General links

https://www.ucl.ac.uk/students/exams-and-assessments/assessment-success-guide/effective-revision-and-assessment-planning

### Integration of Technology with Pedagogy

The typical methods of DL used include blended learning(BL),4,5 live teaching,6 flipped classroom (flipped virtual classroom), online practice questions, video conference, teleconference and telehealth.7 BL refers to a combination of two instruction modes which are e-learning and didactic (face-to-face) teaching.4,5 Live teaching is the delivery of live teaching via online platforms and widely used as an alternative solution for classes cancellations of ‘in-person’ lectures in universities and colleges.6 Flipped or inverted classroom refers to when traditional in-class lectures and homework exercises are reversed8 with four core aspects as such pre-class preparation, in-class activities, after-class activities and assessment of student learning.

The online assessment allows the delivery of constant and real-time feedback that can be given at a time and place appropriate for both the student or the educator.

The online quiz is a method to assess the knowledge that promotes self-directed learning and may improve the effectiveness of teaching.14 The closed-answer type questions (multiple-choice questions) can assess essential knowledge and often used for online educational tool and assessment.10,15 For viva-voce or actual clinical examinations conducted over online (via skype or zoom) would enable the assessor to observe and interact from a distance location, thus may reduce costs (such as accommodation, travel and subsistence for both examiner and student) and eliminate difficulties of traditional clinical assessments (e.g. examination halls and printed paper) in medical education.10 Arguably, essays are the most effective tool to evaluate learning outcomes that indicate learner aptitude to recall, organise and integrate viewpoints in the form of written work. The essay questions can assess learning outcomes. Therefore, automated assessment for essays arguably offers a reliable scoring method that can be costly and time savings.

Meanwhile, the online tools for formative assessment in higher education include self-test quiz tools, discussion forums and e-portfolios. The critical characteristics of practical online formative assessment are the establishment of a learner and assessment centred focus through formative feedback and enhanced learner engagement with valuable learning experiences. The validity and reliability of an online formative assessment include ongoing accurate assessment activities and interactive formative feedback. (Tuah and Naing, 2021)

Artificial intelligence, Virtual Reality, and the Internet of Things, as being crucial elements of Industry 4.0 are just a few examples of the digital technologies that have converged with education resulting in “Education 4.0”. This change has a huge influence on educational practices since it opens up new opportunities for personalized learning, group collaboration, and application in real life.

The fourth industrial revolution's education 4.0 movement aims to change education in the future through automation and cutting-edge technology. It aspires to foster lifelong learning in young people and prepare them for the challenges of the twenty-first century. Free access, individualized instruction, mental evolution, and the use of digital technologies are all parts of “education 4.0”. Significant adjustments to teaching strategies and the incorporation of technology are required for the transition from traditional education (Education 1.0) to Education 4.0. Education 4.0 has been significantly shaped by technological developments such as the growth of the internet, mobile devices, artificial intelligence, and automation. The development of Education 4.0 has been facilitated by the integration of digital platforms, online learning environments, and personalized learning strategies. To comprehend and direct the implementation of Education 4.0, numerous theoretical frameworks and models have been put forth. One such concept is developed by ([Himmetoglu et al., 2020](https://journals.sagepub.com/doi/full/10.1177/20427530231221073" \l "bibr39-20427530231221073)) that cites open access, personalized education, mental development, and digital technology as key components of Education 4.0.

The design and execution of learning experiences that make use of cutting-edge technology, personalised strategies, and active learning techniques are considered innovative curricular practices in Education 4.0.

Online and lifelong learning, as well as digital personal assistants, are identified as significant elements of new curricular practices in Education 4.0. Innovative techniques within Education 4.0 include the utilisation of active learning methodologies, project-based learning, blended learning, flipped classrooms, and gamification. Curriculum innovations can incorporate multidisciplinary methods, real-world problem-solving, and the use of technology, in addition to what should be taught to students.

Education 4.0,” promotes the use of technology, digital tools, and creative methods to improve learning experiences. The design and delivery of educational experiences that make use of technology, active learning strategies, and student-centered methods in order to promote engagement, critical thinking, and problem-solving abilities are known as innovative curricular practices. The innovative curriculum practices in Education 4.0 make use of digital technology to build engaging, real learning experiences that help students gain vital abilities like imagination, problem-solving, and digital citizenship. (Sharma et al., 2023)

The world is now going through a technological revolution, often referred to as the Fourth Industrial Revolution, Industry 4.0, or Industrial Internet, that will radically change the way of living, working, and communicating. The transformation is already taking place in all aspects of business. (Shaturaev, 2023)

The 20th century witnessed an explosion in the digital information and communications technologies (ICTs), leading to the concept of the ‘information society’.

In the UK, the Council for Educational Technology (CET) had been established in 1967, defining educational technology as the development, application and evaluation of systems, techniques and aids to improve the process of human learning. Shortly thereafter, in 1969–70 the US Association of Educational Communications and Technology (AECT) had transitioned from an audiovisual to an instructional technology orientation and was concerned with “the theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning”.

During the lifetime of Computers & Education, technology has changed the world. Computing has progressed from the mainframe era to the microcomputer era to the Internet era, and as the U.S. [Office of Educational Technology (2017)](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib78) states, “the conversation has shifted from whether technology should be used in learning to how it can improve learning to ensure that all students have access to high-quality educational experiences.”

[Zawacki-Richter and Naidu (2016)](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib113) conducted a content analysis of Distance Education, a journal which ranks #20 in the Thomson Reuters 2015 Citation Report “Education and Educational Research” category, with an impact factor of 2.021. By analyzing 515 research articles published between 1980 and 2014, they were able to identify the following main themes over seven 5-year time periods: professionalization and institutional consolidation (1980–1984), instructional design and educational technology (1985–1989), quality assurance in distance education (1990–1994), student support and early stages of online learning (1995–1999), the emergence of the virtual university (2000–2004), collaborative learning and online interaction patterns (2005–2009), and interactive learning, [MOOCs](https://www.sciencedirect.com/topics/social-sciences/massive-open-online-course), and [OERs](https://www.sciencedirect.com/topics/social-sciences/open-educational-resources) (2010–2014). In a recent study, [Zawacki-Richter, Alturki, and Aldraiweesh (2017)](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib112) analyzed 580 articles published between 2000 and 2015 in the International Review of Research in Open and Distributed Learning (IRRODL). They identified three broad themes emerging over this fifteen-year period: the establishment of [online learning and distance education](https://www.sciencedirect.com/topics/social-sciences/distance-education-and-online-learning) institutions (2000–2005); widening [access to education](https://www.sciencedirect.com/topics/social-sciences/access-to-education) and online learning support (2006–2010); and the emergence of Massive Open Online Courses (MOOCs) and Open Educational Resources (OER) (2011–2015)

**The paper’s research results:**

**The advancement and growth of computer-based instruction (1976–1986):** the first decade of publications in Computers & Education reflects the advancement and growth of computer-assisted learning**.** In the second half of the decade more studies were being carried out with regard to the use of language laboratories for modeling correct speech in second language learning, enabling students to practice privately and teachers to save time on routine practice**.** The adoption of CAL in schools was still in its early stages (see project – development – teachers – schools) and there was still the question of how to integrate computer literacy with the curriculum. In order to provide guidelines for curriculum planners Cheng and Stevens (1985) reported on how teachers prioritized the knowledge and skills that their students needed to become ‘computer literate’ and Shaw, Swigger, and Herndon (1985) reported on the kinds of questions that children asked while learning to use the computer. Another issue under discussion was the professional development of teachers. As Keil (1979) pointed out, “The distribution of computers in German schools has reached a point where coordination of the activities and support of the teachers is indispensable” (p. 17). Interestingly, even at this early stage, the question of privacy was being raised. Hussain (1979) questioned whether, with cheaper mass data storage equipment and computers processing data at greater speeds, there was a danger of the security of student data being violated.

### Stand-alone multimedia learning (1987–1996): However, the vast majority of computers at this time were not connected to the Internet and still relied on stand-alone software applications. As the decade progressed, educational practice and the use of computers transitioned to more student-centered approaches such as discovery, problem-based and collaborative learning in the light of advancements in educational and [cognitive psychology](https://www.sciencedirect.com/topics/social-sciences/cognitive-psychology). After evaluating a CAL project at the M.I.T. Department of Ocean Engineering Denson and Yue (1989) concluded that if it was to achieve its objectives, “the software must also have tutoring features which will guide the students in learning the material”. Right in the middle of this period, an updated meta-analysis by Kulik and Kulik (1991) again revealed that CAL was failing to prove its effectiveness with 150 out of 248 studies showing no significant positive effects on student achievement. Such comparison studies led to the famous media debate between R. E. Clark and R. B. Kozma about the influence of media on learning (see Carter, 1996, for a succinct summary of the discussion). However, despite all this debate, most of research continued to be technology-focused and driven by the innovations in ICT

### Networked computers as tools for collaborative learning (1997–2006): In the years following 1997, the Internet expanded faster than predicted and became the world's largest database of information. Search engines such as Google and Yahoo constantly developed new ways of accessing information in the ever-growing number of web pages. Internet-based publishing, discussion forums and personal pages became common. Educational software became more motivating and effective for learning with the incorporation of graphics and video. Increased computer storage capacity and use of CD-ROM and DVD drives in computers made it easier to store multi-media educational programs. SMS was being used widely. There were opportunities for people to learn and take degrees online. With the growing interest in cognitivism and constructivism, researchers now acknowledged that learning is a social exercise and that the computer is not simply a tool for disseminating information and knowledge but for communication and collaboration, something made increasingly possible by the revolutions in the technology. Jonassen, Campbell, and Davidson (1994) contended that Clark and Kozma had been debating the wrong issue, and that researchers should be focusing on the capabilities and characteristics of media for learning rather than for teaching. They argued that both teachers and learners were involved in a complex mediated learning process wherein computers, media and technologies are cognitive tools and “intellectual partners in the knowledge construction process”

**Online learning in a digital age (2007–2016):** In 2010 the iPad was launched and the rapidly growing use of smartphones, social media and wifi gave rise to a whole range of new interactive and participative mobile learning programmes. Learners quickly became acquainted with these new tools; in contrast with the early days of educational computing, many learners came to learning tasks already familiar with interfaces and well versed in using them to find information, learn, create and collaborate. Digital media had assumed a far greater importance in all aspects of life, including education, employment, economics, communication, travel, entertainment and the environment – a social process described as ‘the digital turn’. E-learning was moving into mainstream educational provision. Higher education in particular was adopting these means, both on and off campus. Many studies now investigated web-based learning and teaching platforms (e.g. [Ngai, Poon, & Chan, 2007](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib77)), the transition from traditional to online course delivery (e.g. [Barak, 2007](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib3)) and the importance of learner support, assessment and feedback in online environments. So much so that feedback connected with assessment formed a thematic region of its own. Interactive, collaborative learning was also becoming a central topic.

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| Year | Introduced Trend |
| 1960 | CAL called PLATO (Programmed Logic for Automatic Teaching Operations) |
| 1976 | Many millions of personal computers (PCs) being used worldwide. However, mainframes, minicomputers and computer learning centres were still widely in use. |
| 1982 | The ‘computer literacy’ movement was born in the UK and computer assisted learning (CAL) was being introduced into schools but with the emphasis on teaching children to program and drill and practice learning and behaviorist and cognitive approaches to instructional design. CD-ROMs, simple simulation programmes for PCs and computer-based tutorials and educational games were becoming available and there was increasing convergence of instructional design, educational media and CAL. |
| 1983 | Text-processing system “Word” by Microsoft |
| 1985 | Windows OS |
| Late 1980s | The late 1980's saw the development of laptops. |
| 1990 | In 1990 Tim Berners-Lee invented the World Wide Web and created the first webpage.­­­­­ |
| 1990s | multimedia PCs were developed, simulations, educational databases and other types of CAL programs became available on CD-ROMs, many with animation and sound. Schools were using videodiscs, object-oriented multimedia authoring tools were in use. |
| 1992 | the Internet had one million hosts, computers were nine orders of magnitude faster and network bandwidth was twenty million times greater. |
| 1993 | 1993 saw the first Smartphone, and the Netscape browser was launched. New businesses (such as Amazon or eBay), schools, and individuals were creating web pages and many educational institutions were rewiring for Internet access. There was even the first learning management system (Virtual-U), developed at Simon Fraser University in Canada. [Horney (1993)](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib37) dealt with the design of a learning environment based on hypertext |
| 1994 | Yahoo |
| 1997 | The learning management system WebCT was released in 1997 |
| 1998 | Google |
| 1999 | There were opportunities for people to learn and take degrees online. The term ‘e-learning’ was introduced and the business world was increasingly using this mode for staff training. |
| 2001 | Wikipedia was launched in 2001, |
| 2002 | the MIT OpenCourseWare proof-of-concept pilot site was opened to the public, offering 32 courses in 2002. The term open education resource (OER) was coined (see [UNESCO, 2002](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib103), [2012](https://www.sciencedirect.com/science/article/pii/S0360131518300812" \l "bib104)) and the interactive potential of social media and [Web 2.0](https://www.sciencedirect.com/topics/social-sciences/web-2-0) applications was becoming understood |
| 2002-2006 | Moodle 1.0, BlackBoard, Facebook, Google, YouTube and the Khan Academy were all launched during this time period |
| 2007 | saw the launch of the iPhone, the Web becoming mobile and the release of the e-book reader, Kindle |
| 2008 | n 2008 the first [massive open online course](https://www.sciencedirect.com/topics/social-sciences/massive-open-online-course) (MOOC) was offered |
| 2010 | In 2010 the iPad was launched and the rapidly growing use of smartphones, social media and wifi gave rise to a whole range of new interactive and participative mobile learning programmes. |
| 2011 | In 2011 Stanford University offered three free online courses to over 160,000 students around the world. There followed a whole new range of educational providers such as Udacity and Coursera and proprietary and non-proprietary MOOC platforms designed to increase access and equity, attract mass audiences and market educational wares. |
|  |  |

(Zawacki-Richter and Latchem, 2018)

The 4IR is the current and developing environment in which changing technologies and trends such as the Internet of Things (IoT) and artificial intelligence (AI) are changing the way we live and work. The 4IR presents a number of implications for skills development and education. Some of these implications include reinventing education systems and strategic approaches to increase creativity and innovation.

Stearns (2018:1) argues that “the industrial revolution was the most important single development in human history over the past three centuries.” Industrial revolution could be argued to be a major development, change, or transformation that has taken place in the history of human society; from the use of machines, telecommunications, electricity, to new developments in the form of technology. Any industrial revolution changes government policies and the way the government provides services to various communities, and influences both the social and economic aspects of society. Vries (2008:158) explains that “industrial revolution” refers to the occurence, during the transition from a pre-industrial to an industrial society, of modern economic growth; in other words, a sustained and substantial increase of gross domestic product per capita in real terms.

The world has seen three different industrial revolutions that have taken place in the course of history. Ionescu (2018:184) states that the First Industrial Revolution (1IR) had its roots in the Middle Ages and lasted to the year 1780. The 1IR saw the invention and expansion of the canal and later railway networks, which increased communication ability, and the invention of the stock exchange, which led to the rise of banks, financi-ers, and private investment (Roberts 2015:1). The 1IR was mainly based in Britain. After the transformation of the British Empire, many European countries soon followed in the revolution. The 1IR changed many societies dramatically from lower-income households to rich countries. The 1IR was so successful that it brought European countries out of the Dark Ages. The success of this revolution gave European countries supremacy over other parts of the world. The 1IR was a step in the right direction for human civilization.

The 1IR covered the period between the 18th and 19th centuries. During this period, human communities developed from agricultural activities to the use of mechanisa-tion. The steam engine was invented in the 1IR, which changed the means available for production. Communities around the world, mainly in Europe and North America, developed new ways of doing business and dealing with social issues. These changes brought new possibilities, responsibilities, and abilities. Through the 1IR, many coun-tries were able to develop, expand, increase, and diversify their economies. The 1IR was essentially the improvement of infrastructure. The 1IR across the world is cred-ited with the improvement of living standards, new skills, increased urbanisation, and many more.

The Second Industrial Revolution (2IR) was the continuation of the previous era and began in the early 19th century. The 2IR saw major technological developments in steel, chemicals, electricity, and in various other fields (Agarwal and Agarwal 2017:1063). The invention of electricity was a crucial development as it made it possible for many indus-tries to operate and expand their businesses. This technological advancement also made mineral exploration possible. The 2IR was characterised by the use of machines, which were mostly powered by electricity.

The Third Industrial Revolution (3IR) began in the mid-1900s. Roberts (2015:2) notes that the 3IR was pushed by the development of technological advancements in manufactur-ing, distribution, and energy factors. One of the biggest advancements in the 3IR era was the development of nuclear power, as well as the wide use of electronics. During the 3IR, many parts of the world began to catch up with Europe.

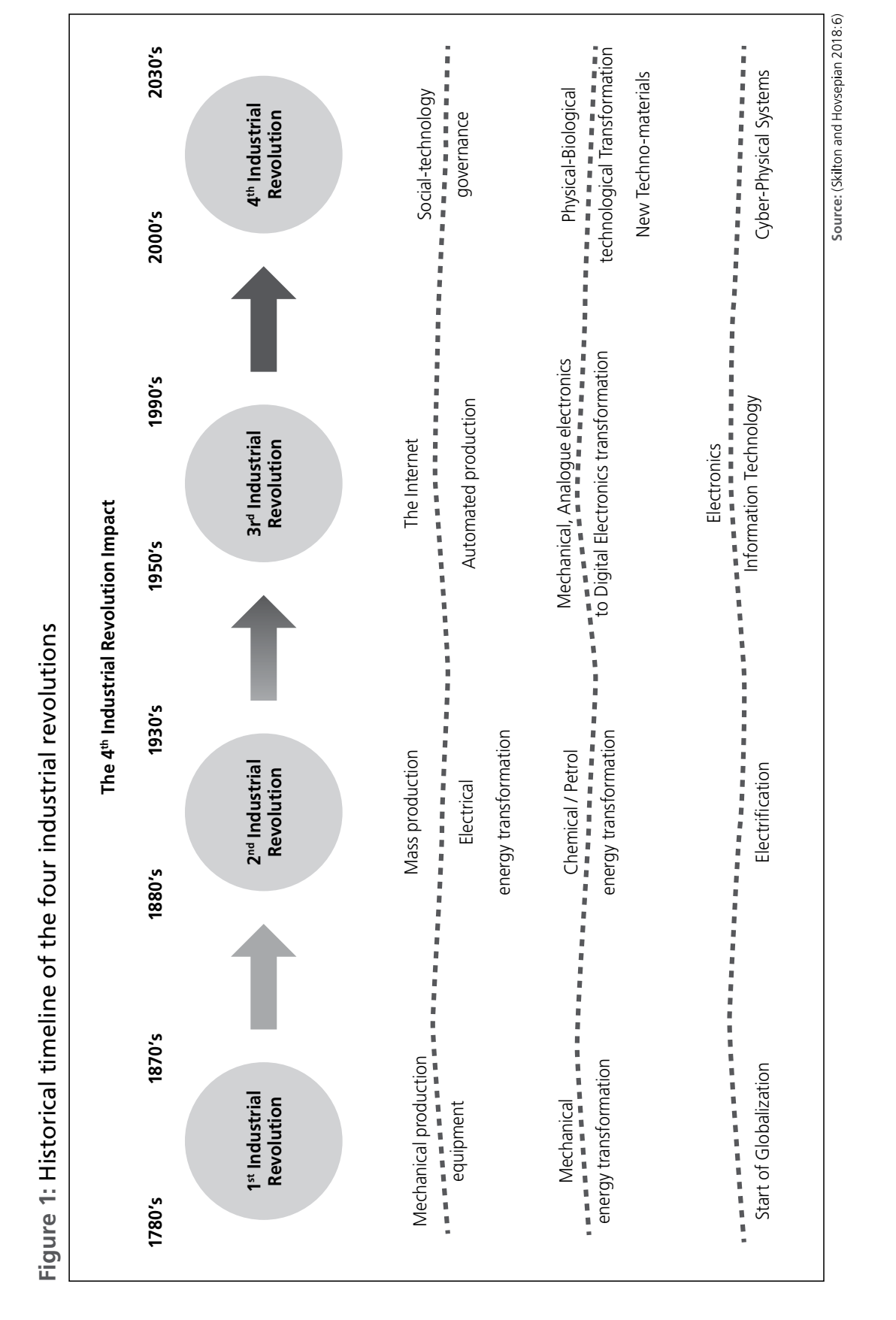
The first three industrial revolutions were characterised by technological advancements but not at the rate of current times. Recent times have seen rapid development, imple-mentation, and use of technology for various reasons. Technology has become a huge part of human beings’ life. Technology is giving societies new abilities and capacities and is changing lives. Society is therefore currently moving towards the 4IR. Miller (2015:3 in Xu, David and Kim 2018:90) explains that the 4IR entails a society whereby individuals are able to move and interact with one another between digital domains with the use of technology to assist and manage life.

Furthermore, the 4IR is about the digital revolution happening at the current mo-ment. The 4IR has ushered in new possibilities and opportunities for society. It is built up from the continuation of many successes of the previous revolutions. The 21st century has different challenges that will need new ideas to solve them. The 4IR encompasses different emerging technologies. The new revolution encompasses new ideas, new possibilities, new creations, and new inventions. This new revolu-tion is about breaking frontiers. Schwab (2016:12) points out that the new revolution is “characterized by a much more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence [AI] and machine learning.” During the turn of the century, the use of mobile devices increase d dramatically.

Schwab (2016:12) states that the 4IR includes gene sequencing, nanotechnology, re-newables, and quantum computing. The new revolution therefore goes beyond the use of smart technology, computers, and much more. It is the fusion of these technologies and their interaction across the physical, digital, and biological domains that make the 4IR fundamentally different from the previous revolutions (Schwab 2016:12). These new developments have been taking place at the same time to move the world into a new phase of growth, development, and discovery. The current revolution is taking place in all fields, sectors, and spheres of life.

The four industrial revolutions seen in the world were technology driven, and the use of various technologies assists the government and the private sector to experience growth at a quick pace. In current times, various new concepts and ideas are brought to life due to the use of technology. Ideas such as virtual worlds, smart cities, big data, Internet of Things (IoT), and AI have taken centre stage in driving development in the new era. Another similarity in these revolutions is the improvement of lives and the ease of doing business and providing services.

The 4IR is also known as Industry 4.0; however, the term “Industry 4.0” is mostly used in the business world. Hermann et al. (2016 in Erboz 2017:2) define Industry 4.0 as a collective term for technologies of value chain organisations. Industry 4.0 deals with cre-ating more digitised systems and network integration via smart systems (Erboz 2017:3). In Industry 4.0, new systems will replace existing ways of performing tasks with human labour by using machines.

Figure 1 presents a historical timeline of the four industrial revolutions. 

Erboz (2017:2) argues that the components of Industry 4.0 are categorised as the IoT, Cyber Physical Systems, Internet of Services, and Smart Factory. There are, however, many other characteristics and features of the 4IR, such as AI, three-dimensional (3D) printing, robotics, blockchain technology, cryptocurrency, quantum computing, na-notechnology, and bioengineering. According to Skilton and Hovsepian (2018:xxxiii), these technologies are changing how materials, products, and services are produced and consumed.

The 4IR is also characterised by the use of information and communications technology (ICT). ICT is widely used in business, government, and civil society organisations. The use of ICT involves computer software and hardware to perform tasks. The 4IR is viewed as the revolutionary change that takes place when ICT thrives in all industries, namely the primary, secondary, and tertiary industries (Lee et al. 2018:3). This is the case that the world has seen since the beginning of the 21st centur y.

Big data refers to large sets of complex data, both structured and unstructured, which tra-ditional processing techniques and/or algorithms are unable to operate on (Taylor-Sakyi 2016). Big data is seen as high-volume, high-velocity, and/or high-variety information assets that demand cost-effective and innovative forms of information processing that enable enhanced insight, decision making, and process automation. Big data platforms could assist organisations to analyse and make meaningful decisions based on the data available to them. As the world becomes more connected each day, large amounts of data are collected from different devices. A need to analyse these data for future use arises in order to reveal hidden information. De Mauro, Greco and Grimaldi (2015:98) state that one of the important reasons for the big data phenomenon is the current extent to which information can be generated and made available. Governments and busi-nesses depend on the amount of information generated through different technological modes for their decisions. For a government, this could be the number of people visiting a local police station or provincial hospital, or categorising a crime hotspot. In addition, the large amounts of data collected will need sufficient space for storage, hence the use of new technological inventions.

The concept of AI has existed for over 60 years. It is the ability of computers to per-form complex functions associated with human intelligence; however, AI has superior intelligence and capacity. Alsedrah (2017:3) states that AI is the field of study that describes the capability of machines to learn like humans and the ability to respond to certain behaviours. Through new computer algorithms and commands, machines are instructed to perform tasks in the same way as human beings. AI is referred to as the field of science aimed at providing machines with the capacity to perform func-tions such as logic, reasoning, planning, learning, and perception (Perez, Deligianni, Ravi and Yang 2018:2). In other words, AI is computer software with human-like characteristics. The world has seen increased use of AI in self-driving cars, Apple’s Siri, and Google. With the use of new technologies, computers are programmed to complete certain tasks by processing large amounts of data and recognising patterns in the data.

Robotics is built on the developments made in mechatronics, electrical engineering, and computing (Perez et al. 2018:24). As the environment changes, so too the use of robotics. Robotics is deeply rooted in industries such as car manufacturing plants that rely heavily on the use of machines for production. As pointed out by Karabegoviand Husak (2018:69), it is impossible today to imagine the production process in any industrial sector without industrial robots. The use of robots in different industries con-tributes to a faster production rate. Different companies resort to the use of robots to perform tasks that are seen as too complex for human beings to perform. Karabegoviand Husak (2018:69) further argue that the 4IR has contributed to the development of robotic technology because the strategies of the leading countries are to fully automate the production process, or to enable “intelligent automation.” Companies seek increased productivity, hence the need for robots with superior abilities and intelligence. This leads to new developments and technologies to create robots in order to surpass the previous generation.

In recent times, there have been developments in technology with the new concept known as IoT. Imagine a world where different electronic devices such as fridges, com-puters, television sets, mobile devices, and many more are connected to one another and to the Internet. This is possible through the concept of IoT. This connection via the Internet enables various devices to send and receive information from one another (i.e. to share data). Gartner.com (2016) defines IoT as the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment. This digital interaction between and within machines and systems forms the heart of the 4IR (Karabegovi and Husak 2018:72). In simple terms, as argued by De Saulles (2017:1), IoT has the potential to change the way humans work and live to a great extent.

According to Eisenberg (2013:7), the era of 3D printing is here. The historical patterns of growth in 3D printing are similar to those associated with the growth of home computing in the late 1970s. 3D printing is a process of making solid 3D objects from a digital file, or, as Chow-Miller (2018:9) refers to it, the process of making items using what is called additive manufacturing. This new technology has seen widespread use in various fields such as medicine, car manufacturing, and many others, for different purposes. Some of the uses of 3D printing include making aeroplane parts, and artificial organs using human cells. This technology has been in use since the 1980s; however, it has passed through different developments. Nevertheless, it is only in recent times that the technology has gained momentum. 3D printing presents a much faster and cheaper way to create objects.

According to Microsoft (2019), quantum computing takes days or hours to solve prob-lems that would take billions of years using today’s computers. It also enables new discoveries in the areas of healthcare, energy, environmental systems, smart materials, and beyond. Similarly, IBM (2019) explains that quantum computers could promote the development of new breakthroughs in science, life-saving medicine, machine learning methods to diagnose illnesses sooner, materials to make more efficient devices and structures, financial strategies to live well in retirement, and algorithms to quickly direct resources such as ambulances.

According to Marshall (2016:288), “modern societies are characterised in part by the value given to education.” In order for countries to benefit from the 4IR, a significant shift in the education sector is required to ensure participation in the digital society. However, education is susceptible to “wicked problems.” Wicked problems entail that there are multiple explanations of key elements and commonly contain mutually de-pendent problems that are interconnected (Marshall 2016:297). This article will discuss a number of key elements for consideration in education. In essence, a new strategy for the consideration of ICT in education is pivotal to overcoming some of the wicked problems presented by the 4IR.(Kayembe and Nel-Sanders, 2019)

The term, Industrial Revolution, was first introduced by Arnold Toynbee [1], a British economic historian, in the late nineteenth century. Klaus Schwab proposed the Fourth Industrial Revolution (4IR) at the World economic forum (WEF) 2016, defining it as “… a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human.” [2]. Today we are already living in the Fourth Industrial Revolution. In fact various elements related to this new revolution have been ongoing for almost a decade. This revolution in the same way as the first, the second, and the third, tells us of many crucial changes in many human activities. The 4IR forces humans to encourage creative thinking about the manufacturing processes, value chain, and customer service processes. Everything needs to be reexamined and connected. In these processes education is required to strategically prepare the coming generations for the challenges ahead.

The 4IR will transform the workplace from the existing pattern to the “human centered” characteristics. It will, due to tendency to merge man and machine, shorten the distance between natural sciences, humanities and social sciences. The same is expected to happen with science and technology. These processes will require a shift to interdisciplinary teaching, research and innovation. Education and, in particular higher education in the 4IR has a special role, being a complex, dialectical and exciting activity which promises to transform society for the better.

In relation to previous industrial revolutions, the 4th IR is affecting almost every industry worldwide by transforming systems of production, management and governance, being characterized by artificial intelligence, digital ubiquity, and cyber-physical systems. The consequences of the 4IR will be much more than, just, technology becoming part of daily life. It will change not only what we do but also who we are. In fact, there is a treat that technology's power will merge the physical world with cyber systems, which has been experienced, already, with 3D printing and some issues of artificial intelligence [3]. This will lead, for the first time in human history, machines acquiring capabilities that have been considered only possible by humans, while affecting social, economic, and cultural aspects of life, and, consequently, the labor market. These changes will redesign our lives. The speed and scope of these technological transformations have the potential for unlimited possibilities and endless opportunities.

In the near future such knowledge, certainly, is going to be forgotten and redundant. In the contemporary world, the possibility of a worker to having just one job over a lifespan, just, based on a “one in life education” has been shortened, even becoming utopia, thus questioning the existing concept of education for one profession. Already in the near future most of today's students will be practicing mostly micro jobs, while living with technologies that we have never even dreamt about. In such situation individuals should be prepared to have 10 or 12 different careers during their working lives and to have, at the same time, multiple jobs.

Many AI researchers believe that by 2040 advanced machines and computers will achieve levels of artificial intelligence that will rival human intelligence [8]. Only this fact is enough to stop thinking of higher education as a once-in-a-life event. Simply, by paying more attention to science, technology, engineering and mathematics (STEM) within existing education systems will not solve the problem. Obviously, increasing the STEM-literacy of the population is very important, but teaching these subjects as disconnected from social sciences and humanities, focusing on theory over application and experiential learning will not meet the needs of the 4IR.

The establishment of different kinds of institutional linkages, both domestically and internationally, such as to offer versatile degree programs and professional qualifications, becomes essential in 4IR. In particular this affects the mobility of students. Associated to this trend is the internationalization of higher education applied equally to the curriculum, students and staff, the most often being the twinning programs in which a local institution collaborates with a foreign allowing course credits to be taken at different locations, while the foreign education provider awards a qualification. Furthermore, often the foreign education provider awards a qualification, but, at the same time, it authorizes a local education provider to deliver their courses/programs. Double or joint degrees, where local and foreign institutions cooperate to perform a program for a qualification that is awarded jointly or from each of them, is practiced, too. The next is Blended learning where local and foreign education institutions perform programs such as e-learning, online learning or on-site learning.

Massive Open Access Courses (MOOCs), in which anyone with a computer, regardless of age, location or education background can join without direct cost.[11]. The MOOCs have been regarded as a dominant force in the transformation of pedagogy. MOOCs are becoming increasingly popular and rapidly spreading, gaining more and more popularity and being extremely vital for meeting the global job markets' needs. Such education is no longer limited to knowledge but has been extended to skills acquisition. (Scepanovič, 2019)

This leads us to Industry 4.0 which is also referred to as the Fourth Industrial Revolution in which manufacturing processes become more digitalized through use of self-learning machine, AI, automation and robot

Industrial revolutions are the backbones that support our routine and very daily life which led to significant improvements. In the history of the revolutions, there were four main and major industrial revolutions namely as Industrial Revolution 1.0 to 4.0. In addition, before the industrial revolutions happened, the period was known as Agrarian Revolution.

*Industrial Revolution 1.0*; the industrial revolution or also known as First Industrial Revolutions occurred in the years from 1760 to sometime in between 1820 and 1840 whereby the introduction of new manufacturing processes in Europe and United States. During this period, the establishment of steam power and mechanization productions were thoroughly used. With these establishment, the steam power replaced muscle power by humans and increased human productivity drastically in the industry. Basically, human labor was cut down and products that were usually handmade could finally be mass produced by machines in factories such as textiles, iron making and many others [9]. Education during the first industrial revolution, formal education reached the poorest people as it was not available during the pre-industrial society.

*Industrial Revolution 2.0;* As the second industrial revolution made its way through the 19th century with the discovery and establishment of electricity and assembly line production. The idea behind this revolution came from Henry Ford whereby he took the concept of mass production of a slaughterhouse in Chicago. He then applied the concept into his automobile production and created a huge impact in the process of automobile industry in which cars were assembled in one station to another with steps through a conveyer belt. This drastically improved the effectiveness and efficiency in car production. Overall, the concept was eventually used in most factories to cut down time and to do mass productions [10].

*Industrial Revolution 3.0;* in the 20th century, the third industrial revolution came in place that was during the period of the early 70s. Partial automation was possible with the usage of electronic devices that were programmable by computers. Human assistance was replaced by these technologies and the production process was finally able to be automated. Programmable Logic Controller (PLC) appeared [11].

*Industrial Revolution 4.0;* currently, we are considered to be experiencing in the ongoing process of the fourth industrial revolution. In short, also known as Industry 4.0, it continues on the progress and development from the third industrial revolution. This era focuses on wireless connectivity and sensors that are connected to a system which can monitors a whole line of production and does decision making on its own without human assistance therefore, smart factories. In the industry, it is also the era of Cyber Physical Systems (CPS) that comprises of smart machines, storage systems and production facilities. With the autonomous exchange of information and independent of control, these are possible with the activities of IIOT (Industrial Internet of Things) consisting of numerous sensors performing in real time and exchanging data at the same time into a local or cloud server. An example of industry 4.0’s application in the medical world is surgery made possible by doctors remotely from far away hence the term ‘smart surgeon’. Basically, doctors use a control to the robots with strong connection and bandwidth to execute a real-time surgery

In order to define or explain Education 4.0, it is imperative to first explain what is Industrial 4.0. Throughout history, mankind has gone through four industrial revolutions in which the first one occurred in the late 1700s where production was mechanized through the use of water and steam [16]. The second industrial revolution happened in the late 1800s in which mass production was facilitated by electricity. The third industrial revolution came about in 1969 where information technology and electronics served to automate production. Finally, the fourth industrial revolution, commonly known as Industry 4.0, brought upon a much more sophisticated and advanced new technology beyond those of which exist during the third industrial revolution and has blurred the lines between digital, physical and biological fields. Due to the fact these technological advancements are rapidly evolving, there have not been any official record that marked the start of Industry 4.0. Thus, the reason why these technologies are known as disruptive technologies such as the internet of things (IOTs), bio and nanotechnology, artificial intelligence, autonomous vehicles, robotics, quantum computing, 3D printing, energy storage and material science

Given how Industry 4.0 had transformed the world through its advanced technologies, it had brought upon chances to major industries, including the way how jobs and education are performed and prepared for e.g. transforming the nature of manually performed jobs by replacing it with machine-handled tasks. Thus, the education system must prepare its current students with the necessary and relevant skills and knowledge to produce a workforce that are inherently capable and competent to work in the present technologically-driven era. This had prompted a revolution in education which made the learning process more peer-to-peer, personalized and a continuous process. The learning process involve the alignment of both technology and humans which enable new opportunities and possibilities

Education 4.0 is an advanced education regarded as changes in the conventional teaching in Universities whereby teaching students on things related with technology should be included with the utilization of technology [18], [19]. Similarly, Education 4.0 focuses on the potential of digital technologies, personalized data, open sourced content and the recent state of mankind where everyone is technologically connected [17].

Education 4.0 is often connected to smart learning. Smart learning environments are based on Information Communication Technology (ICT) that are centered on learners who can use the eco-system and adopt learning styles as well as learning abilities [20]. Furthermore, smart learning environments are high levels of digital environment that are considered convenient, engaging and results in effective learning. Simply put, it is a learning environment that can be accessed at any time, in any way and with any pace.

Education 4.0 can be related with 4IR as both have similar key idea which is the utilization of technology. 4IR has resulted in the emergence of Education 4.0 due to the need of alignment between human and technology to yield new possibilities [13]. Thus this basically shows that the emergence of 4IR has brought disruptive innovation to all sorts of industries including Education whereby in order to keep up with 4IR, the need to practice Education 4.0 is crucial. This is especially important for the future generation to be successful in their life.

To have Education 4.0, first of all, technologies must be made available and can be accessed by all in order to fulfill the students’ needs. For instance, information must be more accessible and to ensure there is connectivity, the internet plays an important role. There are user-friendly modes of learning such as Learning Management Systems that is accessible for all students, as long as they have a valid authorization. For a better experience, there is a free internet for all students in many placeless which makes it easier for students to communicate. When students engage in online discussions, there is a machine-machine interaction taking place even though without the presence of each other in the real world.

The usage of smartphones can be also used as learning aids in the classroom mainly due to its convenience, portability, comprehensive learning experiences, multi-sources and multi-tasking as well as being environmentally friendly [7], [15]. LMS partnered with smartphones can give a better learning experience for all students as they can be accessed at any time and place. Therefore, the smartphones are not just for communication purposes or payment methods but also as a sophisticated learning aid.

Basically, the roadmap for Education 4.0 is not always about how sophisticated the technologies are but more to how learners such as students can utilize the technologies. However, due to the digital environments of different households, not all student-learners have the privilege to incorporate technologies. Therefore, for Education 4.0 to take place, digital technologies such as the internet of things (IoT), among others, must be accessible and complimentary to the needs of the students.

4IR is the automation and interconnectivity of everything (IoT) where everything will be digitized and run by machines and sensors in order to ensure efficiency and productivity [21]. Thus, some pools of human capital will be deemed redundant and replaced by automations. The need for retraining these human capital and equipping future generations with necessary skills are crucial. Thus, to compensate for the change in educational system, knowledge management and creation will need to be revised.

The current educational system will be replaced, parallel to the implementation of IR4.0, into a more efficient way of learning, called Education 4.0. Inevitably, Education 4.0 will change the landscape of traditional education where there will be enhancement of interactions and communication between the teachers and students by means of utilization of technological devices i.e. teleconferencing using smartphones, from all parts of the world. Moreover, the learning process would be more personalized and tailored to the needs of the learners and the teachers, that would fit to their lifestyles and orientation i.e. part-time students’ vs. full time students, but with the same or better impact on knowledge understanding in comparison to traditional learning methods.

The main pointers of Education 4.0 are able to cater to the needs of Industry 4.0, where the workforces (humans) and automations (machines) are to be integrated to open up to more possibilities, diverse utilization of digital technologies, open-sourced contents and personalized data in this ever connected and technologically driven world, creation of new learning models or blue-prints, in replacement of the traditional school-based learning methods (Mulyani et al., 2021)

The Industrial Revolutions appeared as a result of developing science, technology, and community culture; they aim to improve human life. Each revolution has its characteristics and implications. The first industrial revolution IR 1.0 started at the end of the 19th century passed through the introduction of mechanical production facilities powered by water and steam. The second one IR 2.0 which started at the beginning of the 20th century dealt with mass production assembly lines requiring labour and electrical energy. While the third industrial revolution IR 3.0 which appeared in the 70ies of the 20th century characterized by applying automated production using electronics and information technology (Dino & Ong, 2019; Gleason, 2018). Currently, humans try to accommodate the fourth industrial revolution IR 4.0 which is defined briefly as the vital interaction between human and machines.

A lot of products and technologies formed the main features of IR 4.0. Internet of Things IoT is an example is internet-connected sensor embedded in products such as vehicles and home appliances that allow these things to connect, interact and exchange data. Another example of IR 4.0 products is Cloud Computing which refers to the use of a network to host massive volumes of data collected by IoT systems on the internet rather than on your personal computer. Analysis of this Big Data leads to smarter business decisions and drive innovations (Menon & Castrillon, 2019; Neves & Ambassador, 2017). Artificial Intelligence AI is also an example of IR 4.0 products which are formed by computer science learning algorithms capable machines like robots to perform complex tasks such as visual perception, speech recognition, and decision making.

According to IR 4.0, technologies are fused and there are no solid lines between the physical, digital, and biological aspects of life. Nowadays, IR 4.0 is immersed in most active sectors such as industry, agriculture, medicine, and economics.

The educational system is not isolated from IR 4.0 technologies which are predicted to have a significant effect on learning opportunities, educational policies, and instructional procedures(Al Lily, Elayyan, Alhazmi & Alzahrani, 2018). Changing starts from schools and universities when they design a suitable program and curricula that matching with employment. World Economic Forum (2018) referred that 65% of the students in school today will work in jobs that do not currently exist and 47% of today’s jobs will be automated in the next decade. Also, until 2020 more than 50% of the content in a graduate degree will be useless in 5 years. These data excite experts and educators to research more and more to suggest methods and strategies that ensure quantitative and qualitative learning that helps the students to face the future.

The fourth Industrial Revolution IR 4.0 will accelerate the rate of disruption in jobs which we are already experiencing and it is necessary to empower individuals to take charge of their education and career strategies (Reaves, 2019). World Economic Forum reports that IR 4.0 requires reshaping the future of education and work to diversify talents (Yang, 2019). So, Organizations need to have a successful strategy and adopt new products of IR 4.0 such as big data, blockchain technology and artificial intelligence in education instead of traditional procedures (Shahroom & Hussein, 2018; Ceylan, 2020). Janikova & Kowalikova (2017) considered that the key role in the future is summarized by ensuring long-life learning and providing individuals with experiences about the dynamic market and socio-economic changes. While Sharma (2019) emphasized that when we teach our students according to IR 4.0, we must preserve our core attributes, our ethical standards, and our way of life. Also, she considered that the transformation of higher education is a key factor in the digital transformation of IR 4.0.

it is important to activate student-centered learning. To achieve that it is important to measure the students’ learning style and multiple- intelligence to transform classrooms from old-fashioned to flexible. A flexible classroom allows during a specific time to implement more than one event compatible with visual, verbal, and kinesthetic students. This paradigm helps to improve the student’s learning according to their interests and abilities which lead to too long life learning and dealing with the future’s technology easily. Another procedure that helps to prepare the students for the IR 4.0 is the transformation from knowledge skills to liquid or soft skills. Reading comprehension, writing expressions, and mathematical reasoning are not valid skills to have a job in the future. It is important to develop the students’ right-brain skills to have other types of skills such as technical skills, critical thinking, coordinating with others, verbal communications, and time management. These soft skills will be fundamentals and the basic requirements to deal with IR 4.0 technologies and ideas. Also, It is necessary, nowadays, to improve digital skills such as blogging, filming, podcasting, wiki building and uploading by preparing a virtual learning environment (VLE) as a platform to facilitate e-learning and enable the students to design and online delivery of modules

In the same context, it is important to revise our learning outcomes and curricula content. Also, how the scientific content design and deliver to the students. In the future it is not probable to still presenting content by text (written) books; Massive Open Online Courses (MOOCs) will be an active substitution in the future. MOOCs are a potentially disruptive innovation and match with IR 4.0 technologies and the global job markets’ needs. The number of MOOCs are increasing exponentially across the globe, making learning more accessible to people. Also, the number of participants has doubled in 2015 from 18 million students to 35 million students across all MOOC providers; even universities are digitizing some of their courses (Reaves, 2019).

On the other hand, using MOOCs and other educational platforms allow to adopt Student's Global Identity, which is a portable and secure card that stores individual information and can be used across countries especially in cases of conflict eruption, natural disaster, and coronavirus (covid-19) pandemic. During covid-19 which is declared as a pandemic on 11 march 2020, all countries start learning online and applying technology in education. Time by time this type of learning will be an educational culture and maybe an alternative to traditional learning. IR 4.0 technologies and products will facilitate this transition. So, in the near future, it is not unusual for robots to deliver a model lesson in science or the students solve their mathematics problems by using artificial intelligence, and probably that there’s no use of working and teaching in traditional schools and universities. (Elayyan, 2021)

LinkedIn and other [Massive Open Online Courses](https://www.sciencedirect.com/topics/social-sciences/massive-open-online-course) (MOOC) platforms are transforming the way professional information, including teaching and learning, is disseminated [[6](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0035),[7](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0040)]. While digital technology is diffusing at an exponential rate across many sectors, its ethical, pedagogical, and epistemological implications, especially in the education sector, remain questionable, especially with the topical [fourth industrial revolution](https://www.sciencedirect.com/topics/social-sciences/fourth-industrial-revolution) (4IR). Nevertheless, it is worth mentioning that the past three industrial revolutions are fundamental and instrumental to the current technological advances and economic productivity, although the current trend, including the future of 4IR innovations, remains unknown. According to Penprase [[8](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0045)], the early 1950s marked the foundation of the third industrial revolution, which was influenced by the advances in technology through the first and second industrial revolutions. As a result, industrialization took its stance in the global economy, and machinery was introduced in the form of computers, creating new and faster methods of channeling information and communication in the world of work, including teaching and learning [[8](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0045),[9](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0050)]. For example, powers of technology, particularly through the third industrial revolution, with the power of computing and the internet, transformed the world of work, including teaching and learning, from huge stagnating mechanical machines to small hand-fitted smart devices [[9](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0050),[10](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0055),[11](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0060)]. According to Buckenmeyer [[12](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0065)], computer technology provides the opportunities that were not available prior to the third industrial revolution, to enhance teaching and learning through simulations of complex and time-consuming as well as dangerous scenarios.

Accordingly, 4IR, which is perceived as a fusion of many technologies and perceived to blur the boundaries between the physical, digital, and biological spheres [[13](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0070)], is now attracting increasing attention from policymakers, business practitioners, and academics. the second industrial revolution, with the discovery of combustion engines, and third industrial revolution, which was characterized by innovations in information and communication technology (ICT) and automated production, formed the basis for the rapid diffusion and penetration of 4IR. According to Lee et al. [[14](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0075)], any attempts to define 4IR should consider the integration of technical innovation and institutional innovation as the key building blocks, such that the interaction of human and technology (i.e., smart systems) are applied to increase operational efficiency, including teaching while enhancing socioeconomic and environmental performances.

Despite the advancement in technology innovations, the education sector has been reluctant in accepting technology to facilitate teaching and learning, although the use of robots in education, particularly in teaching science, technology, engineering, and mathematics (STEM) subjects, has been around since the 1980s [[10](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0055)]. Moreover, the use of technology has been predominantly limited to a didactic approach of teaching and learning, whereby teaching is facilitated with the use of a [personal computer](https://www.sciencedirect.com/topics/social-sciences/personal-computer) and the provision of electronic teaching materials. However, the use of digital technology underpinning 4IR is beyond the use of computer and e-materials and should be compatible with the learner-centered approach for it to be effective in enhancing students [learning experience](https://www.sciencedirect.com/topics/social-sciences/learning-experience).

The level of technology acceptance, due to its costs, perceived limited application, and lack of training, is considerably low, and its effectiveness is not well documented in the education sector [[10](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0055),[12](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0065)]. The starting point in understanding the roles and relevance of 4IR in facilitating teaching and learning practices is to have adequate knowledge of different components of 4IR, using the current categorizations in the literature. According to Rüßmann et al. [[15](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0080)], there are nine pillars of [digital innovation](https://www.sciencedirect.com/topics/social-sciences/digital-innovation): (1) autonomous robots, (2) simulation, (3) horizontal and vertical system integration, (4) [internet of things](https://www.sciencedirect.com/topics/social-sciences/internet-of-things), (5) [cybersecurity](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/cybersecurity" \o "Learn more about cybersecurity from ScienceDirect's AI-generated Topic Pages), (6) cloud, (7) additive manufacturing, (8) [augmented reality](https://www.sciencedirect.com/topics/social-sciences/augmented-reality), and (9) big data and analytics. The current categorizations of 4IR suggest that its adoption is not restricted to the use of a computer, especially in the education sector, and may involve other opportunities, such as the development of an ecosystem that may facilitate sharing of learning materials and [data analytics](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/data-analytics) to understand learners’ teaching needs. While the 4IR components have many things in common, the sophistication of connected platforms, networks, and devices can exacerbate the process of establishing the inherent consequences of 4IR.

In this present study, however, 4IR in the education sector is modeled after the World Economic Forum [[13](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0070)] and defined as the integration of human and technology intelligent systems that are fusing the physical, digital, and biological worlds with unprecedented consequences across different education disciplines, and pose significant challenges on how we learn, teach, and work

 While the previous three industrial revolutions have impacted our society and contributed to the nations’ economies, 4IR is more germane to our daily lives, including how we work and learn [[2](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0015),[8](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0045)]. Nonetheless, the last three industrial revolutions culminated in mass production of education services through innovative curricular development and legitimizing online teaching with the establishment of many academic institutions around the world. With computer-based learning, especially through e-learning, there is an opportunity to facilitate teaching and training anywhere and anytime, thus reducing operational costs and minimizing logistical issues that are often associated with face-to-face classroom teaching. According to Chang and Wills [[3](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0020)], using a blended learning approach, which is the integration of e-learning and classroom-based learning, could increase learners’ satisfaction and performance by about 15% compared to only the classroom teaching approach. In comparison to the traditional face-to-face classroom teaching and learning, the internet and other forms of emerging technology facilitate competency-based and self-directed learning, while increasing the variety, including the speed at which information is provided to learners irrespective of their location [[16](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0085),[17](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0090)]. Consistent with Beetham and Sharpe [[18](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0095)], digital technology is not only facilitating interactions between tutors and learners, but it also augments, as well as transforms, the teaching and [learning process](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/learning-process). With the rate of diffusion and acceptance of technology, especially in many production and service [industries](https://www.sciencedirect.com/topics/economics-econometrics-and-finance/industry), scholars and practitioners in the education sector have questioned the effectiveness and efficacy of technology (see [[16](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0085),[19](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0100)]), particularly online teaching, in facilitating teaching and learning.

Using five different examples of interactive learning, the contribution of interactive e-learning method in improving teaching and [learning experience](https://www.sciencedirect.com/topics/social-sciences/learning-experience) has been demonstrated [[21](https://www.sciencedirect.com/science/article/pii/S2199853122004267" \l "bb0110)]. The study further emphasized the roles of students and tutors in presenting structured and organized e-learning that could improve learners’ motivation, personal competency, and learning satisfaction. According to Chang [[21](https://www.sciencedirect.com/science/article/pii/S2199853122004267#bb0110)], e-learning is more effective when there is an interaction between human and technology, by combining face-to-face learning and online teaching in a collaborative, blended, and flexible manner. (Oke and Fernandes, 2020)

Information and communication technologies are changing the teaching and learning process, therefore, the higher education (HE) system should promptly adopt new advanced tools and know how to harness their power to train learners. Education 4.0 is a response to the needs of the 4IR where technological progress aligns with human needs.

Lifelong learning opportunities, quality and affordable education (along with the fight against hunger and environmental challenges) are the key priorities of the United Nations in 2020. UNESCO believes that inequality in education could be eliminated through the application of online technologies, namely, services for distance learning. The World Forum (WEF) released the Education 4.0 framework to respond to the needs of the modern economy. The program involves the launch of the international knowledge marketplace, where educators can create joint projects on online platform.

The growing labor-market skills gap changes the structure of the economy. WEF experts believe that automation will displace 75 million jobs globally by 2025 but create 133 million new ones [1]. They will be occupied by employees possessing digital skills, who are in a high demand among business now. Moreover, there is shortfall of almost 1 million tech professionals in Russia today. This may mean that educational system needs training and retraining programs supported by 4IR technologies.

The expansion of mechanical production, precisely, steam engine, powered the 1st Industrial Revolution and enables massive increases of manufacturing. The 2nd Industrial Revolution is generally associated with new manufacturing technologies based on electricity. The 3rd Industrial Revolution is attributed to computerization and wide array of web-based resources.

there is no common definition of the 4IR, many scholars approach the concept from different methodological angles. For instance, it could be defined as a technology fusion that involves physical, digital and biological spheres [4]. Penprase asserts that the 4IR is a compounding effects of multiple “exponential technologies,” such as AI, biotechnologies and nanomaterials

The 4IR is generally associated with the fields of Big Data, IoT, AI, automation, robotics, VR/AR, 3D printing and quantum computing.

In the field of pedagogy, it is highly essential to provide teachers with information about process of extracting useful information from Big Data, processing activities and data protection rules. It might be valuable to track students’ digital footprints in order to better understand their needs, interests, expectations, moods and optimize educational process and create personalized learning pathways

IoT encompasses a set of advanced equipment (sensors), network-level connectivity architecture and smart devices that enable machines to interchange information. Advanced IoT products and solutions have great potential benefits for the HE, that is why it should be integrated into STEM (Science, Technology, Engineering, and Mathematics) core courses and vocational education and training.

The 4IR has also unleashed the mobile technologies. The proliferation of mobile devices leads to game-based learning. Today there are a lot of researchers that investigate the implementation of game elements into e-Learning environments. The incorporation of game elements into courses increases student engagement, motivates them to complete assignments, fosters collaboration, activates a competitive spirit and enhances their digital competencies

The next technology is robotics, it is a factor of development engineering education today. Therefore, it is highly essential for the HE to launch programs to train teachers in engineering and robotics industries

Alongside with the study of the 4IR technologies’ impact on the HE system there should be taken into account the influence of information revolution that is closely related to industrial revolutions [13, 14]. It is suggested to distinguish six information revolutions: the human speech (the possibility of information exchange between people who are not far from each other), writing system (the possibility of long-term storage of information), book printing (the possibility of replication, dissemination of information), electronic communication that embraces telephone, telegraph, television or gramophone recording (the ability to disseminate information freely and massively), computer technology (the huge capacity and versatility of information systems; information processing that includes acquisition, recording, organization, retrieval and display of information), global computer networks (fast distribution of multimedia information at the global scale when the recipient has the opportunity to select it and verify).

The WEF establishes eight critical characteristics in learning content and experiences based on 4IR technologies to promote “Education 4.0” [15]. We then illustrate the list of these characteristics with the examples of various Russian education programs:

1. Global citizenship skills – content that focuses on building awareness about challenges on a global scale (climate change, civic engagement). For instance, Russian government promotes global citizenship by organizing the Interuniversity Ecological Cup. It is a platform for communication between students, representatives of business, government and public organizations about issues in the fields of environmental science and protection.
2. Innovation and creativity skills – content that fosters innovation and creativity skills. State-owned Russian banking and financial services company Sberbank is noted for a lot of events and initiatives in this sphere. For example, it held the championship for students “Sberbank challenge cup”. Participants developed projects of how to feel safe and comfortable in the urban environment by using products of Sberbank ecosystem.
3. Technology skills – content that is based on developing digital skills, including computer programming and the use of technology. Ministry of Digital Development, Communications and Mass Media of the Russian Federation launched program for improving students’ digital literacy skills in leading universities. Another example is the cooperation between business and education institutions. Russian multinational technology company Yandex and the Higher School of Economics formed a computer science faculty to increase the efficiency of business operations. Students learn Big data technology along with machine learning algorithms.
4. Interpersonal skills – content that focuses on interpersonal emotional intelligence, including empathy, cooperation, negotiation, leadership and social awareness. At Peoples’ Friendship University of Russia there are a lot of science and social events that emphasize cultural diversity where students can train and improve communication skills.
5. Personalized and self-paced learning – content that is based on the diverse individual needs of each learner and flexible enough to enable student to progress at their own pace. The School of Advanced Studies at the University of Tyumen is best known educational institute in Russia that offers students personalized learning pathways that fit their objectives, interests, and needs.
6. Accessible and inclusive learning – increasing accessibility in learning by shaping more inclusive education. Ural Federal University, for example, offers students various forms of education: blended learning, MOOCs by UrFu and even online courses of partner institutions. The presence of diversity and inclusion encourage active learning.
7. Problem-based and collaborative learning (PBL) – implementation of collaborative projects to create solutions to real-world challenges. PBL teaching method is widely spread in Russian medical universities, because this profession require hands-on learning and realistic learning scenarios.
8. Lifelong and student-driven learning – it focuses on the joy of learning, rather than the pressure of assessment. The supreme example of this characteristic is learning management system “School digital platform” created by Sberbank. The LMS motivates learners and boosts their engagement. (Grinshkun and Osipovskaya, 2020)

### Advantages

The advantages of online assessment include costs saving (such as for printing costs, examination spaces, travel) and use of freely available online tools, e.g. SurveyMonkey, Google Form, HubSpot Forms, CANVAS free for teachers17 and educational software products.

Studies showed the benefits of using online assessments are reduction of paper usage, decreased concerns over the security of transporting test papers, flexible time and venue, continuous feedback and random selection and reproducibility of exam questions. (Tuah and Naing, 2021)

* Memory -a processed object (colors, sound ...) is easier for the student to remember and, if necessary, he can also use it. Content is processed to make it easier for the learner to remember it.
* Comprehension -the presentation is intended not only for the student to remember the subject, but also to understand it, be able to classify it by value and include it in the system of their knowledge.
* Active Learning -Unlike the classic presentation of the curriculum, curriculums are designed to be interactive, so the student learns not only by observing and reading, but also by performing certain actions.
* Motivation –compared to classical education, the presentation of the curriculum is more motivated by the program –variety of presentation, various processing options, etc. Using games as a teaching method.
* Error notification -the program can notify the student immediately after an error, the student receives a notification not personally (for example, from a teacher), but as part of the training.
* Knowledge transfer -the actual processing of content and the ability to present it, link it to other content, etc. is an important prerequisite for using the curriculum in other situations.
* Individual Opportunities -ICTs offer various opportunities for individualization, even high-quality software can adapt to the student's progress (in the beginning, the use of ICTs was one of the main criticisms, not respecting the student's individuality). (Mirsharapovna et al., 2022)

Improvements in student engagement, motivation, and accomplishment are just a few of the possible advantages of implementing new curriculum practices in Education 4.0. These methods can help students become more creative, collaborative, and critical thinkers, better prepare them for the challenges of the twenty-first century. (Sharma et al., 2023)

There have been major disruptions to education and the education system as a whole – not only at home but globally as well. The 4IR provides an opportunity for South African education institutions to create an environment of creativity and innovation. The 4IR sci-ence, technology, engineering, and mathematics (STEM) curriculum should reconsider new approaches. Apart from the need for 4IR literacy, new curricula should emphasise 4IR collaborative skills. Furthermore, educational responses to 4IR require the restruc-turing of institutions to provide new interdisciplinary science programmes (Penprase 2018 :219 ) .

According to Chetty and Pather (2015:5), the use of technology can resolve issues of so-cial exclusion. In other words, new technological advancements can be used as a bridge to close the gap between the rich and the poor and between different races. In addition, the 4IR provides an opportunity for education institutions to foster partnerships with other stakeholders such as the government and private companies especially. The South African president has established a commission on the 4IR, comprising various people, including academics from various education institutions. The 4IR has largely been pushed by pri-vate stakeholders such as IBM, Microsoft, and others. These corporations or stakeholders can collaborate with one another in R&D. Moreover, South African education institutions can collaborate with education institutions in other parts of the world. (Kayembe and Nel-Sanders, 2019)

### Disadvantages

Meanwhile, the disadvantages of online assessment include software costs to develop educational content and supporting infrastructure, for example, internet servers, data storage, computer-aided learning rooms.10,18 Other problems of online assessment are unreliable systems (due to poor network connectivity, hardware, software, power supply), lack of online and physical security systems to safeguard assessments and cheating.

In contrast, some studies argued that online assessments have negative impacts, mainly psychological stress to both teachers and students due to rigid technological settings, reduced personalised engagement with faculty19 and negatively influence student’s grades. The factors that may influence students’ scores and grades for online assessment involve the comparability of identical tests taken in different formats, students’ level of preparedness for the mode of test and the quality of the test,22 slow logins to test, delayed loading of a test, and inexperienced teachers.

Potential problems with coursework assessment include collusion, plagiarism and personation (in particular ‘contract cheating’ through the use of tailored essays).27 Educators may use online plagiarism checking platform,29 which are freely available at present, such as DupliChecker and Grammarly. Also, educators must recognise that there were differences between sciences and arts-type subjects which indicate distinctive assessment practices.

Evidence34-36 shows distinctive cheating practices during online examination such as impersonation, forbidden aids, peeking, peer collaboration, outside assistance and student–staff collusion.36 The common possible cheating practices during the mock online examination include screen sharing among candidates, using multiple monitors, using a mobile phone, using Bluetooth technology headset, impersonation, taking a screenshot and sending to friends, and traditional ways such as notes on their palms or attached notes to computer monitors. The various countermeasures for those cheating practices were using biometry, mingling, shuffling, random drawing, sequencing, broadcasting methods36 and physical screens parting candidates.10 We recommended affordable and straightforward ways to minimise possible cheating attempts among candidates in low resource settings. The strategies are to check the identity of the candidate, check examination room and setting, record both audio and video throughout the examination, and closely observe on candidate’s computer screen or monitor. Nonetheless, we recognise that there is no cheat-proof online and paper-based examinations.

There are various types of diversity existed among students in the context of online learning that include: socioeconomic status; access to devices; stability of internet connection; racial and cultural differences; learners with special education needs; and second-language English speakers. Therefore, educators must consider diversity when selecting online assessment methods. Some students may not have internet access and computers for web-based assessments, however able to use mobile for text-based collaborative tools (messaging, WhatsApp). Students with physical and learning impairments may use assistive devices. Students who have English as a second language may utilise technology tools with listening and speaking functions to accommodate diversity in the assessment. (Tuah and Naing, 2021)

Challenges such resource scarcity, lack of support for teachers, resistance to change, and the requirement for efficient assessment techniques in innovative curricular practices should be addressed, albeit

The lack of skills and knowledge among students and instructors is one such issue. The necessity for a digital literacy that promotes the use of technology in the classroom presents another difficulty. Digital literacy is the capacity to access, assess, produce, and share information using computers, mobile devices, and the internet in an effective and critical manner. The core literacies of reading, writing, and mathematics are all intimately related to digital literacy. For students, educators, and lifelong learners to traverse the digital world, interact with digital tools and resources, and adjust to the shifting needs of the digital age, digital literacy is essential in Education 4.0. It allows people to actively engage in online collaborative settings, connect with others, and work together while using digital technology for learning, innovation, and creativity. (Sharma et al., 2023)

Education in the 4IR (HE 4.0) is a complex, dialectical, and exciting opportunity that can potentially transform society for the better. The 4IR has different implications for many other sectors of life.

According to Butler-Adam (2018:1), one of the implications of the 4IR in the educa-tion sector has to do with curricula, teaching, and learning – rather than with robotic tutors. In other words, there must be cross-sector teaching and learning. Students and educators from various fields need to learn about the different factors involved in the successful implementation of the 4IR. As Butler-Adam (2018:1) explains, students studying the basic and applied sciences need to understand the political and social nature of the world in which they live, and, in turn, students who study the humani-ties and social sciences need to understand at least the foundations on which AI is based and how it operates. Given the statement above, the 4IR drives the idea of a multidisciplinary field, whereby humanities and social sciences join technologies to solve problems. The 4IR and the development of biotechnology and AI funda-mentally challenge assumptions about humans and their relationship with the natural world. 4IR liberal arts programmes should be developed to account for the social dislocations from the 4IR. The 4IR curriculum, in general, should respond to politi-cal and social tensions resulting from the rapid pace of technological advancement

n terms of teaching and learning, online instruction and the expanding use of AI ne-cessitate new guidelines to provide a theoretical basis for digital pedagogy (Penprase 2018:221). Digital literacy is a basic prerequisite for students to develop adaptive capa-bilities to participate in the global digital society, to benefit from the digital economy, and to derive new opportunities for employment, innovation, creative expression, and social inclusion

Any digital education strategy should consider the impact of change on the education system. This presents a wicked problem. Changes could affect the quality of the gradu-ates if students are not well prepared and there is insufficient investment in resources (Marshall 2016:295). Education is particularly susceptible to wicked problems, especially in terms of quality measures (Marshall 2016:298). Conceptualising and operationalising quality measures, performance indicators, and educational outcomes become increas-ingly challenging in a contested space of educational change and strategy (Marshall 2016 :297) .

Furthermore, the successful implementation of the 4IR in education will require appro-priate skills. Skills are required to implement, manage, and work with new technology, and with one another (Butler-Adam 2018:1). The required set of skills is very important in order to achieve the goal of obtaining the best results from new technology. Gray (2016) argues that in the near future, approximately 35% of skills that are considered important in today’s workforce will change. Hence, new sets of skills will be required for the new revolution and for the use of new technology. For instance, those working in sales and manufacturing will need technological literacy skills (Gray 2016). As new technologies create new jobs (such as social media experts), job displacements will also occur (e.g. toll booth operators) (Nordin and Norman 2018:1).

In addition, the 4IR has a potential implication in terms of moral and ethical decisions that must be taken into consideration. Technology shapes people’s lives in many ways. With the wide use of new technology in business, government, and other spheres of life, a number of dynamic changes are taking place. Hooker and Kim (2019:7) argue that new technological advancements such as the AI revolution could lead to a more radical outcome; it could displace workers on a scale that has not been seen before. This could lead to a large fraction of the population losing employment opportunities. However, many authors, researchers, academics, and policymakers disagree regarding the point made above. On the one hand, some people argue that the new revolution will lead to increased job creation. On the other hand, the argument is the demise of current or future jobs due to the wide use of technology.

There is clear and visible evidence of machines taking over in certain industries. It remains to be seen whether government or business is to be held responsible for the decline in labour and employment, due to the use of new technologies such as robotics. One of the questions raised is related to the human cost due to the use of new tech-nologies. In terms of education, ethics plays an important role in the field of academia. As more and more educational products are becoming available and accessible, ethical boundaries should be highlighted to ensure that ethical values are cultivated in education (Nordin and Norman 2018:6).

The first risk of the 4IR for education is inequality. here is a risk of only the wealthy portion of the population being able to afford new technologies for educational purposes while the poor population is left behind. This is evident with the implementation of the previous three industrial revolutions. Many today still have no access to clean drinking water, transport and electricity, or the Internet. Hence, a bigger inequality gap between the “haves” and “have nots” will create further alienation, lack of trust, and social unrest.

One of the main challenges that will affect the successful implementation of the 4IR in education in South Africa is the lack of funding. Although funding for education in-creased in the previous years, it is still not sufficient for the full functioning of education institutions. It has led to increased university fees and reduced research funding, among others. The challenge for education institutions is to invest more in new technological advancements and to prioritise what the funding could be used for. In order for new technology to thrive in education institutions, substantial financial backing is needed. The biggest cost for the provision of training is related to qualified teachers and techno-logical infrastructure

(Kayembe and Nel-Sanders, 2019)

### Psychological Insights into Meeting Deadlines

https://www.sciencedirect.com/science/article/pii/S1041608015000655

<https://www.sciencedirect.com/science/article/abs/pii/S1041608021000315>

<https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2023.1224533/full>

<https://journalhosting.ucalgary.ca/index.php/TLI/article/view/73960>

<https://journals.sagepub.com/doi/abs/10.1111/1467-9280.00441>

<https://dl.acm.org/doi/abs/10.1145/3564721.3564728>

<https://link.springer.com/article/10.1007/s11573-017-0865-5>

<https://heinonline.org/HOL/LandingPage?handle=hein.journals/wmlr50&div=16&id=&page>=

<https://scimatic.org/show_manuscript/393>

## Digital Solutions for Coursework Management

<https://www.tandfonline.com/doi/pdf/10.1080/0958822042000319575>

<https://academic.oup.com/iwc/article-abstract/11/5/485/776734>

<https://www.jstor.org/stable/44429009>

<https://bera-journals.onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-8535.2006.00589.x>

CANVAS:

* Set up different types of exam questions such as multiple-choice, true/false, fill in the blank, fill in multiple blanks, multiple answers, multiple dropdowns, matching, numerical answers, formula question, essay question, and file upload questions. Some of these questions are suitable for lower-order learning objectives in online examination, and also for coursework assessment.
* Set up the questions to appear one question at a time that only allows candidates to see and attempt each question while moving forward when answering them. If we set one question at a time, there is an option available to lock each question so that the candidates cannot go back to previous questions and change their answers.
* For multiple-choice questions, there is a function to shuffle answers randomly that enable the sequence or order of answers to choose for each question to be different for each candidate.
* For all question types, educators can set starting available time and date, end time and date, and duration for the examination. The timer is shown on the screen while the candidate is attempting the examination.
* For multiple-choice and true/false questions, set correct answer so that CANVAS will automatically mark the questions at a set due date and time of examination. The candidate can see the marks immediately after the submission. Therefore, educators may have to set the option to hide the marks if they wish not to show the marks then. (Tuah and Naing, 2021)

Introduction statements:

Education is necessary to prepare people for the opportunities and challenges of globalization and the digital revolution and to ensure that everyone can fully participate in, benefit from and adapt to new occupations and skills needs. (Dignum, 2021) <https://discovery.ucl.ac.uk/id/eprint/10121456/1/lre19010001.pdf>