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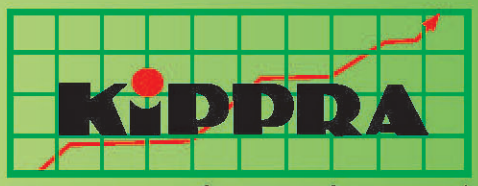


The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

# Essential Skills for the Fourth Industrial Revolution in Kenya

Morris Mbaluka and Rachel Munyifwa

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

YOUNG PROFESSIONALS (YPs) TRAINING PROGRAMME

# Essential Skills for the Fourth Industrial Revolution in Kenya

*Morris Mbaluka and Rachel Munyifwa*

*Kenya Institute for Public Policy Research and Analysis*

*KIPPRA Discussion Paper No. 327*
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Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

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This paper is produced under the KIPPRA Young Professionals (YPs) programme. The programme targets young scholars from the public and private sector, who undertake an intensive one-year course on public policy research and analysis, and during which they write a research paper on a selected public policy issue, with supervision from senior researchers at the Institute.

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## Abstract

*To succeed in the Fourth Industrial Revolution (4IR), individuals must have skills that match what industries need, covering physical, digital, and cognitive abilities because technology is rapidly changing how businesses work worldwide. Kenya has the potential to embrace 4IR fully but currently faces challenges like gaps in policies and mismatched skills that don't meet employers' needs. Technical and vocational training institutions (TVETs) and universities need more government support to offer innovative blockchain and Virtual Reality (VR) programs. These institutions often struggle due to insufficient funding and unclear guidelines from policies like the National Employment Authority Act (NEAA), which focuses more on job placements than collaborating with industries to define necessary skills. Industries should specify the skills they need across different 4IR sectors, and educational institutions can then figure out how to teach and assess these skills. The government's role is crucial in effectively providing a clear framework for implementing and evaluating these programs. The research focuses on four 4IR technologies: AI and machine learning, Internet of Things, BlockChain, Metaverse virtual and augmented reality to assess the current state of 4IR skills and needs among employers and entrepreneurs, which shows some of the hard skills: digital literacy, data analysis, programming languages, data analysis, and soft skills: creativity, communication, problem-solving, and teamwork. The results also indicate a low transition from primary and secondary education to tertiary education, implying that most learners only gain the foundation skills but fail to get the skills necessary for industries developed at the tertiary level (TVETs and universities). Coordination between skills supply and employer needs through inclusive policy frameworks can address gaps, but TVETs and universities require more robust government support for innovative programs like blockchain and VR. Current obstacles, including inadequate funding and policy misalignment, hinder institutions from meeting 4IR skill demands. The study recommends cultivating essential skills in 4IR through an increase in budgetary allocation in digital infrastructure in learning institutions to provide access to important digital tools and resources for teaching and learning Fourth Industrial Revolution (4IR) skills, bridging the digital divide. Improved collaboration of PPPs between educational institutions, industries, and government to establish policy framework and implementation will enhance the alignment of educational programs with industry needs. A clear monitoring and evaluation framework is needed to facilitate the co-development of curricula that incorporate industry trends and technological advancements, ensuring graduates possess relevant skills for 4IR jobs and are prepared effectively for the evolving job market. An increase in the scope of programs to incorporate 4IR technologies and future technologies.*

## Abbreviations and Acronyms

| | |
|---|---|
| 4IR | Fourth Industrial Revolution |
| AI | Artificial Intelligence |
| AR | Augmented Reality |
| BeTA | Bottom-up Economic Transformative Agenda |
| CBET | Competency-Based Education and Training |
| CIPIT | Intellectual Property and Information Technology Law |
| CUE | Commission for University Education |
| EC | Exclusion Criteria |
| HELB | Higher Education Loan Board |
| IC | Inclusion Criteria |
| ICT | Information and Communication Technology |
| ILO | International Labour Organization |
| IoT | Internet of Things |
| IT | Information Technology |
| KeSCO | Kenya Standard Classification of Occupations |
| KICD | Kenya Institute of Curriculum Development |
| KLB | Kenya Literature Bureau |
| KNBS | Kenya Bureau of Statistics |
| KNIA | Kenya National Innovation Authority |
| KNQA | Kenya National Qualifications Authority |
| KYEOP | Kenya Youth Employment Opportunities Project. |
| MLSP | Ministry of Labour and Social Protection |
| MoE | Ministry of Education |
| MQ | Mapping questions |
| MTP | Fourth Medium Term Plan |
| NEA | National Employment Authority |
| NEAA | National Employment Authority Act |
| NSDP | National Skills Development Policy |
| OECD | Organization for Economic Cooperation and Development |
| PPP | Public-Private Partnership |
| PSC | Public Service Commission |
| QA | Quality Assessment |
| RQ | Research Question |
| SLR | Systematic Literature Review |
| TAM | Technology Acceptance Model |
| TSC | Teachers Service Commission |
| TVET | Technical and Vocational Education and Training |
| UNESCO | United Nations Educational, Scientific, and Cultural Organization |
| VR | Virtual reality |

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# 1. Introduction

Skills are the ability to perform a task through education, training, practice, and experience. Developing skills is crucial for quality work delivery and boosting economic growth. The Fourth Industrial Revolution (4IR) involves the rapid adoption of advanced technologies like Artificial Intelligence and Machine Learning (streaming service algorithms), the Internet of Things (smart appliances), blockchain (cryptocurrency), Metaverse virtual and augmented reality (3D), impacting various sectors through expected and unexpected changes, in an article titled "Fourth Industrial Revolution: what it means, how to respond" (2016) by Klaus Schwab, World Economic Forum, it is discussed.

The world is amid the 4IR, blending physical, digital, and biological technologies. Skills needed for this era include digital literacy, data management, coding, cybersecurity awareness, critical thinking, collaboration, communication, environmental awareness, creativity, innovation, and ongoing learning. Kenya's constitution emphasises the importance of practical education and training, ensuring the Country remains proactive and competitive. Practical education and training would help prepare everyone for job opportunities in various industries.

During the Country's pre-colonial period, skills development relied on indigenous knowledge and traditional practices passed down through generations within communities through informal education and community-based learning, with children learning practical skills and valuable insights into cultural heritage and sustainability practices from family members and elders (Wolff, 1970). This rich heritage continues to influence contemporary education and skills development approaches in Kenya today.

During British colonial rule from the 1870s, the curriculum emphasised basic math and language skills to support colonial administration, with limited technical and vocational education aimed at low-skilled jobs to serve economic interests like resource extraction. Cullen (2022) states that in the 1950s, leaders recognised the importance of vocational skills for economic growth, establishing training centres for agriculture, manufacturing, and construction to support independence and nation-building aspirations. This laid the foundation for skills development to become central to the Country's post-independence development agenda.

Developing skills for the Fourth Industrial Revolution (4IR) is crucial to keep pace with rapid technological advancements. These skills are categorised into physical, digital, and biological areas, further divided into functional, self-management, and specialised knowledge domains. Key skills for 4IR include digital literacy, coding, data analysis, cybersecurity, AI and machine learning, e-commerce, digital marketing, entrepreneurship, creativity, communication, problem-solving, and teamwork (World Economic Forum, 2020).

While humans have been actively inventing and developing various skills and technologies, the nature of work and the skills demanded by employers have reshaped over time. According to the 2020 World Economic Forum report, there is a significant skills gap suggesting that the speed at which technology develops is faster than what is being taught in current education systems and training

programs worldwide. Bughin et al. (2018) point out that minimum opportunities for lifelong learning and upskilling exacerbate this disconnect even more. Addressing the pressing issue of workforce readiness in response to changing job demands driven by the 4IR is crucial.

Despite the potential for growth and innovation, a significant skills gap threatens workforce preparedness. This gap is exacerbated by the rapid development of technologies like big data analytics, artificial intelligence, machine learning, the Internet of Things (IoT), blockchain, metaverse virtual reality, and augmented reality, which are advanced digital literacy and technical expertise. The minimal opportunities for lifelong learning and upskilling further widen this disconnect, risking a rise in unemployment due to obsolete job skills. Urgent action is needed to bridge this gap and ensure the workforce is equipped with the essential skills demanded by the 4IR. In 2023, Kenya's unemployment rate was 5.50%, according to the Kenya National Bureau of Statistics (KNBS). The Federation of Kenya Employers (FKE) states that the youth unemployment rate is 12.7%. The integrative nature of 4IR technologies necessitates a workforce skilled in technical and soft skills, as Schwab (2017) highlighted. Ignoring these skills gaps could have several negative consequences that could result in a significant amount of the workforce becoming obsolete due to the changing job requirements, which may cause a sharp increase in unemployment (Manyika et al., 2017).

Essential Skills for the Fourth Industrial Revolution (4IR) in the Country are vital due to the urgent necessity of preparing the Country's workforce for the significant changes and opportunities presented by the 4IR. The Country aims to establish itself as a critical player in the global digital economy; however, it faces notable challenges such as rapid technological advancements, increased automation, the growing digitalisation of industries, minimal collaboration of PPPs, gaps in policy frameworks, slow integration of 4IR technologies in education and training programs, limited promotion of lifelong learning opportunities, minimal digital infrastructure and a weak link between educational institutions and the job market, and other challenges like political and economic instability.

The skills demanded by the 4IR, including digital literacy, critical thinking, problem-solving, and adaptability, are becoming increasingly essential for individuals to excel in the evolving job market. Research on fundamental skills for the 4IR provides valuable insights into the specific skill sets required to meet the demands of emerging industries and technology-driven workplaces. This research is pivotal for guiding policy decisions, shaping educational reforms, and devising workforce development strategies to equip Kenyan workers with the necessary competencies to thrive in the digital era and contribute to the Country's socio-economic progress.

This study aims to assess the current state of skills development in Kenya and examine the skills needs among employers and entrepreneurs in the context of the Fourth Industrial Revolution (4IR). This study identifies the institutions and policies formulated to support skills development in 4IR and the future workforce trends.

Vision 2030 aims to enhance the skills of technically proficient individuals for better deployment of human capital across sectors and government. This involves identifying talent early in education to support career growth (Kenya Vision 2030, n.d.). The Bottom-up Economic Transformative Agenda (BeTA) emphasises developing a skilled and responsive public workforce by defining roles for civil servants and service providers (Manifesto – delivery.go.ke, n.d.). BeTA also prioritises skills development, including through initiatives like the Hustler Fund, to boost capabilities in critical sectors like manufacturing, focusing on improving skills for producing leather goods.

The Fourth Medium Term Plan (MTP IV), which is the development roadmap for the Country from 2023 to 2027, emphasises the importance of developing a skilled labour force to drive economic growth and generate long-term job opportunities (The National Treasury and Economic Planning, 2024). MTP IV places a high priority on bridging gaps between training facilities and the corporate sector while acknowledging the vital connection between industry demands and educational readiness. With this cooperative approach, training programs will be continuously updated to give graduates the most recent skills and knowledge that are directly relevant to the demands of the labour market (The National Treasury and Economic Planning, 2024).

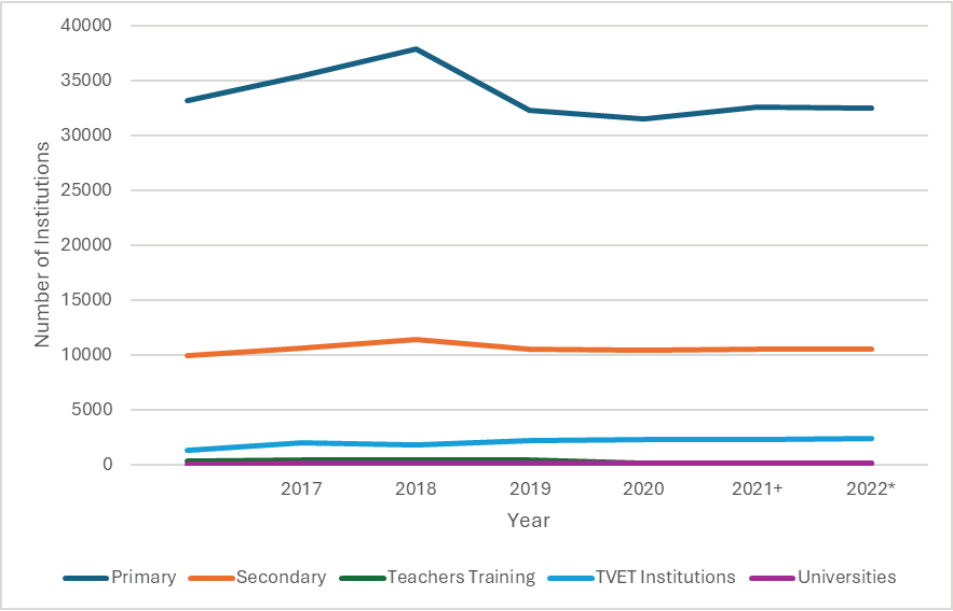
MTP IV also describes programs that are specially designed to empower young people. One of the most important initiatives to close the skills and qualification gap between youth and the workforce is the Kenya Youth Employment Opportunities Project (KYEOP). The plan also emphasises growing the national internship program with a nationwide expansion of skill development initiatives. Through internships, these two-combined strategies seek to give youths real-world work experience while also supporting the Country's infrastructure for skills development to meet the nation's expanding need for qualified labour. The County's economic potential may be unlocked by this emphasis on skill development, enabling its people to make significant contributions to the Country's ongoing development.

Basic skills are learned early in the formal education system, which is where skill development starts. Early childhood education centres and nursery schools are often the first places where basic skill development begins. These environments emphasise fundamental abilities like numeracy, motor skills, social interaction, and reading. Primary education is the first step in formal schooling, usually beginning between the ages of 6 and 10. Primary education places a strong emphasis on foundational subjects like math, science, social studies, and language (English and Swahili) (Kenya National Qualifications Authority).

The foundation established in primary school is reinforced in secondary education, which also provides a more varied curriculum. Depending on their interests and desired careers, students may choose to specialise in particular subjects. After completing their high school education, people can choose to attend TVET, colleges, or universities for their post-secondary education. These levels provide specialised teaching and training geared toward industrial sectors and occupations. Opportunities to acquire advanced skills relevant to the workforce,

such as technical skills, professional credentials, and academic degrees, are offered by tertiary education.

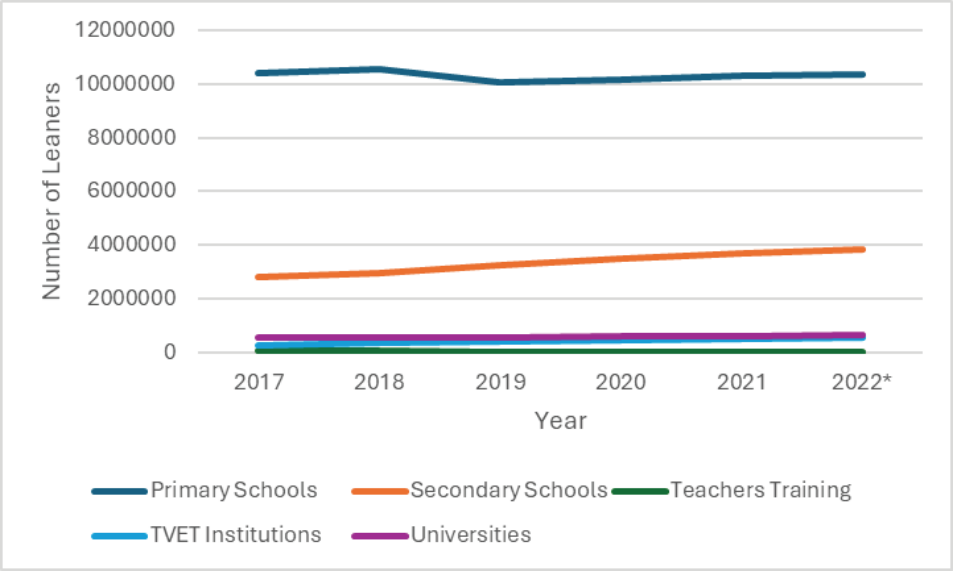
**Figure 1.1: Educational Institutions by Category/Type**




*Source: KNBS (2023)*

Figure 1 shows the trend of the number of educational institutions in Kenya from 2016 to 2022. There has been upward growth in the number of primary school institutions over the years, with a slight decline between 2018 and 2019. The same upward trend is noted with secondary education institutions. The number of teacher training institutions has significantly reduced since 2020, while there is a steady increase in TVET institutions. The number of universities has also been increasing but at a very low rate. Generally, secondary and primary institutions offer fundamental skills to learners, and they are the majority. The institutions offering skills required in industries like teacher training, TVETs and universities are the least. However, the growth in the number of TVET institutions is especially noteworthy when it comes to the acquisition of skills specific to the industry.

**Figure 1.2: Enrollment in Educational Institutions**




*Source: KNBS (2023)*

Figure 2 shows the student enrolment in various educational institutions in Kenya. The majority of the learners are enrolled in primary and secondary institutions where they can gain foundational skills and advanced academic knowledge. On the other hand, the minority are enrolled in teacher training, TVETs, and university institutions where they gain skills needed in the industries. The graph precisely depicts that although many learners are enrolled and gain foundational skills, the transition to tertiary institutions is low; hence, only a few of the learners can gain the skills that are needed within the industries.

## 2. Educational Institutions in Kenya

The field of skills development is broad and varied, with many different educational establishments and initiatives that provide individuals with the skills they need to be competitive in today's labour market. The Country has a strong infrastructure devoted to offering its citizens opportunities for education and training, comprising 72 universities and 2,430 Technical and Vocational Education and Training (TVET) institutions (CUE and TVETA).

In addition, the approval of 5,551 programs and the registration of many universities and other institutions that offer degree programs demonstrate the variety and depth of educational options that Kenyan students have access to (KNBS, 2023). This indicates the government's dedication to supporting post-secondary education and creating an atmosphere that encourages academic achievement and creativity. The acceptance of a broad range of programs in a variety of disciplines reflects the changing demands of the labour market as well as the goal of giving graduates the knowledge and skills needed to take on today's challenges and make a significant contribution to society. The development and enhancement of technical and vocational education and training (TVET) facilities is a major priority because these institutions are essential in supplying the kind of practical skills that employers need. The TVET sector has experienced significant reforms, according to the Kenya National Qualifications Authority (KNQA), with the goal of improving its quality and relevance to industry needs (KNQA, 2020). Organisations that provide specialised training programs to give teachers the skills they need to deliver high-quality technical education, like the Kenya Technical Trainers College (KTTC), are crucial to this effort (KTTC, 2021).

Initiatives are underway to enhance cooperation between TVET establishments and industry participants to guarantee that training curricula correspond with the competencies required by the labour market. As stated in the Sessional Paper NO. 14 of 2012, the creation of industry-specific Centers of Excellence intends to close the knowledge gap between industry and education by offering specialised training in important industries like ICT, manufacturing, and agriculture. Furthermore, programs like the German Dual Training System, which is run in collaboration with the German government and business leaders, provide apprenticeships that combine theoretical instruction with real-world work experience, improving graduates' employability (Delegation of German Industry and Commerce for Eastern Africa).

In addition, the Country's higher education system is undergoing changes to improve the quality and applicability of university education. Ensuring adherence to quality standards and encouraging innovation in higher education delivery are the responsibilities of organisations like the Commission for University Education (CUE) (CUE, 2014). The Ministry of Education is promoting the use of Competency-Based Education and Training (CBET) approaches, which are designed to give graduates employable skills and competencies that meet industry demands (Ministry of Education, 2019). Furthermore, to increase students' exposure to real-world challenges and promote innovation, university-industry partnerships are encouraged through internship programs and research collaborations.

Despite the efforts that show that the Country's education system is improving, issues with relevance, quality, and accessibility still exist. Inequalities in access to chances for education and training continue to be a concern, especially for people living with disabilities and those living in rural areas (United Nations Development Programme, 2020). Furthermore, improving the employability and productivity of graduates depends on programs being of high quality and relevant to industry and market demands.

However, the country has made several efforts to equip its citizens with the skills necessary to thrive in the fourth industrial revolution. A minimum of 12 universities offer academic programs aligned to Data science and analytics: UoN, KCA, Strathmore University, JUAT, MKU, USIU, Meru University, Kirinyaga University, Kabarak University, Open University of Kenya, and The Cooperative University of Kenya. Zetech University also offers a diploma program in artificial intelligence and cloud technologies, which greatly contributes to the AI industry. Kenya has also made a step in the efforts to acquire the skills necessary in virtual reality by the creation of the Siemens Mechatronics Certification Centre in Africa, which is based in - Dedan Kimathi University of Technology (DeKUT), Nyeri. The university has undertaken several virtual reality projects, including Analytical Process Control, Compressed Air Energy Process Control System, VR-ROS and Policy for VR Multi-Lab.

Embu university and KCA university usually offer certification in Blockchain technology, depicting another effort to equip employees with 4IR skills. Also, Strathmore university has the Internet of Things and Wireless Networks, which focuses on developments in the emerging IoT, wireless networks and Big Data space. It focuses on training such as Certificate in Cisco IoT Fundamentals, Internet of Things and 3D Printing, Embedded Systems, IoT Security Fundamentals, and Low Power Wide Area Networks (LoRa, Sigfox, NarrowBand-IoT and Weightless) among others.

# 3. Literature Review

## 3.1 Theoretical Framework

### The Human Capital Theory

The human capital theory covers both economic and sociological aspects, with great emphasis placed on education, training, and other forms of human investment that aid in successful performance in the workplace. This theory, which was developed by economists Becker (1962) and Rosen (1976), outlines that people can increase their economic productivity and earning potential by learning and growing in their knowledge, experience, and skills. Key principles and components of human capital theory include education and training, skills accumulation, earnings and economic outcomes, investment decisions, communication, management skills, talents, and intelligence. Human Capital Theory is a key component of understanding the competencies required for the 4IR. Within the framework of 4IR, which is marked by swift technological progress and automation, the theory emphasises the significance of ongoing education and skill development. People need to invest in their human capital by learning new technical skills, becoming more adaptive, and becoming digitally literate as industries change. In the digital era, programming skills and data analysis are the most common skills required across industries due to the low cost of internet usage. Companies offer re-skilling and upskilling programs to employees to improve their human capital.

Some of the limitations of the human capital theory that have been stated include assuming that education and training equate to increased productivity; human capital is portable since it is owned by the employee and not the employer (Gary Becker and Theodore Shultz 1960), human capital should not be considered as a factor of production because real productivity is measured through training, motivation and capital equipment (Richard Freeman 1976), turning people into capital limits issues on class conflict and efforts to empower workers' rights (Samuel Bowels and Herbert Gritis 1976), the assumption that human beings are rational (behavioural economists 1980s and 1990s).

### The Lifelong Learning Theory

The Lifelong Learning Theory is the ongoing pursuit of knowledge on a self-motivated level for personal and professional growth, which is crucial for competitiveness and employment. This theory was developed by Basil Yeaxlee in 1929 and acknowledges that for people to stay relevant in the workforce and in society, they must constantly adapt to the fast-changing nature of the world. The concept of lifetime learning extends beyond traditional schooling to include non-formal and self-directed learning. The key principles and components of Lifelong Learning Theory include Lifelong Learning as a necessity, self-directed learning, informal and non-formal learning, and lifelong learning policies. The theory of Lifelong Learning emphasises the vital importance of lifelong learning and skill development, a notion that is especially relevant considering the 4IR. People need to develop an adaptive and resilient mindset in addition to learning new

skills as the 4IR brings about rapid technological advancements and automation. Accepting lifelong learning becomes essential because it enables people to stay up to date with changing technologies, improve their digital literacy, and gain the skills they need to function in the digital age.

Lifelong learning is achieved through traditional -to-face learning, online distance learning, and self-managed learning. The rapid development of ICT has made digital learning grow exponentially, making learning cost-effective, borderless, flexible, and learner-experience-oriented. Lifelong learning is incorporated among adults who are catching up with existing and new technology. In the 4IR era, digital literacy is one of the major skills required to adapt to the change in technology in how we study, work and live. Some of the challenges associated with long-distance learning include digital literacy, the use of the English language in learning, negative attitudes, low participation caused by low connectivity, lack of training resources, lack of structure policy and funding and assessment and recognition issues.

### Technology Acceptance Model

The Technology Acceptance Model (TAM) is described as how users perceive the usefulness and ease of use of a technology. Fred Davis first suggested it in 1986, and Venkatesh and Davis expanded on it in 2000. The goal of TAM is to forecast and explain how individuals or organisations will accept and utilise new information systems or technologies. According to the model, perceived utility and ease of use are the main variables influencing the uptake of new technologies. Ma, Qingxiong and Liu, Liping. (2005). The Technology Acceptance Model. In relation to the skills required to navigate a technologically driven landscape in the context of the 4IR, TAM is highly relevant.

Knowing how people accept and adopt new technologies is essential in the 4IR era when rapid technological advancements are drastically changing industries. The model's focus on perceived usefulness and ease of use is in line with the requirement that people become digitally literate and adjust to new technologies. TAM will continue to be accepted based on the nature of each new technology. One major challenge of TAM is that it is not robust enough to explain the user's behaviour regarding accepting or rejecting a technology; another challenge is the simplicity of the model since it does not explain how to measure a user's perception of ease of usefulness.

## 3.2 Empirical Literature

The Future of Jobs Report (2018) by the World Economic Forum indicates that most industries will see a shift in the skill sets needed for both new and old jobs, which will also affect where and how people work within the 4IR. The report points out that robotics, artificial intelligence, and data analysis technical skills are predicted to be in high demand. Furthermore, soft skills like emotional intelligence, creativity, and complex problem-solving would also become more and

more crucial. Additionally, the report emphasises how important lifelong learning and re-skilling are. It implies that to adjust to the shifting nature of the labour market, people, companies, and governments must make ongoing investments in education and training.

The UNESCO (2019) report titled "I'd Blush if I Could: Closing Gender Divides in Digital Skills Through Education" draws attention to the ongoing gender digital divide, which places obstacles in the way of women and girls using and benefiting from digital skills and technologies. This gap has the potential to worsen gender inequality. The report places a strong emphasis on education's role in bridging the gender gap in digital skills, particularly in inclusive and high-quality education. It demands that educational establishments give women and men equal chances to acquire digital literacy.

Njuguna and Signé (2020), in the article "The Fourth Industrial Revolution and Digitisation Will Transform Africa into a Global Powerhouse," demonstrate that having digital skills is essential in the 4IR. People who are proficient in digital skills such as coding, data analysis, and digital literacy are likely to be in high demand as Africa embraces digital technology. The article further emphasises the importance of the youth population in Africa. Innovation, creativity, and problem-solving abilities are essential for maximising this group's potential to propel technological progress and entrepreneurial endeavours. According to the report on the state of AI in Africa (2018) by the Centre for Intellectual Property and Information Technology Law (CIPIT), Artificial Intelligence has great potential to impact African economies in various sectors if robust policies are put in place and collaboration between governments, private sectors, and startups are observed. The adoption of AI in Africa should be strategic based on the needs of each Country, but most African countries face challenges of limited infrastructure, knowledge, data, and human resources, which are necessary for the adoption of AI technologies. The Country is currently utilising AI through technology by applying precision agriculture (Strathmore University, 2023). The article emphasises the importance of establishing policy frameworks that are relevant to deploying AI and the integration of an efficient ecosystem established by policymakers, research institutions, startups, businesses, and government agencies.

The Internet of Things (IoT) refers to the network of interconnected physical devices with sensors, software, actuators, and connectivity, which enables them to collect and exchange data over the internet. IoT technology enables the integration of the physical world with the digital realm, facilitating real-time monitoring, control, and optimisation of processes, and the overarching goal of IoT is to enhance efficiency, productivity, and convenience while enabling innovative applications and services that can improve quality of life and drive economic growth (Khupe and Turpin, 2023). The issues of unemployment have been persistent, but with the advancement of IoT, youths can associate themselves with the right industries to thrive in employment and create employment. Governments also play a crucial role in catalysing youth employment in IoT (Khupe and Turpin, 2023).

The article "The increasingly significant role of blockchain technology in Africa" by Web3Africa (2023) explains that Sub-Saharan countries have adopted

blockchain and cryptocurrencies to solve the issue of centralisation to access payments. Blockchain is like a digital ledger or record book that stores information securely across a network of computers. Each piece of information, or "block," is connected to the one before it, forming a chain. Once recorded, the information cannot be changed, making it very secure. It's commonly used for keeping track of transactions, verifying identities, and managing supply chains without needing a central authority. Blockchain technology has eliminated the borders of countries and regions within Africa. Kenya is determined to improve its healthcare system through the application of blockchain by having a data management hub. The National Safety and Transport Authority has incorporated blockchain by collecting data on vehicles and insurance to alert relevant government agencies to necessary information.

Virtual reality (VR) is experiencing the reality of a computer- generated simulation of a 3-dimensional image or environment using special equipment. Education and training institutions are adapting to VR training to improve student learning through hands-on learning experiences. VR has made education more accessible due to its affordability and has improved learning through personalised learning, collaborative learning, experiential learning, and skills development. For VR to succeed, it is paramount to put in place the required infrastructure, equipment, internet connectivity and access, maintenance, and support. Virtual reality: could it be the next big tool for education? (World Economic Forum, 2020).

## 3.3 The Futures of Work

The Futures of Works is defined by technological developments and societal shifts that would drive a dynamic shift in labour dynamics and employment patterns. AI and automation are changing the nature of work and putting a premium on adaptability and digital skills. Flexible scheduling and remote work have become essential, giving workers more freedom of time, location and working hours (OECD, 2019). The gig economy is growing, which promotes opportunities for freelance work and entrepreneurship. Some of the skills required for 4IR include programming languages, big data, cloud computing, AI, 3D engineering, design skills, problem-solving, analytical skills, blockchain architecture, cryptography, and data structures (OECD, 2019). As skills develop, it is essential to never stop learning, and workplace cultures are becoming more and more focused on diversity and well-being. Global cooperation and sustainability practices are growing, and government regulations and human-machine interaction are crucial in forming this new environment. The future of work requires adapting to change, learning new skills, and building resilience in a workplace that is changing quickly.

# 4. Methodology

## 4.1 Introduction

This chapter precisely outlines the research methodology which was used to explore essential skills for the Fourth Industrial Revolution (4IR) in Kenya. It is made to effectively address the research objectives by incorporating a relevant methodological approach.

## 4.2 Research Design

The research opted for a qualitative research design to provide a comprehensive analysis of the current state of skills development in Kenya and assess the skills needed by employers and entrepreneurs in the 4IR. Specifically, the research used a Systematic Literature Review (SLR) and Mapping Approach. The process involves identifying, categorising, analysing, evaluating, and interpreting all research relevant to skills development in the 4IR.

## 4.3 Review and Mapping Planning

The planning stage included the development of a review protocol that helped identify the specific research. The research objectives were classified as mapping questions (MQ) and systematic literature review questions (RQ). The mapping questions were necessary in the first stages of brainstorming the literature and the scope of studies to incorporate. The questions used in the systematic mapping were.

(i) What articles/reports discuss the current state of skills development in Kenya and skills needed by employers and entrepreneurs in 4IR?

(ii) What articles/reports discuss the most complete process of learning skills necessary in 4IR?

The systematic Literature Review Research Questions were;

RQ1: What is the current state of skills development in Kenya?

RQ2: What types of skills are required by employers and entrepreneurs in the 4IR?

The Conducting stage involved the identification of research, selection of primary articles/reports, assessment of articles/reports quality, extraction and monitoring of data and data synthesis.

### 4.4.1 Research identification

At this phase, the search and selection of all relevant previous research was carried out. The search was done from trusted electronic sources.

The search was carried out in 3 ways;

(i) Identification of key search terms from the research objectives.

(ii) Identification of the search terms in titles, abstracts, and relevant keywords within the articles/reports. Articles and reports considered were only those published between 2011 and 2024.

(iii) Identification of the synonyms and antonyms of the search terms to be used.

### 4.4.2 Inclusion and Exclusion Criteria

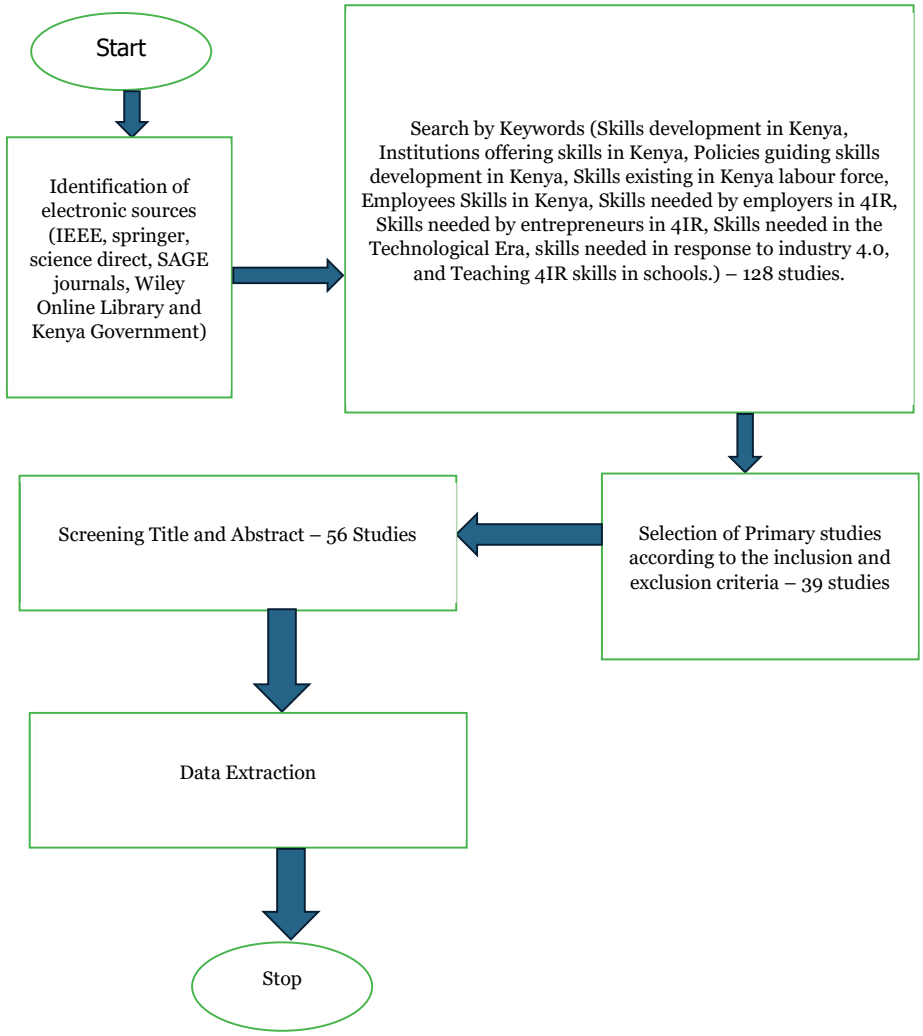
Quality assessment was aimed to provide more details about the inclusion and exclusion of the studies and reports. The exclusion and inclusion criteria were set to help guide the selection of the studies and reports. The inclusion criteria of the study were based on methodology, timeline, focus, language, and the type of study. Regarding methodology, the studies incorporated used either qualitative methodology or both qualitative and quantitative methodologies. On the type of studies, the research included peer-reviewed articles and government report publications. In the area of focus, the research selected studies that aligned with the research objectives, which are studies related to essential skills for the Fourth Industrial Revolution. Articles and reports published between 2011 and 2024 were considered for inclusion. The study excluded all studies that were not written in English and included studies published both in Kenya and internationally.

### 4.4.3 Search for Studies

Th process of searching for the studies started with the identification of online databases where IEEE, springer, science direct, SAGE journals, Wiley Online Library and Kenya Government were identified as the main online databases. The articles and reports were searched using specific keywords such as Skills development in Kenya, Institutions offering skills in Kenya, Policies guiding skills development in Kenya, Skills existing in Kenya's labour force, Employees Skills in Kenya, Skills needed by employers in 4IR, Skills needed by entrepreneurs in 4IR, Skills needed in the Technological Era, skills needed in response to industry 4.0, and Teaching 4IR skills in schools. Some of the keywords used during the search, such as "Policies guiding skills development in Kenya" and "Skills existing in Kenya labour force", were used together. The next stage was screening, which was done by reading the titles and abstracts for articles and reports selection. The last stage was the selection of the primary studies using the inclusion and exclusion criteria. This was done by reading all content in the articles that remained after the screening stage.

Figure 4.1 below gives a precise illustration of the steps involved in the identification and selection of primary studies.

**Figure 4.1: Steps of Identifying the Primary Sources**




### 4.4.4 Data extraction

The selected primary studies and reports were utilised to collect data that helped answer systematic literature review research questions. A data extraction form that consists of the title, objective, methodology, results, and recommendations was used to collect data from the primary articles and reports.

Two components were used to help in answering the review research questions.

**Table 4.1: Mapping of Data Extraction into Research Questions**

| Components | RQ |
|---|---|
| The current state of skills in Kenya's labour force | RQ1 |
| Types of 4IR skills needed by employers and entrepreneurs | RQ2 |

### 4.4.5 Quality Assessment of the Studies Selected

The following questions were used to gauge the quality of the studies chosen.

(a) Was there a clear statement on the study goals and objectives?

(b) Was the qualitative or quantitative methodology used in the study appropriate?

(c) Was the data collected for the study appropriate for addressing the research issue?

(d) Was the data correctly analysed?

(e) Does the study have a clear statement of findings?

(f) How valuable is the study in question? (in relation to skills for 4IR)

Studies that were utilised in the research were those that met at least four of the above-listed indicators for good quality and eligibility.

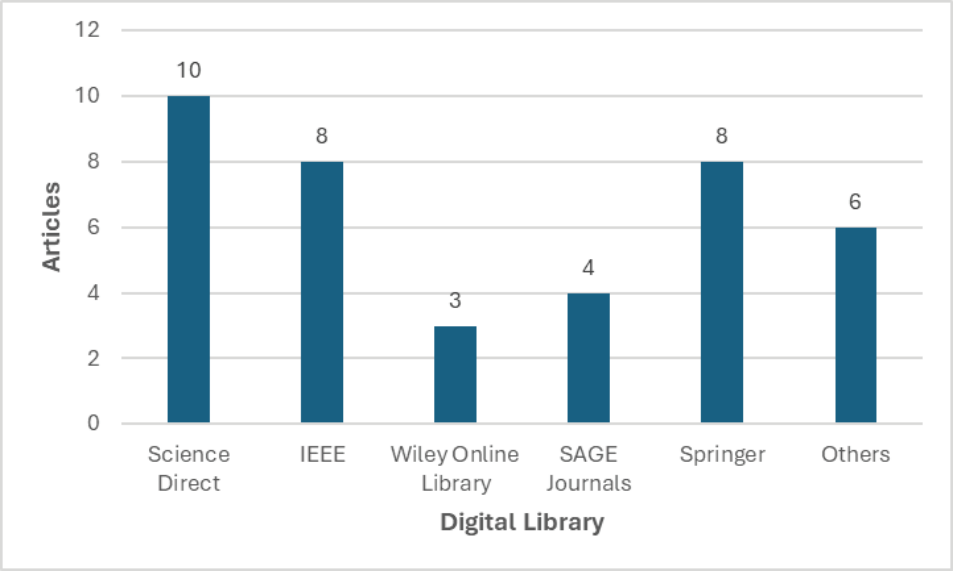
# 5. Study Results and Discussion

## 5.1 Results

In the systematic literature review, 128 articles and reports were found after the planning and conducting process. The articles were obtained from IEEE, springer, science direct, SAGE journals, Wiley Online Library and Kenya Government, among others. The articles were identified from a search using keywords and phrases. The selected articles were to be reselected using the inclusion and exclusion criteria.

Out of the significant articles found, only 39 were left after the consideration of the inclusion and exclusion criteria, which was done through exclusive reading of the entire articles that remained after the screening stage. Figure 4 below is a distribution of the selected articles and reports from the different digital libraries.

**Figure 5.1: Selected Articles and Reports from the Different Digital Libraries**



## 5.2 Current State of 4IR Skills Development in Kenya

The reports reviewed (as shown in Annex A) classified the current state of skills development in Kenya into four existing policies, as summarised below.

| Policy and Legal Framework | Gaps | Recommendations |
|---|---|---|
| The National Skills Development Policy (NSDP) 2022 | While the NSDP outlines a comprehensive strategy, implementation and funding gaps hinder its effectiveness. | Increasing budgetary allocation for all NSDP initiatives.<br>Strengthening monitoring and evaluation frameworks to track progress and identify areas for improvement.<br>Fostering greater public-private partnerships, that is, collaboration between industries and educational institutions. |
| The National Employment Authority Act (NEAA) of 2016. | The Act places less emphasis on skill development and instead concentrates mainly on employment services under the NEAA. | Expanding the Act's mandate to include a more proactive role in skills development initiatives. Encouraging the Act to collaborate with training institutions and industry to identify and address skill gaps. |
| The Ajira Digital Program 2 | The Ajira program emphasises digital skills but does not cover all the skills required per industry. | Conducting regular industry consultations to assess evolving skill requirements. Broadening the Ajira program's scope to include in-demand skills beyond just digital literacy.<br>Developing specialised training modules for specific industries. |

| | | |
|---|---|---|
| Sessional Paper No. 1 of 2019 | There is insufficient clarity regarding the precise methods necessary for skill development. | Developing a clear action plan with a definition of roles and responsibilities for stakeholders involved in implementing the Sessional Paper's recommendations. Allocating specific resources for implementing the proposed initiatives.<br>Establishing regular progress reporting mechanisms to ensure accountability. |

## 5.3 Skills Required by Employers and Entrepreneurs in the 4IR.

Different studies pointed out how different skills were essential in the 4IR, as shown in Annex A. The skills were then grouped into soft and hard skills and then classified according to the 4IR pillars.

| 4IR Pillar | Hard Skills | Soft Skills |
|---|---|---|
| AI and Machine Learning | Algorithm skills, Programming languages, data processing, model evaluation and selection, deep learning, natural language processing | Critical thinking, communication, creativity, and collaboration. |
| Internet of Things | Networking protocols, data analytics, cloud computing, programming, and data management | Critical thinking, effective communication, adaptability, and creativity |
| BlockChain | Understanding of cryptographic, programming, and scalability. | Critical thinking, communication, adaptability, and creativity |
| Meta Verse-Virtual and Augmented Reality | 3D modelling, animation, spatial computing, computer vision, and software applications | Effective communication skills, adaptability, and creativity |

### AI and Machine Learning

Several skills revolve around AI and Machine learning, including Algorithm skills, Programming languages, data processing, model evaluation and selection, deep learning, natural language processing, critical thinking, communication, creativity, and collaboration (Chaka, 2020). These skills pose a combination of both hard skills and soft skills. Hard skills, however, tend to dominate the field of AI and Machine learning, although they would need reinforcement from the soft skills (Gumbo et al., 2023). Studies such as Abe, Abe, and Adisa (2021) precisely describe the importance of understanding machine learning algorithms and programming languages like Python and R. These skills are essential for promoting competitiveness, efficiency, and innovation within industries (Di Battista et al., 2023).

First, the importance comes from their capacity to glean valuable insights from enormous volumes of data, enabling well-informed decision-making in different industries. Further, skills like machine learning algorithms help businesses find trends, patterns, and correlations in data, which improves risk assessment, strategic planning, and forecasting (Chaka, 2020). Proficiency in specialised fields like natural language processing (NLP) and computer vision, as described by Rahman et al. (2024) and deep learning architectures, as explored by Mhlanga (2020), are essential technical competencies. These hard skills give employees the groundwork they need to use AI and machine learning effectively, which allows them to mine data for insightful information and create intelligent systems that spur innovation in a variety of sectors.

In addition, soft skills are essential for the effective use of AI and ML, and they work hand in hand with hard skills. Research such as that conducted by Ayinde and Kirkwood (2020) highlights the value of critical thinking in figuring out difficult issues and coming up with original solutions. As noted by de Vries and Kroukamp (2023), collaboration and the effective communication of technical ideas to a wide range of stakeholders depend on effective communication skills. Teamwork and creativity within interdisciplinary teams play a great role as different viewpoints come together to spur creativity (Hernandez-de-Menendez et al., 2020). All these soft skills stimulate the investigation of essential approaches and applications, resulting in the creation of state-of-the-art AI solutions that tackle challenging problems in the 4IR.

### Internet of Things

The data revealed that a combination of hard and soft skills is necessary for individuals to navigate through IoT and perform better in the 4IR. Some of the technical skills identified include networking protocols, data analytics, cloud computing, programming, and data management (Islam, 2022). Critical thinking, effective communication, adaptability, and creativity were the soft skills identified (Ayinde and Kirkwood, 2020). The IoT is a transformative force in the Fourth Industrial Revolution, reshaping daily life and industries through interconnected devices and systems. The technical basis required for people to navigate and

meaningfully contribute to the IoT landscape (Chaka, 2020).

Employees seeking jobs and those willing to engage in entrepreneurship need to master hardware components, including sensors and microcontrollers, so that they can perfectly work with interconnected devices to increase outputs (Madanayake et al., 2020). Proficiency in networking protocols such as Bluetooth and Wi-Fi facilitates the smooth integration and communication of Internet of Things devices with pre-existing infrastructures. In addition, processing and analysing the massive volumes of data produced by IoT devices requires expertise in data analytics and cloud computing (Karpenko, Zasorina, and Karpenko, 2020). This allows for actionable insights and well-informed decision-making.

Apart from the hard skills, soft skills are essential for the effective adoption and deployment of IoT solutions in the 4IR. To analyse technical issues, come up with new opportunities, and have creative solutions using IoT technologies, people need to be critical thinkers (Kruger, 2022). Strong communication skills are also essential for explaining technical requirements and concepts to a wide range of stakeholders, as well as encouraging cooperation and coordination amongst multidisciplinary teams (de Vries and Kroukamp, 2023). All employees willing to utilise IoT within their working environments also need to be adaptive and creative to ensure that the technology effectively helps them to undertake their jobs with ease. As depicted by Agolla (2022), resilience helps employees understand the changing market dynamics well through the utilisation of IoT.

### BlockChain

Blockchain technology is a key component of the Fourth Industrial Revolution (4IR), providing decentralised solutions with a wide range of applications. The systematic literature review revealed that a combination of hard skills (understanding of cryptographic, programming, and scalability) and soft skills (critical thinking, communication, adaptability, and creativity) is essential to help blockchain be able to offer better solutions to most industries in the 4IR (Ayinde, and Kirkwood, 2020). The technical foundation required for people to navigate and meaningfully contribute to the blockchain ecosystem is comprised of hard skills.

According to studies like Chaka (2023), understanding cryptographic principles is essential to understanding the underlying security mechanisms of blockchain networks (Landsberg and van den Berg, 2023). Furthermore, developing decentralised applications and enterprise blockchain solutions requires expertise in blockchain platforms like Ethereum and Hyperledger Fabric. Also, programming languages like Solidity for smart contract development are essential to help navigate through blockchain (Islam and Rihan, 2023). Knowing consensus mechanisms (like proof of work and proof of stake) and blockchain scalability solutions (like sidechains and sharding) is essential for resolving the scalability issues that blockchain networks are facing in the fourth industrial revolution.

In addition to hard skills, soft skills are critical to the successful implementation and adoption of blockchain solutions in the 4IR (Ayandibu et al., 2021). Critical

thinking is necessary for people to analyse all issues in decentralised systems and come up with creative solutions within the blockchain dynamics (Adepoju and Aigbavboa, 2021). Strong communication skills are necessary to explain blockchain use cases and technical concepts to a variety of employers and employees, which promotes collaboration and alignment across multidisciplinary teams (Adepoju et al., 2022). Furthermore, resilience and adaptability help people navigate the changing blockchain environment, where new regulations and technological advancements necessitate ongoing learning and adaptation (Ajani et al., 2022). Innovation across industries is sparked by creativity, which propels the investigation of novel blockchain applications and business models.

**Meta Verse-Virtual and Augmented Reality**

The Fourth Industrial Revolution (4IR) is marked by an ideal shift brought about by the convergence of virtual and augmented reality (VR/AR) technologies, which offer immersive experiences and transformative applications in a variety of sectors. Hard skills are the technical prerequisites that people need to navigate and meaningfully contribute to the metaverse, which is a shared virtual environment (Al-Zoubi et al., 2023). Some of the hard skills that align with metaverse include 3D modelling, animation, spatial computing, computer vision, and software applications (Chaka, 2023).

In order to create immersive environments and interactive experiences, one must be proficient in VR/AR development platforms and tools like Unreal Engine and Unity3D (Borrageiro and Mennega, 2023). Having experience with 3D modelling and animation programs like Blender allows users to create virtual objects and characters that have an authentic appearance. Further, a comprehensive understanding of the spatial mapping and tracking technologies that support immersive experiences in VR/AR environments requires a strong foundation in spatial computing and computer vision (AL-GNBRİ, 2022). Creation and implementation of immersive solutions in the metaverse requires an understanding of hardware such as AR glasses and VR headsets. Additionally, the users need to know how the hardware interfaces with the software so that they can effectively thrive in the 4IRT error.

For VR/AR technologies to be successfully implemented and adopted in the 4IR, soft skills are essential (Pillay, Lawrence, and Gumbo, 2024). Effective communication skills are crucial for explaining VR/AR concepts and use cases to diverse individuals, fostering collaboration and alignment across multidisciplinary teams. Moreover, adaptability and resilience enable individuals to navigate the evolving VR/AR landscape, where emerging technologies and user preferences demand continuous adaptation and learning (Acerbi et al., 2019). Also, creativity drives the exploration of new applications and experiences for VR/AR technology, hence unlocking new possibilities for the use of these technologies in the 4IR.

### Policies vs Labour Force Demand

The issue of policy gaps and employer demands may be resolved by coordinating the supply of skills with the demands of the labour market through inclusive methods that incorporate skill development into national and sectoral policies. The capacity of TVETs and universities to provide innovative programs like blockchain and Virtual Reality depends on appropriate government support. Although a thorough plan is outlined in the National Skills Development Policy (NSDP), obstacles are caused by inadequate financing and improper implementation. Without funding, TVETs and universities may find it difficult to create innovative programs or educate staff members on the 4IR. In addition, there is a communication gap between training institutions and 4IR industries, which is well evidenced by the National Employment Authority Act (NEAA), which primarily focuses on employment services. The NEAA does not actively work with industries to determine the precise skills they require. It is challenging for TVETs and universities to modify their curricula to meet employer demands without proper guidelines from the policies.

The Ajira Digital Program, while a great initiative, provides another example of the disconnect between policy and skills demand. The full range of in-demand skills for 4IR is not covered within the program, which only focuses on digital skills. This leaves a gap in which TVETs and universities might provide specialised training for specific industries such as blockchain, AI, or VR/AR. However, they might not know exactly what must be taught because of the absence of clear guidance from the NEAA or Ajira Digital Program.

When all these policies are being revised, or new policies are being put in place, there is a need for all key stakeholders to be involved, that is, the government, 4IR industries and the learning institutions. In this case, the industries will be able to specify the skills they demand within the various 4IR pillars, and the learning institutions will be available to brainstorm how they can teach and examine such skills. The government, on the other hand, would be of significant help in providing a clear framework on how such programs can be implemented and evaluated.

# 6. Conclusion and Recommendations

## 6.1 Conclusion

The research reveals significant policy gaps in the existing frameworks that could hinder employees from acquiring the 4IR skills. The National Skills Development Policy (NSDP) 2022 lays out a comprehensive framework, yet there are significant financing and implementation gaps. Closing these gaps requires improving public-private collaborations, bolstering monitoring and evaluation mechanisms, and improving financial allocations. The National Employment Authority Act (NEAA) of 2016 needs to proactively address skills development through cooperation with training institutions and industries. Although the Ajira Digital Program is good for digital skills, it needs to expand its scope to specific training modules to cover a larger variety of industry-relevant skills. A detailed action plan with clearly defined stakeholder responsibilities, resource allocation, and strong accountability systems is also required under Sessional Paper No. 1 of 2019. In order to prepare the workforce for the Fourth Industrial Revolution, which includes AI, IoT, Blockchain, and virtual and augmented reality technologies, it is essential that these gaps be filled.

## 6.2 Policy Recommendations

1. Increase budgetary allocation for skills development initiatives. Adequate funding will imply that learning institutions can access the necessary infrastructure to aid them in comprehensive training on both hard and soft 4IR skills required by the industries.
2. Foster Public-Private Partnerships. To effectively align skills training to the market needs, it is essential that educational institutions, government, and industries work closely. Private-public partnerships will bridge the gap between practical industry requirements and academic knowledge. Such partnership would result in better curriculum development, hands-on training, and internship opportunities, hence leading to a more skilled 4IR workforce.
3. Strengthen monitoring and evaluation frameworks. To evaluate the development of skills development efforts, it is important to put in place strong frameworks for monitoring and evaluation (MandE).
4. Expanding the scope of existing programs. Programs like Ajira are essential in the 4IR error since they provide digital literacy. However, broadening such programs to incorporate training of all 4IR skills would help the workforce to meet the diverse job market demands.

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# Appendix

## Appendix A

| No. | Title | Author | Objective | Findings |
|---|---|---|---|---|
| 1 | National Skills Development Policy. | Ministry of Education (2020) | To equip people with the skills they need to get jobs and contribute to economic prosperity. | Implementation and finding gap between the workforce's capabilities and the demands of the job market. |
| 2 | National Employment Authority Act No. 3 Of 2016 | Ministry of Labour ands Social Protection | To Establish a comprehensive framework for employment management | More emphasis on employment and less emphasis on skills. |
| 3 | Sessional Paper NO. 14 of 2012 Reforming Education and Training Sectors in Kenya | KIPPRA | To reform Kenya's education and training sectors to ensure they meet the demands of a globalised world and contribute to national development goals. | The education system needed to be more responsive to the needs of the job market, with a focus on equipping graduates with relevant skills. |
| 4 | The Ajira Digital Program 2 | Ajira | Empower young Kenyans to access digital job opportunities | The program seems to be successful in equipping youth with digital skills, with a significant portion of graduates finding online work although it does not addressing all areas in 4IR |
| 5 | Skills, competencies and literacies attributed to 4IR/ Industry 4.0 | Chaka, C. (2020). | To identify what Industry 4.0 skills are from a cross-disciplinary perspective. | Communication, creativity, problem solving, programing skills. |
| 6 | Fourth industrial revolution—a review of applications, prospects, and challenges for artificial intelligence, robotics and blockchain in higher education. | Chaka, C. (2023). | To explore fourth industrial revolution's (4IR) contributions to and its impact on higher education (HE). | Critical thinking, communication, creativity, digital literacy skills. |

| | | | | |
|---|---|---|---|---|
| 7 | Skills provisioning for the fourth industrial revolution: A bibliometric analysis. | Gumbo, S., Twinomurinzi, H., Bwalya, K., and Wamba, S. F. (2023). | To examine the landscape of skills needed for the Fourth Industrial Revolution (Industry 4.0). | Industry 4.0 skills started since 2016 some essential skills identified include programming, AI and Big data. |
| 8 | Investigating the Research Landscape of Virtual Reality in Built Environment Education on the African Continent: A Bibliometric Review. In KEEP ON PLANNING FOR THE REAL WORLD. Climate Change calls for Nature-based Solutions and Smart Technologies. | Pillay, N., Lawrence, K., and Gumbo, T. (2024, April). | Investigating the Research Landscape of Virtual Reality in Built Environment Education. | Virtual reality requires sustainable design practices and development of smart technologies. |
| 9 | Future of work: Skill obsolescence, acquisition of new skills, and upskilling in the 4IR. In Future of work, work-family satisfaction, and employee well-being in the fourth industrial revolution. | Abe, E. N., Abe, I. I., and Adisa, O. (2021). | To investigate the mpact of the Fourth Industrial Revolution (4IR) on job skills. | Intricate underlying factors about the future of work have fuelled debates bothering on the issues of digitisation on work and professions, artificial intelligence (AI), and the uncertainty of work and careers left after automation. |
| 10 | Future of jobs report 2023. In World Economic Forum, Geneva, Switzerland. | Di Battista, A., Grayling, S., Hasselaar, E., Leopold, T., Li, R., Rayner, M., and Zahidi, S. (2023, May). | To analyse the impact of technological advancements and other disruptions on the job market | Technological advancements have created new job opportunities in areas like artificial intelligence, data science, and cybersecurity. |
| The report emphasises the growing importance of cognitive skills like critical thinking, problem-solving, and creativity. Additionally, soft skills like communication, collaboration, and adaptability are becoming increasingly crucial. | | | | |

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| 11 | The Impact of the Fourth Industrial Revolution and Machine Learning on Employee Skill Sets for Sustainable Survival in the Retail Industry. | Rahman, M. H., Islam, M. A., Hossain, Y., Sulaiman, R. B., Chowdhury, M. N., and Nur, A. H. (2024). | To Impact of the Fourth Industrial Revolution and Machine Learning on Employee Skill Sets for Sustainable Survival in the Retail Industry. | Automation, Data-driven decision making, e-commerce, omnichannel, communication, creativity, data analysis skills. |
| 12 | Artificial Intelligence (AI) and poverty reduction in the Fourth Industrial Revolution (4IR). | Mhlanga, D. (2020). | Leverage AI to gather better data on poverty, allowing for more targeted interventions and resource allocation. | Big data, AI, digital divide, job displacements. Therefore, the study recommends that governments, development institutions and other organisations that are striving to fight poverty to invest more in AI as well as adopting and scaling up its use as it presents benefits in the quest to ensure that poverty is reduced. |
| 13 | Rethinking the roles and skills of information professionals in the 4th Industrial Revolution. | Ayinde, L., and Kirkwood, H. (2020). | bridge the gap based on the skills needed to survive and provide possible solutions to challenges faced by information professionals. | Information professionals should adopt the missing middle model/ techniques in organisation which asserts that robots, by and large, will not be taking our jobs; instead, human Machine collaboration will reconfigure some of our work, making and make human skills more unique and important than ever. |
| Critical thinking, problem solving, communication and collaboration skills. | | | | |
| 14 | Decision-making skills in the fourth industrial revolution. | de Vries, M. S., and Kroukamp, H. (2023). | The paper argues that this is unfortunate as skills therein are severely needed to steer developments towards the Fourth Industrial Revolution. | Decision-making by individual and corporate actors is judged to be central in the 4IR. |

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| 15 | Competencies for industry 4.0. | Hernandez-de-Menendez, M., Morales-Menendez, R., Escobar, C. A., and McGovern, M. (2020). | Identify the competencies needed by workers to succeed in the age of Industry 4.0. | Industry 4.0, characterised by automation, data-driven processes, and intelligent machines. |
| Technical skills: programming, AI, Machine learning, 3D printing, robotics. Soft skills: Critical thinking, communication, creativity, adaptability, and data literacy. | | | | |
| 16 | The Impact of the Fourth Industrial Revolution and Machine Learning on Employee Skill Sets for Sustainable Survival in the Retail Industry. | Rahman, M. H., Islam, M. A., Hossain, Y., Sulaiman, R. B., Chowdhury, M. N., and Nur, A. H. (2024). | To investigate the Impact of the Fourth Industrial Revolution and Machine Learning on Employee Skill Sets for Sustainable Survival in the Retail Industry. | The Impact: Automation, Data driven decision making, and rise in e-commerce. |
| Technical Skills: Computer literacy, Data analysis skills. | | | | |
| Soft Skills: Communication, critical thinking, creativity, Adaptability. | | | | |
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| 17 | Investigating the Skills and Knowledge Requirements for IOT implementation in construction. | Madanayake, U., Seidu, R., and Young, B. (2020, August). | Identify the unique skillset and knowledge base required for integrating and utilising IoT technologies within construction projects. | Technical Skills: IOT Sensor technologies, analysis, visualisation, data acquisition, network security. |
| Soft Skills: project management, communication, problem solving skills. | | | | |
| 18 | Developing workforce skills for Industry 4.0. | Karpenko, A., Zasorina, H., and Karpenko, N. (2020, October). | Identify the skills and knowledge required for success in Industry 4.0: | Technical skills: Data analysis and visualisation, programing, Automation, Cybersecurity, cloud computing. |
| Soft Skills: critical thinking, problem solving, communication, collaboration, adaptability and creativity. | | | | |
| 19 | Reviewing Skills Needed to Leverage 4IR Technology to Remain Relevant: Insights from a Makerspace. | | | |

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| | Kruger, S. (2022). | Aims to explore the skills needed for individuals to thrive in the era of the Fourth Industrial Revolution (4IR) by examining the learning environment of a makerspace. | Technical skills: 3D printing and coding | |
| Soft Skills: problem solving, creativity, innovation, critical thinking, collaboration and communication. | | | | |
| 20 | Developing Critical Workplace Skills through Education in Africa: The Case of Industry 4.0 Revolution. Global Initiatives and Higher Education in the Fourth Industrial Revolution, 153. | Agolla, J. E. (2022). | Aims to explore and discuss substantial changes in critical skills development and education systems for I4R (Industry 4.0 Revolution) in Africa. | 4R is characterised by digital transformation, the IoT (internet of things), DA (data analytics), AI (artificial intelligence), CPS (cyber-physical space), IoS (internet of services), AM (additive manufacturing), and CC (cloud computing) respectively. I4R is to become a reality in the next decade |
| 21 | 4th Industrial Revolution skills in the current South African accountancy curricula: A systematic literature review. | Landsberg, E., and van den Berg, L. (2023). | Aims to analyse the current accountancy curricula at universities in South Africa to identify how well they prepare graduates with the skills needed for the Fourth Industrial Revolution (4IR). | Findings from the systematic literature review indicate that universities adequately address business acumen skills; however, the categories of digital-, relational and decision-making acumen were insufficiently evident within the current curricula of the top five South African universities. |
| 22 | Developing global relevant skills in the fourth industrial revolution. | Ayandibu, A. O., Kaseeram, I., Vezi-Magigaba, M. F., and Oladejo, O. M. (2021). | Carries out extensive review of literature on the 4th Industrial Revolution. | The 4th Industrial Revolution brought about 'disruptive technologies' such as artificial intelligence, robotics, blockchain, and 3D printing, which transforms social, economic, and political systems, often in unpredictable ways. |

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| 23 | Assessing knowledge and skills gap for construction 4.0 in a developing economy. | Adepoju, O. O., and Aigbavboa, C. O. (2021). | To assess knowledge and skills gap for construction 4.0 in a developing economy | The result shows a high skills gap in human machine communication, data analytics and cyber security. |
| 24 | Construction 4.0. Re-skilling Human Resources for Construction 4.0: | Adepoju, O., Aigbavboa, C., Nwulu, N., Onyia, M., and Adepoju, O. (2022). | To explain the impact of Industry 4.0 on the construction industry | Technical Skills: BIM, 3D Printing, Robotics, automation, data analytics and IoT. |
| Soft Skills: Adaptability, critical thinking, problem solving, collaboration, communication, project management skills. | | | | |
| 25 | Information Professionals of the Future and their Prospects in the Era of Fourth Industrial Revolution: The Need for Transformative Potential in Nigeria. | Ajani, Y. A., Adeyinka, T., Dunmade, A. O., and Adeniran, C. O. (2022). | This study examined information professionals of the future and their prospects in the Fourth Industrial Revolution. | The findings show that participants were fully aware of the emergence of the 4IR. They indicated the impact of the 4IR era on the future job market as driverless cars, the Internet of Things (IoT), Artificial Intelligence (AI), robot technology, metaverse, blockchain and soft skills. |
| 26 | The middle east higher education experience: implementing remote labs to improve the acquisition of skills in industry 4.0. IEEE Transactions on Learning Technologies. | Al-Zoubi, A., San Cristobal, E., Shahroury, F. R., and Castro, M. (2023). | To investigate the effectiveness of implementing remote labs in Middle Eastern higher education institutions for improving student acquisition of skills relevant to Industry 4.0. | It explores innovative assessment techniques to foster virtual collaboration, social intelligence, and communication skills among students, highlighting remarkable enhancements in performance and achievements |
| 27 | Essential Skills Needed in the Fourth Industrial Revolution (4IR): A Systematic Literature Review. | Borrageiro, K., and Mennega, N. (2023, May). | To assess what skills are needed for individuals to remain relevant in The Fourth Industrial Revolution (4IR). | Four main categories of skills are identified, educational learning approaches are described and workforce skill development programs are listed. It was found that human capital development is a prerequisite for countries' participation in the 4IR, and specifically the development of soft skills. |

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| 28 | Accounting and auditing in the metaverse world from a virtual reality perspective: A future research. | AL-GNBRİ, M. K. (2022). | The research aims to illuminate and raise questions about the future of accounting and auditing from the perspective of the most prominent technology, virtual reality technology, the Metaverse. | etaverse technologies will serve as auxiliary tools for them. Furthermore, Metaverse creates new digital assets that require accounting measurements to provide tools and disclosure methods that are accurate. In addition, the Metaverse has potential effects on planning the audit process and collecting evidence. |
| 29 | Investigating the Research Landscape of Virtual Reality in Built Environment Education on the African Continent: a Bibliometric Review. In KEEP ON PLANNING FOR THE REAL WORLD. Climate Change calls for Nature-based Solutions and Smart Technologies. Proceedings of REAL CORP 2024, 29th International Conference on Urban Development, Regional Planning and Information Society (pp. 375-387). | Pillay, N., Lawrence, K., and Gumbo, T. (2024, April). | This research uses a bibliometric review approach to analyse existing research on the use of virtual reality (VR) in education for the built environment (architecture, construction, urban planning) on the African continent. | Disruptions by technologies such as Building Information Modelling (BIM), Virtual Reality (VR), Augmented Reality (AR), 3D Printing, Artificial Intelligence (AI) in various automated derivatives and other technologies have shown a significant impact on the design and creation of the Built Environment (BE |

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| 30 | A methodology to assess the skills for an Industry 4.0 factory. In Advances in Production Management Systems. Towards Smart Production Management Systems: IFIP WG 5.7 | Acerbi, F., Assiani, S., and Taisch, M. (2019). | A methodology to assess the skills for an Industry 4.0 factory. | Job analysis, skills gap and skill mapping. |
| 31 | Understanding and measuring skill gaps in Industry 4.0—A review. | Rikala, P., Braun, G., Järvinen, M., Stahre, J., and Hämäläinen, R. (2024) | To analyse existing research on the skills required for success in Industry 4.0. | Skill gaps are an extremely nuanced phenomenon, so paying careful attention to their definition and interrelating social, environmental, and technological factors when measuring them is essential. |
| 32 | Understanding 21st century skills needed in response to Industry 4.0: Exploring scholarly insights using bibliometric analysis | Saleem, S., Dhuey, E., White, L., and Perlman, M. (2024). | To analyse existing academic literature to identify the crucial 21st century skills required for the workforce in response to the significant technological advancements of Industry 4.0. | The study found that research on 21st century skills has grown exponentially in the past two decades, however, few researchers focus primarily on this topic. The existing research is primarily dominated by psychologists, education researchers and technology researchers. |
| 33 | Skills Needs Survey Report 2023 | FKE. (2023). | To identify the skills demanded by Kenyan employers in 2023. | High demand for technical skills., Importance of soft skills, skill gap and Industry variation. |
| Technical Skills: ICT, Engineering, Big Data, and machine learning. | | | | |
| Soft Skills: Critical thinking, teamwork, problem solving and interpersonal skills. | | | | |

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| 34 | Future of Jobs Report 2023 | World Economic Forum. (2023). | To predict how job markets across various sectors and regions are expected to evolve in response to technological advancements, economic shifts, and societal changes. | The findings show technology will remain a key driver and the impact of most technologies on jobs is expected to be positive over the next five years. Projections and scenarios for the future of work over the next decade highlights potential disruptions and opportunities for individuals, businesses, and economies. |
| 35 | Skilling and re-skilling students for relevance in a 4IR economy. | Olaitan, O., and Mavuso, N. (2022, November). | To investigate the current state of skills among students and the extent to which they align with the demands of the Fourth Industrial Revolution (4IR). | Findings discuss future trends and developments in skilling and re-skilling efforts, emphasising the need for continuous adaptation to technological advancements and evolving industry demands in the 4IR economy. |
| 36 | Strategically aligning human resources skills in preparation for the fourth industrial revolution. | Mkhize, L. V. B., and Parumasur, S. B. (2022) | To explore and propose strategies for aligning human resources (HR) skills with the demands and challenges posed by the Fourth Industrial Revolution (4IR). | The findings outline the essential skills and competencies required in the 4IR era, such as digital literacy, data analytics, AI proficiency, and adaptive learning capabilities. |
| 37 | Preparing graduates with digital literacy skills toward fulfilling employability need in 4IR Era: A review | Khuraisah, M. N., Khalid, F., and Husnin, H. (2020). | To review and analyse the current state of digital literacy skills among graduates and the strategies needed to enhance their employability in the Fourth Industrial Revolution (4IR) era. | The findings shows effective strategies and educational interventions aimed at enhancing digital literacy skills among graduates, such as curriculum reforms, specialised training programs, and partnerships between academia and industry. |

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| 38 | Key skills and competencies of a new generation of LIS professionals. | Nonthacumjane, P. (2011). | To identify and discuss the essential skills and competencies required by Library and Information Science (LIS) professionals in the context of a changing information landscape and evolving technological advancement. | The article underscores the need for LIS professionals to engage in lifelong learning and professional development to adapt to evolving information technologies and user expectations. |
| 39 | Jobs and skills in Industry 4.0: an exploratory research. In Advances in Production Management Systems. | Pinzone, M., Fantini, P., Perini, S., Garavaglia, S., Taisch, M., and Miragliotta, G. (2017). | The study aims to identify the key competencies and technological advancements required by industries embracing the fourth industrial revolution. | The findings identify new job roles and skill requirements arising from Industry 4.0 technologies such as IoT, AI, robotics, and data analytics. Recommendations for policymakers and educational institutions to adapt curricula and training programs to meet the evolving needs of Industry 4.0, ensuring a future-ready workforce. |

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Kenya Institute for Public Policy Research and Analysis
Bishops Garden Towers, Bishops Road
PO Box 56445, Nairobi, Kenya
tel: +254 20 2719933/4, 2714714/5, 2721654, 2721110
fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org