skills

Design Expectations

Teachers and trainers of ICT related programmes should be sufficient, with proper digital skills and qualifications and with the ability to adapt to changing technology (ITU, 2020a).

Reality

Table 12: Academic Staff by Rank and Chartered Universities (Public and Private)

University Type	Professor	Associate Professor	Senior Lecturer	Lecturer	Tutorial Fellow	Graduate Assistant	Total
Public	487	781	1,842	5,988	5,174	914	15,186
Private	127	209	654	2,181	1,606	445	5,222

There are 20,408 academic staff with a majority (74.45%) in public universities. The academic staff have different ranks and they are distributed differently across the universities.

Table 13: Academic Staff Teaching ICT in Public and Private Universities, Organized by Rank

Professor	Associate Professor	Senior Lecturer	Lecturer	Tutorial Fellow	Graduate Assistant	Total
19	35	114	484	653	132	1,437

The academic staff for ICT courses are 1,437. This represents 7% of all the academic staff teaching ICT. Based on the number of students enrolled in ICT (36,452), the academic staff-student ratio is 1:26 which is contrary to the recommended ratios by

CUE for Applied Science programmes (1:10) and practical based courses (1:20). The high percentage indicates a significant demand on the teaching faculty, insufficient learning space, and limited teaching and learning materials. Furthermore, there is some variance in staff levels, with the majority of them being tutorial fellows and lecturers, with only a few professors and associate professors. Similarly, there is a scarcity of well-trained teachers and trainers at TVET institutions(IFC, 2021). They are understaffed due to poor remuneration, minimal upskilling opportunities and a way of managing the high attrition which makes it difficult for them to retain most of their good trainers. The available ICT trainers are inadequate with minimal experience as a result of a lack of quality standards. The registration and development of TVET trainers have not followed the quality demands of the labour market or been governed by any quality standards. The trainers lack exposure to the industry trends due to a lack of linkages with the industry. Contrary to that, some universities have invested in academic staff training amidst the coronavirus pandemic to develop online platform skills and capabilities to facilitate remote learning. UoN, through the ICT department, has trained their teaching and support staff as well as students in the use of Google classrooms, Webex, and Zoom (https://ict.uonbi.ac.ke/latest-news/virtual-working-teaching-and-learning-training) to support remote learning. It is the country's first public university to provide virtual exams. As a method of empowering the learner and instructor, the University has also supplied free Telkom packages to all students and academic staff (https://ict.uonbi.ac.ke/latest-news/uon-hit-ground-running-online-exams-amid-covid-19). However, curriculum delivery and management of the individual courses continues to depend on the skills of the individual faculty. There is a need for further training and development to ensure that the academic staff are prepared and supported to not only deliver the existing curriculum but to adapt to the technological trends and deliver the requisite skills to the graduates.

Design-Reality Gap

There is inadequate human resource capacity in learning institutions which is one of the issues affecting the delivery of ICT programmes. The findings revealed that there is a big shortfall of academic staff with PhD in the universities which has serious implications in terms of academic leaders to run academic programmes and mentor

upcoming faculty with Master's qualifications as indicated in the CUE guidelines. The quality of teaching and research in learning institutions has been impacted by a lack of academic staff in TVET and universities. Students can acquire skills when institutions are well-staffed with qualified and experienced instructors who use effective and efficient teaching methods. There is a need for retooling of the current trainers to enhance their competencies and improve the delivery of the curriculums. The academic staff should keep abreast with current trends, latest technologies of teaching and learning. They should be exposed to the industry regularly. Furthermore, higher education institutions must have a comprehensive training programme that outlines their human resource development strategy in order to assure upskilling, career paths, and national digital transformation. They should hire academics with real-world experience who can lead by example, and they should endeavour to expand the staff's capacity through scholarships, lower workloads, and more time off, as well as encouraging academic staff with master's degrees to pursue PhDs.

4.8 Milieu

Design Expectations

Given the existing and future demand for skills, political shifts and dynamics should favour the development of higher education.

Reality

CUE has been unable to perform its duties due to the 'politicisation of decision-making' which has reduced its powers and effectiveness to carry out its functions of planning, development and maintenance of the quality of university education(Sifuna, 2006). Lengthy government bureaucracy processes and conflicts in governance structures in university education institutions pose threats to the operations of the commission. The commission is prone to the political environment. Similarly, TVETA is affected by multiple and fragmented policies and legislation which negatively impact the institutions. Additionally, the regulator is affected by overlapping mandates with other Government Agencies.

Design-Reality Gap

Although the regulators are not free to operate, they realize the importance of the political context in the successful implementation of their goals, as well as the need to lobby important parties to minimize any negative consequences on their operations. The authorities intend to take advantage of political shifts and dynamics in order to promote higher education development.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 Findings Summary

Objective 1: Review the current policy specifications that exist for the digital skills

While Kenya's higher education regulators have the authority to completely implement published principles and standards for higher learning institutions, they are limited in their budget, resulting in graduates with digital skills that are irrelevant to market needs.

Objective 2: Analyse the student enrolment and graduation for the ICT programmes

The student enrollment and graduation analysis for ICT programmes make a strong case for a big increment in both the number of students and programmes from the current 15.97% and 11.3% levels respectively. There is a need to address the disparity between the number of students enrolled in ICT and those that graduate. Learning institutions and the industry will need to improve the perception of the ICT profession to improve enrolment in ICT programmes.

Objective 3: Determine the market needs for digital skills

Key stakeholders in the country (FKE, KEPSA, KAM, National Chamber of Commerce and Industry, Kenya Labour Market Information System) give the least information about digital skills market demands. Employers want graduates, but they're worried about the lack of practical experience and skills supplied by education and training institutions, which could lead to a skills gap.

Objective 4: Evaluate the alignment of curriculum implementation with the technical needs

To address the mismatch of the curriculum with industry demands, there is a need for universities in Africa to update their ICT curriculum to cope with the growing and changing demands of the ICT landscape to provide a hands-on technical and industry-related curriculum to guarantee market responsiveness, the relevance of skills and employability of the graduates.

Objective 5: Develop an implementation strategy that will serve as a road map for developing digital skills and minimizing the digital skills gap

An implementation strategy has been proposed to bridge the digital skills gap in Kenya among government agencies, educators/trainers, and employers. The strategy is broken down into six broad themes: Enrolment and Graduation, Learning Curriculum, Laboratory and Learning Equipment, Policies and the Regulators, Academic Staff and Skills, Learning Institutions-Industry Partnership.

5.2 Conclusion

The design reality gap framework was used in the study to gain a deeper understanding of the design, reality, and gaps associated with the development of advanced digital skills in learning institutions. The application of this framework brought out key challenges and opportunities affecting and contributing to the development of the advanced digital skills gap in the country. The main challenge being a mismatched curriculum which is causing inappropriate competencies to be developed among the graduates making them underprepared and unqualified in meeting the demand of the industry. Additionally, poor enrolment and graduation rates from ICT programmes is a contributing factor to the skills gap in the country. Inadequate staff and limited digital equipment in the learning institutions contribute further to the poor quality of the graduates. Policy development and enforcement by the regulators is key in the operations and training of students by the institutions. The regulators need to take an active role in regulating learning in the institutions. While the study identified initiatives towards training academic staff in the wake of the COVID-19 epidemic, the focus has been on the development of online platform skills to support remote learning; curriculum delivery remains dependent on individual faculty competencies. Further training and support are needed to ensure that academic staff deliver the requisite skills to the graduates. The study identified opportunities such as the availability of academic staff for the ICT programmes, existing relationships between the industry and the learning institutions and the presence of standards and guidelines for the operations of the learning institutions. An implementation strategy was developed outlining possible initiatives to bridge the digital skills gap in Kenya among the government agencies, educators/trainers, and employers. Skill gaps arise from technological advancements which are constantly happening. This implies that organizations will always face some

skill gaps from time to time. However, the strategy developed by this study will help minimise that gap and will aid in the development of appropriate competencies among the graduates.

5.3 Limitations of the Study

This study was conducted in the context of higher learning institutions that teach ICT programmes in the country by looking at their enrollment, graduation, curriculum, staff, laboratory and equipment. The study did not cover technology hubs and complementary programmes offering training programmes for advanced digital skills.

5.4 Suggestions for Future Research

While this study recommends initiatives to increase enrolment in ICT related programmes through the developed strategy, there is a need to understand the influence of Computer Studies subjects in lower levels of education on the choice of the degree programme for higher education. Technology hubs and complementary programmes have been identified to contribute to the development of advanced skills in Kenya. To fully comprehend the impact of these programmes, more research is required.

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Appendices

APPENDIX 1 - IMPLEMENTATION STRATEGY FOR BRIDGING DIGITAL SKILLS GAP

Thematic Area: Enrolment and graduation from ICT programmes

Strategy 1: Increase student enrollment into ICT programmes

Initiatives	Output	Performance Indicator	Resources
Increase the number of ICT programmes offered in the learning institutions	Learning institutions to offer more ICT programmes aligned to the trends and industry needs	● Increased ICT programmes ● Reduced programme to student ratio	● Learning ● institutions
Change/improve the perception of students towards ICT programmes by increasing visibility of the ICT professions	Better perception of the ICT profession by students	Increased enrolment in ICT programmes	● Learning institutions ● Industry

Strategy 2: Increase the number of graduates from the ICT programmes

Initiatives	Output	Performance Indicator	Resources
Minimise student dropout after enrollment through support programmes	Support systems for students such as mentorship	A tally in the number of students enrolled and graduates	● Learning ● institutions
Link students to the industry to guarantee absorption into IT professions	Transition programmes to support graduates	●Increased absorption of graduates into IT professions ● Reduced unemployment of graduates	● Learning institutions ● Industry

Thematic Area: Learning Curriculum

Strategy: Use of an up-to-date curriculum to develop appropriate competencies in graduates

Initiatives	Output	Performance Indicator	Resources
Create/increase the linkage between industry and academia	Industry representation in the curriculum review process	● Curriculum in sync with the industry needs High-level curriculum design and development	● Learning institutions ● Industry
Regularly review the curriculum every two to five years to bring it up to speed with the technological advancements	A responsive curriculum to the current and future ICT needs	● Curriculum inclusive of modern technologies ● Graduates with the requisite digital skills	● Learning institutions ● Industry
Curriculum to focus on graduate employability, needs of employers and the country	A curriculum more aligned to the needs of the industry	● Reduced unemployment rate among the graduates ● Improved graduate employability ● Industry satisfaction with graduate skills	● Learning institutions ● Industry
Curriculum to focus on the extensive practical application of theoretical concepts to enable skills acquisition	A curriculum with more practical courses	● Increased laboratory activities for students ● Improved skills acquisition	● Learning institutions ● Industry
Learning institutions to benchmark their curriculums against the guidelines provided by regulators	A standard curriculum across all institutions	Use of a standard curriculum by all learning institutions	● Learning institutions ● Regulators

Thematic Area: Laboratory and Learning Equipment

Strategy: Increase exposure and hands-on experience by students to improve the quality of graduates

Initiatives	Output	Performance Indicator	Resources
Increase learning resources such as workstations in the institutions	Enable and increased exposure and hands-on experience among graduates	● Graduates with hands-on skills ● Increased digital equipment ● High computer: student ratio	Learning institutions
Create an adequate ICT environment in institutions	An improved ICT environment to enable graduates to learn and acquire technical skills	Access to digital learning equipment A suitable environment to support learning activities	Learning institutions
Involve the industry and their modern learning equipment for learning purposes	● Graduates able to access modern learning equipment ● Industry lending their equipment to institutions ● Students visiting the industry for learning purposes	Increased skills acquisition by the graduates	● Learning institutions ● Industry

Thematic Area: Policies and the Regulators (CUE and TVETA)

Strategy: Enable the regulators to perform their functions as regulators for higher education

Initiatives	Output	Performance Indicator	Resources
More resource allocation to support the regulators	● Better funds allocation ● Regulators to find ● means of generating revenue ● Regulators to reduce spend on expenditure	● Increased budget of the regulators ● Regulators performing their duties	● Government ● Regulators
The regulators to use available channels of communication at their disposal	Use of social media, emails and any other means of communication at its disposal to enforce current standards and guidelines	● Increased visibility of the regulators ● Increased ● engagement between the regulators and the learning institutions ● Increased adoption of policies by the ● institutions	● Learning ● institutions ● Regulators
Regulators to work closely with the industry and seek support where necessary	● Collaboration between regulators and the industry ● Involve the industry during review and ● development policies Having industry ● representatives within the	● Feasible and achievable policies ● Industry support in the adoption of policies	● Regulators Industry

	regulating authorities		
The regulators work closely with institutions and use their research resources to research higher education and benchmarking	Improved sources for research on higher education	● Improved knowledge and information on higher education ● Attainable and feasible policies, guidelines and standards	● Learning ● institutions Regulators
The regulators to oversee the quality of all universities instead of relying on institutions' internal quality assurance mechanisms	Improved quality of education and graduates in all the institutions	Availability of a benchmarking curriculum for institutions to adopt	● Learning ● institutions ● Regulators
Regulators to work closely with the government to ensure its interest are represented and to lobby the relevant stakeholders to ensure their success	Having a government representative(s) in regulating authorities	Presence of a government representative(s)within the regulators	● Government ● Regulators
The regulators to publish accreditation results as a remedial reaction to underperforming institutions to guide and influence the behaviour of institutions and enable them to commit to quality	Accreditation results for publication/sharing	● Accreditation results distribution ● Changes in the ranking of the institutions in the results	● Learning ● institutions Regulators

Thematic Area: Academic Staff and Skills

Strategy: Empower the academic staff and faculty with practical experience to teach by example

Initiative	Output	Performance Indicator	Resources
Increase the number of academic staff in the institutions	Reduced faculty load	Increased proportion of the academic staff for the ICT programmes	Learning institutions
Institutions to make use of guest lectures from the industry	Guest lectures to help the graduates connect to the broader industry	● Improved the interactions between academic staff and industry ● Graduates exposure to the industry	● Learning institutions ● Industry
Institutions to support continuous staff training through a conducive infrastructure and collaboration	Empowered staff with increased/ improved skills	Training and increased opportunities for the academic staff	Learning institutions
Academic staff to establish more connections in the industry to increase their knowledge, industry awareness, and trends, contributing to student learning	Empowered staff with increased knowledge of the industry	Forums to connect the academic staff and the industry	● Learning institutions ● Industry

Thematic Area: Learning Institutions-Industry Partnership

Strategy: Create meaningful relationships between institutions and the industry

Initiative	Output	Performance Indicator	Resources
Create/increase the linkage between industry and academia	● Meaningful and beneficial interactions ● Funding opportunities for the institutions ● Industry equipment access to the institutions	● Forums to connect the academic staff and the industry ● Strengthened relationship between the industry and the institutions	●Learning institutions ●Industry
Industry involvement in the curriculum design and review	A curriculum aligned to the industry needs	● Industry involvement in curriculum design ● Industry feedback and interventions incorporated into the curriculum	●Learning institutions ●Industry
Industry to participate in training the graduates	Graduates aware and informed of the industry needs	● Improved the interactions between the academic staff and the industry ● Exposure of graduates to the industry needs	●Learning institutions ●Industry
Learning institutions to provide short courses desired by the industry for professional development	Learning institutions to participate in training the industry	Improved interactions between the industry and the academic staff	●Learning institution ●Industry

Industry to provide internships, school to work transition programmes and placement opportunities after graduation	Guaranteed opportunities for graduates to join the industry	● Attachment and internship opportunities for students programmes to facilitate transitions ● Faster graduate absorption into the industry	● Learning institutions ● Industry

APPENDIX 2 - CURRICULUMS REVIEWED

BSc Computer Science Curriculum from the UoN

Year	Semester One	Semester Two
One	CSC111 Introduction to Computer Systems CSC112 Introduction to Programming CSC113 Discrete Mathematics CSC115 Programming Lab CSC126 Physics for Computing Systems CCS001 Communication Skills CCS009 Elements of Economics	CSC122 Database Systems CSC123 Data Communications CSC125 Linear Algebra CSC127 Object-Oriented Programming CSC211 Data Structures and Algorithms CSC214 Digital Electronics CCS010 HIV/AIDS
Two	CSC114 Differential and Integral Calculus CSC212 Systems Analysis and Design CSC213 Computer Architecture CSC217 Knowledge-based Systems & Prog CSC223 Operating Systems CSC224 Software Engineering CSC225 Computer Networks	CSC124 Probability and Statistics CSC216 Assembly Language Programming CSC222 Automata Theory CSC227 Programming Project CSC228 Web and Services Programming CSC229 Machine Learning Algorithms & Prog CSC313 Foundations of HCI
Three	CSC311 Analysis and Design of Algorithms CSC314 Computer Graphics CSC315 Distributed Systems CSC316 Intro to Organ. & Management CSC317 Artificial Intelligence Applications CSC318 Network Design Implementation & Management CSC319 Innovation & Entrepreneurship	CSC321 ICT Project Management CSC322 Network and Distributed Programming CSC326 Compiler Construction CSC327 Embedded Systems & Mobile Prog CSC328 Business Intelligence & Analytics CSC411 Computer Network Security CSC311 Industrial Attachment
Four	CSC414 ICTs and Society CSC417 IS and Organizations CSC418 Emerging Technologies Bootcamps CSC451 Distributed Databases CSC481 Computer Games Programming CSC416 Computer Systems Project	CSC416 Computer Systems Project CSC434 Cloud Computing and Services CSC452 Information Systems Control Audit CSC455 Info for Emerging Online Solutions

BSc Computer Science Curriculum from the JKUAT

Year	Semester One	Semester Two
One	HRD 2102 Development Studies and Ethics SMA 2104 Mathematics for Sciences SMA 2100 Discrete Mathematics SMA 2101 Calculus I SCH 2110 Chemistry ICS 2100 Introduction to Computer Systems ICS 2101 Computer Organisation ICS 2102 Intro to Computer Programming SZl 2111 HIV/AIDS	HRD 2101 Communication Skills SMA 2102 Calculus II SMA 2103 Probability and Statistics I SPH 2172 Physics ICS 2103 Introduction to Systems Programming ICS 2104 Object-Oriented Programming I ICS 2105 Data Structures and Algorithms ICS 2106 Discrete Structures I
Two	SMA 2220 Vector Analysis SMA 2230 Probability and Statistics II SMA 2304 Ordinary Differential Equations I ICS 2200 Electronics ICS 2201 Object-Oriented Programming II ICS 2202 Operating Systems I ICS 2203 Internet Application Programming ICS 2204 Programming Languages	HRD 2104 Principles of Industrial Management ICS 2205 Digital Logic ICS 2206 Database Systems ICS 2207 Scientific Computing ICS 2208 Operating Systems II ICS 2209 Design and Implementation of Computer Applications ICS 2210 Systems Analysis and Design ICS 2211 Numerical Linear Algebra ICS 2213 Industrial Attachment I (8 Weeks)
Three	HRD 2103 General Economics SMA 2343 Operations Research I ICS 2300 Abstract Data Types and Algorithms ICS 2301 Design and Analysis of Algorithms ICS 2302 Software Engineering ICS 2303 Multimedia Systems ICS 2304 Programming Paradigms ICS 2305 Systems Programming	SMA 2305 Complex Analysis I ICS 2306 Computer Networks ICS 2307 Simulation and Modelling ICS 2308 Artificial Intelligence ICS 2309 Commercial Programming ICS 2310 Discrete Structures II ICS 2311 Computer Graphics ICS 2312 Software Systems Development ICS 2313 Industrial Attachment II (8 Weeks)

Four	SMA 2433 Quality Control Methods ICS 2400 Transaction Processing Systems ICS 2401 Compiler Construction ICS 2402 User Interface Architectures ICS 2403 Distributed Systems ICS 2404 Advanced Database Systems ICS 2405 Knowledge-Based systems ICS 2406 Computer Systems Project	HRD 2115 Accounts and Finance ICS 2407 Theory of Computing ICS 2408 Network and Systems Security ICS 2409 Neural Networks ICS 2410 Parallel Systems ICS 2411 Cryptography ICS 2412 Digital Image Processing ICS 2406 Computer Systems Project*

BSc Computer Science Curriculum from the KU

Year	Semester One and Two
One	UCU 100: Communication Skills SCO 100: Computer Fundamentals SCO 102: Introduction to Programming SCO 104: Computer Organization and Architecture I SCO 106: Electronics SCO 108: Discrete Mathematics SCO 110: Mathematical Foundations for Computer Science UCU 101: Development Studies UCU 103: Introduction to Critical and Creative Thinking SCO 103: Object-Oriented Programming I SCO 105: Data Communication Technologies SCO 113: Foundations of Artificial Intelligence SCO 109: Linear Algebra for Computer Science SMA 104: Calculus I
Two	SCO 200: Object-Oriented Programming II SCO 204: Data Structures and Algorithms SCO 206: Database Systems SCO 208: Object-Oriented Analysis and Design SMA 200: Calculus II SCO 212: Probability and Statistics for Computer Science SCO 201: Computer Organization and Architecture II SCO 203: Software Testing and Quality Assurance SCO 207: Web Development Technologies

	SCO 209: Microprocessor and Assembly Language Programming SCO 211: Automata Theory SCO 215: System Analysis and Design SCO 217: Operating Systems SIT 205: Entrepreneurship and Business Planning
Three	SCO 300: Computer Networks SCO 302: Software Project Management SCO 304: Advanced Database Systems SCO 306: Programming Languages SCO 308: Design and Analysis of Algorithms SCO 310: Component Programming SMA 330: Numerical Analysis I SCO 301: Compiler Construction SCO 303: Simulation and Modelling SCO 305: Computer Graphics SCO 307: Human-Computer Interface SCO 309: Research Methods and Technical Writing SCO 311: Electronic Commerce SCO 312: Industrial Attachment
Four	SCO 400: Project (2 units) SCO 402: Legal and Ethical Issues in Computing SCO 404: Entrepreneurship SCO 406: Computer Systems Security SCO 408: Information Systems Management SCO 410: Distributed Systems SCO 412: Mobile Computing and Wireless Technology ECU 400: Research Methodology **Electives** **(To select 4 units)** Net-Centric Computing SCO 401: Network Management SCO 403: Networked Applications SCO 405: Compression SCO 407: Multimedia Technologies Intelligent Systems SCO 409: Natural Language Processing

	SCO 411: Neural Networks SCO 413: Robotics SCO 415: Data Warehouse and Data Mining Information Systems SCO 417: Geographic Information Systems (GIS) SCO 419: Enterprise Resource Planning (ERP) Systems SCO 421: Decision Support Systems SCO 423: Information System Auditing

BSc Mathematics and Computer Science from KeMU

Year	Semester One and Two
One	COMP 101 Introduction to Computer Science COMP 110 Introduction to Programming MATH 102 Foundations of Mathematics MATH 103 Calculus I SOST 131 Introduction to Sociology THEO 111 Christian Beliefs COMM 111 Communication Skills COMP 104 Analogue Electronics COMP 111 Structured Programming 3 MATH 104 Calculus II MATH 110 Linear Algebra I MATH 132 Probability and Statistics I
Two	COMP 131 Introduction to Computer Networks COMP 211 Object-OrientedObject-Oriented Programming COMP 231 Telecommunication Networks MATH 200 Calculus III MATH 210 Linear Algebra II MATH 230 Probability and Statistics II COMP 201 Computer Organization and Architecture COMP 210 Data Structures 3 COMP 220 System Analysis and Design HSCI 225 HIV/AIDS MATH 211 Discrete Structures MATH 220 Ordinary Differential Equations I

Three	COMP 300 Operating Systems COMP 302 Digital Electronics COMP 340 Database Management System ENVI 201 Environmental Science MATH 221 Vector Analysis MATH 310 Real Analysis I BUSS 114 Fundamentals of Entrepreneurship COMP 303 Computer Hardware and Maintenance COMP 304 Research Methodology MATH 320 Numerical Analysis I MATH 331 Operation Research I PHYS 310 Electrical Circuits
Four	COMP 400 Internship COMP 422 Automata and Formal Language MATH 410 Complex Variable Theory I MATH 412 Algebraic Structures MATH 420 Partial Differential Equations I One Course in Option COMP 401 Research Project COMP 445 Information Systems Security MATH 430 Operation Research II One Course in Option One Course in Option

BSc Computer Science Curriculum from the USIU

Year	Semester One and Two
One	MTH1110 Calculus IST 1025 Introduction to Programming APT 1030 Fundamentals of Programming Languages APT 1040 Introduction to Web Design and Applications APT 1050 Database Systems

Two	APT 2010 Systems Analysis and Design APT 2020 Computer Organization APT 2022 Introduction to Assembly Programming APT 2030 Digital Electronics APT 2040 Operating Systems IST 2045 Introduction to Computer Networks APT 2050 Computer Networks and Telecommunication APT 2055 Hardware and Software Practicum APT 2060 Data Structures & Algorithms APT 2080 Introduction to Software Engineering APT 2090 Computer Graphics MTH2215 Discrete Mathematics
Three	APT 3010 Introduction to Artificial Intelligence APT 3025 Applied Machine Learning APT 3040 Object-Oriented Design and Programming APT 3050 Introduction to Project Management APT 3060 Mobile Programming APT 3065 Mid-Term Project APT 3080 Management Information Systems APT 3090 Cryptography and Network Security APT 3095 Cloud Computing and Visualization APT 4900 Applied Computer Technology Project APT 4910 Applied Computer Technology Internship IST 3015 Business Data Analytics IST 3050 Introduction to Security Systems
Four	IST 4035 Advanced Web Design and Applications IST 4078 IT Innovation and Entrepreneurship DST 4010 Distributed Systems DST 4020 Mobile computing DST 4030 Parallel Computing DST 4040 Digital Wireless Communication and Networks DST 4050 Embedded Real-Time Systems