

# Excellence VS Relevance in Engineering Education in the Era of the Fourth Industrial Revolution

Kehdinga George Fomunyam

**Abstract:** *Engineering is crucial for economic development in developed and developing countries. With various changes taking place globally over the years, it has had influence on all aspect of human endeavor and we are now at a time of pervasive breakout of technologies known as the fourth industrial revolution. This study therefore conceptualizes excellence VS relevance in engineering education in the era of the fourth industrial revolution by first demystifying what the fourth industrial revolution is and then conceptualizing excellence and relevance in engineering education. Findings from the study revealed that Findings from the study revealed that the world is at a stage of massive changes and this requires solutions to these numerous changes. It was also found out that excellence and relevance are not new as it is a common term used across various spheres of human life especially within the university where excellence in research and learning is emphasized. The study recommended that STEM education should be encouraged across board so as to develop the skills necessary in the fourth industrial age and also effort should be made at intensifying action on adopting some of the technologies that are emerging in the fourth industrial revolution especially in the developing countries.*

**Keywords:** *excellence, relevance, engineering education, engineering, fourth industrial revolution*

## I. INTRODUCTION

Engineering is crucial for economic development in developed and developing countries. The impetus brought about globalization and modernization have influenced this and the need to deal with prevailing changes (OECD, 2015, Wankat *et al* 2016). Also, the discipline is often evolving as a result of the dynamic nature of engineering-related industries. Engineering education in the same vein is the process of that deals with the teaching and learning of engineering. With the dynamic nature of the discipline, it has evolved over the years and taking reference from history, engineering education is as old as human civilization and as humans evolved, they gained mastery of the environment and developed tools that helped them explore the environment for their survival. This has changed over the years as a result of many factors which include education and development. Going from primitive, local systems of engineering, we are now at a time of massive technological development called the fourth industrial revolution. With various changes taking place globally over the years, it has had influence on all aspect of human endeavor and we are now at a time of pervasive breakout of technologies known as the fourth industrial revolution. The fourth industrial revolution is a time of massive technological innovation which includes automation, additive manufacturing and the industrial internet as revealed by Schwab (2016).

It is a build up to the first, second, and third industrial revolution which also has different peculiarities. Schwab (2016) opines that the fourth industrial revolution is a period of exponential changes in new technology which is characterized by a fusion of technologies across physical, digital and biological worlds which has massive influence on all industries and the emergence of new business models that can influence every sphere of life. This will definitively impact engineering education as a discipline hence the need to analyze excellence VS relevance in the discipline. The need for engineering graduates with 21st century skills has gained more attention recently as a result of the fourth industrial revolution. For engineering education to proffer solution to the various challenges of the society, there is a need to have graduates with the need skills important at this time. The fourth industrial revolution has immense opportunities for engineering education as a result of the technologies emerging with it which necessitates an inquiry into excellence and relevance in engineering education. This study will therefore conceptualize excellence VS relevance in engineering education in the era of the fourth industrial revolution by first demystifying what the fourth industrial revolution is and then conceptualizing excellence and relevance in engineering education.

## II. METHODOLOGY

This paper aims at answering the question how excellence and relevance can be achieved in engineering education in the era of the fourth industrial revolution. Research methodology is the path through which researchers need to conduct their research. It highlights the process through which the researcher formulates the problem and objective and present their result. To address the key research objectives, this research was a theoretical inquiry using evidence from secondary sources to address the topic under consideration. Policy documents, international organization reports, government reports, journals etc were used as sources of data.

## III. THE RESEARCH GAP

Engineering educators are vital within the academia and they channel their expertise towards the teaching and learning of engineering education. This is not only restricted to the academia; their learning experiences must culminate in producing graduates that are able to proffer solution to challenges of the society in any industry they find themselves. The fourth industrial revolution is an era that presents massive opportunities for engineering education as a result of the emerging technologies embedded in it.

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Dr. Kehdinga George Fomunyam, Mangosuthu University of Technology, Durban, South Africa

Though, engineering education policies, systems of learning, and teaching practice of engineering educators are incompatible across various dimensions and this necessitates a two-pronged inquiry into excellence versus relevance in engineering education in the era of the fourth industrial revolution. The 21st century has its own peculiarities as a result of the changes that are taking place with it. Much more than ever before, there are changes in the environment, the economy, social and cultural sphere, technical and ecological systems which requires new approach to effectively deal with these changes. Hence, the need to encourage the development of teaching and learning process relating to engineering education.

#### IV. LITERATURE REVIEW

##### Understanding the era of the fourth industrial revolution

The fourth industrial revolution is a concept that has gained popularity and it has been the focal point of discourses at venues such as the World Economic Forum (WEF) at Davos and in various aspects of business leadership. It has roots in early evolution of technology called the first industrial revolution which harnessed power from water and steam to create a better and systematic form of manufacturing. Some of the application of these first steam power was deployed in mining and manufacturing. Taking a cue from history, industrial revolution can be traced to the 1884 work of Arnold Toynbee which was titled lectures on the industrial revolution (Toynbee 1884). He further revealed that the industrial revolution is not only an expansion of power and mechanical production which culminates in acceleration of economic growth but an acceleration of growth made possible as a result of economic growth and social transformation (Eric Hobsbawm, 1968). This typifies that the first industrial revolution was driven as a result of economic and social transformation. The Fordist-type of manufacturing which broke out in the late 19th and 20th century are gradually becoming irrelevant and obsolete to deal with the challenges of the now. It is vital to put in mind that what obtains in the past are no longer obtainable and there has been massive shift across all aspect of human lives. We are now at a time where the economy, environment, production and manufacturing processes, social and cultural activities are experiencing tremendous changes which necessitates a new approach to them in order to ensure relevance in the 21st century. As a result of massive breakout of technologies as revealed by Schwab (2016) there is now the fusion of technologies across the physical, digital and biological sphere which is capable of influencing and causing massive shifts in industries. The physical includes the tangible aspects of the technologies such as 3D printing, robotics and automation, new materials etc. while the digital include artificial intelligence (AI), internet of things (IoT), blockchain while biological sphere include biomedical engineering and biotechnology. Industry 4.0 as defined by McKinsey is the next phase of digitization of the manufacturing industry which will be championed by four disruptions which includes massive rise in data volumes, increased computational power and connectivity, evolution of analytics and business intelligence strategies, new systems of human-machine interphase such as adaptive

and touch sensitive systems and augmented reality systems, and overall improvement in transmuting digital codes or instructions into tangible, physical substance brought about by advanced automation and 3D printing. It was also demonstrated by Zhou, Liu & Zhou (2015) that the fourth industrial revolution has future industry development trends which will help in achieving more intelligent manufacturing systems and processes and dependence and construction of cyber-physical systems, and smart industries that utilizes advanced technologies. It is needful to understand that technologies are vital for all processes and much more than that, they must be smart and intelligent which the fourth industrial revolution guarantees. The world is moving towards smart systems where all processes will be seamless and easy to navigate. Voice activated commands in electronic devices and automobiles are a huge testament to this and this is also been integrated into industrial processes. According to the European Parliament (2015) there are various nomenclature for this current revolution and it includes smart industry, industry 4.0, advanced manufacturing, industrial internet of things etc. as a result of the massive and rapid adoption of some of the technologies emerging such as internet of things (IoT) and the Internet of service (IOS), it has given much impetus to the rise of the fourth industrial revolution. Klaus Schwab who is the founder and executive chairman of the World Economic Forum made a description about a world where individuals will transit between various domains such as digital domains and offline reality by applying connected technology to enable and improve their lives (Miller 2015). This implies that the fourth industrial revolution has with it the opportunity to allow for synergy and interaction across digital and physical domains by applying connected technologies which will in the long run influence and improve their lives. Technology is important more than ever before now as a result of the changes that are taking place and to deal with these changes, rapid adoption of these technologies must be encouraged. With the rate and pace at which technologies are emerging from the fourth industrial revolution, having a full grasp of the eventualities associated with it might be herculean as it will definitely have impact on government of the world and businesses. People might not have control over the disruption that comes with the fourth industrial revolution but predictions can be made on the outcome of the fourth industrial revolution which is capable of influencing production processes, changing business models, shorten the divide between the inventors and markets which can be made possible due to new technologies such as additive manufacturing or 3D printing for prototyping (Anderson C, 2012), fuse technologies, improve processes and quality of life. This is not only the case as the fourth industrial revolution has its own consequences. With the increasing trends associated with the fourth industrial revolution, there will be disruption to economic systems in years to come and this will influence nature of work and employment patterns.



A report by Mckinsey & company has revealed that more than half of the existing work activities would be changed and automated thereby replacing currently existing technologies while saving huge volumes of money and creating new jobs (Manyika *et al*, 2017). Most production processes that require human hands will be replaced by automation which will result to job losses and unemployment for people. With this knowing, having the necessary skills that are pivotal for thriving in the fourth industrial revolution is necessary so as not to become irrelevant as time gets by. There are now autonomous vehicles and driverless cars which will in time cause an overhaul in the transportation sector. This is in line with WEF (2017) which revealed that the fourth industrial revolution will definitely impact jobs and employment by creating new and fewer jobs which will require advanced skills. Other challenges that will come with the fourth industrial revolution will include cybersecurity, breach of protocols, hacking, risk assessment, and others. (Lambert 2017). This will be made possible as a result of the interconnectedness of systems which makes them prone to cybersecurity issues. There is now greater risk more than ever before as a result of connection of systems which requires adequate measures to curtail such. It is therefore vital to ensure strict cyber security measures on personal and industrial systems while also protecting networks, assessing accessibility to systems from internal sources, employees, human error and external sources such as cyber criminals. One of the greatest knowing at this time is the knowledge that with the connectivity between systems now, it cannot be undone and there is no going back (Goode, 2018). It can only be developed further to prevent intrusion and access by external parties. As our lives are becoming connected and human relationships getting shaped as a result of various devices such as cell phones, cars, electrical appliances, home security cameras, electrical appliances at home, effort must be placed on guaranteeing the integrity of these connected systems. This has necessitated various attempt by individuals and organizations at ensuring that effort be intensified on protecting their digital space from compromise which if it happens can have damaging consequences on people.

#### **Demystifying excellence and relevance as concept**

Most individuals and group assert excellence more often and this is peculiar to universities asserting in their vision and mission statement that they strive for excellence in research and learning. The concept is recognized in many fields of endeavor and it is used to establish exceptional or outstanding performance. The concept is vague in that one need to ask questions such as excellent in what, excellence for what which is enough to allow for research into its theoretical and practical veracity. There are numerous definitions of the concept which suits different purposes and different areas of human endeavor. Excellence has ties with excellent and according to the Merriam Webster Dictionary (2020) and in its literal meaning, it means very good of its kind, eminently good. Thus, excellence is a defining characteristic conferred on a person, organization, government, institution as a result of commendable achievements recorded in specific endeavor. This typifies

that people as a result of different characteristics, talents, and skillsets they possess deploy such towards any endeavor they are in to and by the exceptional values and qualities they bring to the fore, they are said to be excellent. When people surpass a particular threshold or benchmark in a field of human endeavor, they are said to be excellent. Much more than that, standing out amongst others also exemplifies excellence. Humans are social animals and they exist in groups in a social system, interacting and communicating. As a result of this, they compete for various things in the workplace, society, religious places, school, and other place humans are. Though, it might not be easily manifested, humans are in competition with one another and when one exhibits peculiar characteristics, such person is seen as an excellent individual. Excellence is a function of one's ability and strength and various people at various times have demonstrated excellence along their field of endeavor. Excellence is the basis by which individuals, and groups are differentiated from others. This agrees with the opinion of EC Masis Report (2009) which emphasized that the idea of excellence means being better than other in some competition rather than being good. There are various models and dimensions for defining excellence and some include excellence in management (The European Foundation for Quality Management (EFQM), The Baldrige model, Excellence in the USA, Excellence in research (The research excellence framework), Excellence in teaching, excellence in student's performance, excellence in practice etc. Relevance in the same vein is a complex concept as its definition depends on context. It occurs in various forms and across various disciplines. There is also a dearth of theoretical information on what relevance is as a result of its complexity and multifarious nature. In appropriately defining relevance, people can inquire what sort of relevance do you want to define probably social relevance, economic relevance, cultural relevance, disciplinary relevance, pedagogical relevance, technical relevance, ecological relevance, environmental relevance etc which becomes a challenge. Some theoretical definition of relevance will be opined on to understand more about the concept. Relevance was defined as the extent to which information is pertinent, connected or applicable to a matter at hand according to Jovan Pehcevski (2007). This definition showcases specificity, relationship and appropriateness to a prevailing condition. Much more than this, information is not the only avenue to ensure relevance, knowledge can be relevant, discipline can be relevant, findings can be relevant etc. This definition of relevance also has in it a dimension of applicability with time. As time passes, what obtains in the past seems to be obsolete and cannot meet up with the challenges of the now which necessitates new approaches which must be able to deal with the issue at hand. Merriam Webster Dictionary (2020) also defined relevance as practical and especially social applicability. This is a workable and pragmatic approach to issues as revealed above.



## Excellence VS Relevance in Engineering Education in the Era of the Fourth Industrial Revolution

Relevance ensures that changes with time are factored into any approach at solving a challenge and it is worthwhile to bear in mind that we are at a time of social, cultural, political, economic, environmental changes which necessitates a call for relevance. The times we are in now has changed and the problems that were in existence before are not the problems we have now. What this portends it that there must be new solutions which must be pertinent, connected or applicable to solving these new challenges. Therefore, relevance encourages dynamism as it is characterized by activity and progress.

### Achieving excellence VS relevance in engineering education in the era of the fourth industrial revolution

With the challenges of the now, there is a need to have graduates of engineering education with requisite skillsets crucial to overcoming societal challenges. The development of fourth industrial skills is key in this discourse to ensure excellence and relevance. The times are changing and the overall learning experience might not be applicable now to solve the prevailing challenges hence, the need to produce engineering graduates with fourth industrial era skills. There is a need for an overhaul in the teaching learning process to ensure that elements of the fourth industrial revolution are factored in for excellence and relevance. Also, the curriculum must be tailored towards this current time to consider the changes taking place in the economy, environment, social-cultural sheer, technical and ecological sphere. Having graduates that are outstanding and have demonstrated excellence in the line of engineering education saddled with the fourth industrial era skills will ensure excellence and relevance in the discipline. Thus, the emphasis must be on developing 21<sup>st</sup> century skills in people and according to WEF (2015) the 21<sup>st</sup> century skills include nonroutine interpersonal and nonroutine analytical skills. The challenges of the now are numerous and these requires new technologies to deal with them such that excellence and relevance in engineering education is guaranteed. The technologies that existed in time past might no longer be applicable to solve current challenges again and the world needs a new system of dealing with these challenges which necessitates excellence and relevance. With youths being crucial for economic production and sustainable development globally, haven developed the necessary skills in the fourth industrial revolution, they will be able to provide the technologies that will influence positively systems, structures and processes thus encouraging excellence and relevance in the discipline in the fourth industrial revolution. With the fourth industrial era being a time of massive technological breakout, there are pervasive technologies that can influence the conduct and practice of engineering education globally. It is vital to understand that the world has moved from the Fordist-era to one where there is a fusion between digital, cyber and physical sphere which has massive emerging technologies capable of influencing engineering education. The challenges of the old are not the challenges of now as there are wide changes across the social, physical, cultural, technological, environmental, ecological sphere which requires outstanding and appropriate solution that are applicable to the matter at hand hence the need to have a workforce that will leverage on

these technologies to ensure excellence and relevance. With the old production process characterized by low skilled routine patterns, in the fourth industrial revolution, most of these processes will be automated (Frey *et al*, 2016) which therefore necessitates new skills that can ensure excellence and relevance. With the dawn of a new era along technological lines which has the impetus to influence engineering education as a discipline, it is important to consider the existing skill set and those needed to confer excellence and relevance in this new era. Some of the skillsets vital to engineering include communication, teamwork, problem solving, ethics and professionalism, lifelong learning, critical thinking, leadership, creativity, technology, management. As times are changing and with the need to ensure excellence and relevance, there are now new skills that must be developed in engineering education and some of the skills include analytical thinking and innovation, active learning and learning strategies, creativity, originality and initiative, technology design and programming, critical thinking and analysis, complex problem solving, leadership and social influence, emotional intelligence, reasoning, problem solving and ideation, system analysis and evaluation (WEF,2016). The fourth industrial revolution is a period characterized with massive breakout of technologies that will influence the world of work and work processes. It offers huge application in engineering education which must be properly tapped into to enjoy the potential it offers. But as a result of poor skills vital to the fourth industrial revolution viz-a-viz its relation to engineering education in Africa, some countries in the region has not yet tapped fully into it. This has huge drawbacks for social and economic development in the region which consequentially impacts the lives of inhabitants of countries in Africa. it is therefore good to encourage the development of skills that are relevant to this present time so as to benefit from the opportunities it offers for engineering education in Africa. This is in line with the findings of entrepreneurship Brynjolfsson and McAfee (2012b) Autor and Dorn (2013) which maintained that there are vital opportunities for certain types of skills crucial in the fourth industrial revolution. Some of these skills include creativity, innovation and social skills which can encourage with engineering education being a discipline that prides itself as a solution bringer, these skills are important in the fourth industrial revolution and effort must be intensified on ensuring that people acquire these skills so as to culminate in excellence and relevance Quality of teaching is also key in excellence and relevance in engineering education in Africa. As revealed in the works of Heystek and Minnaar (2015), academic institutions and government agencies often use terms such as academic standards, standard of degree, student assessment and accountability to refer to quality in higher education. It is important to note that without quality, excellence and relevance cannot be achieved in the higher education domain hence the need to ensure quality in the higher education landscape so as to encourage excellence and relevance.



Increase investment in technical and stem education will ensure excellence and relevance in engineering education in the fourth industrial revolution. The world is in a stage where proper investment must be made in technical and stem education so as to build the capacity of entrants into the labour market with the skills needed in the fourth industrial revolution. The nature of jobs has changed and there are new and emerging jobs called the jobs of the future which include robotics and automation engineers, industrial engineers, data analysts, cloud architects, security analysts etc (Frey *et al*, 2016). Having the technical and stem skills will be vital in ensuring excellence and relevance in engineering education in the fourth industrial revolution. Relevance is also key in this discourse as it highlights relation to matter at hand or social applicability. There are various issues at hand to grapple with globally and most major among them are the pandemic which has ravaged most countries and cascaded down to affecting economies, massive shutdown of businesses and unemployment, widespread poverty especially in developing countries, massive environmental changes manifesting as climate change, insecurity and unrest, decline in human welfare as a result of poor economic conditions etc. All these must be met with appropriate solutions important to solving them which engineering education in the era of fourth industrial revolution has been able to respond to. With the advent of the fourth industrial revolution, some of these changes have been factored in which has influenced some systems, structures and processes. Take for instance, manufacturing has been shaped by technologies such as additive manufacturing and the divide between producers and consumers is being closed now. Also, in response to the pandemic, the massive technologies that came with the fourth industrial revolution where deployed in curbing the COVID-19 menace and elements of these technologies were used in producing devices that aided recovery of patients such as ventilators. Work patterns have also changed as people embraced remote work and remote monitoring of projects as a result of the emergence of the pandemic which was only made possible as a result of widespread technological breakout which influenced work environment. Big data offer tremendous benefits for dealing with environmental challenges and from the volume, velocity, variety, and veracity of big data, it offers tremendous opportunities for influencing decision making in the environment. by the application of big data, trends and patterns can be studied by simulating and modelling events so as to have predictive information for future events. By the technologies emerging from the fourth industrial revolution made possible by engineering education, I can attest that the discipline is related and socially applicable to some of the issues at hand hence its relevance. Engineering education in the era of the fourth industrial revolution has come with new technologies which makes the discipline outstanding. Some of these technologies include 3D and 5D printing, big data, artificial intelligence, new materials, smart systems, robotics and automation. These also has been a defining character that made the discipline stand out amongst many others. Having new technologies is important in these times we are in and effort must be placed on leveraging on these new technologies. Distinction in engineering education in the era

of the fourth industrial revolution can be likened to the various technologies that emerged while relevance is also manifested in the ways and manner through which engineering education has been able to provide solution to various challenges of humans and the society.

## V. FINDINGS AND DISCUSSION

Concretizing what excellence and relevance is seem difficult as a result of dearth of theoretical resources on the concepts. Though, some works have been done on excellence and relevance, defining appropriately the concepts might be subject to context as questions on various dimensions of both concepts will be raised. In broad parlance, excellence can be in various dimensions such as career excellence, academic excellence, pedagogical excellence, economic excellence etc. while relevance also can be in various dimensions such as social relevance, economic relevance, technical relevance etc. The literal meaning and some theoretical evidence were used in understanding the concept of excellence and relevance. Findings from the study revealed that the world is at a stage of massive changes and this requires solutions to these numerous changes. With engineering being a discipline that seeks to proffer solution to challenges, it has been seen as a tool for socio-economic development in developing countries (Matthews *et al*, 2012). It also has the impetus to provide solution to the problems of nations of the world. But for the discipline to thrive well in the fourth industrial revolution, there is the need for excellence and relevance. The fourth industrial revolution is different from previous epochs because of the peculiarity of the era. There is a fusion of technologies between the physical, digital and biological space which is occurring at a pace that has not been seen before. With these fusions, there is the emergence of various technologies that will influence the conduct and practice of many disciplines including engineering education. It is therefore imperative to understand that for engineering education to fulfil its ideals in the fourth industrial revolution, there must be excellence and relevance. Findings also revealed that excellence is not new as it is a common term used across various spheres of human life especially within the university where excellence in research and learning is emphasized. This showcases distinction and exemplary performance amongst others while relevance implies relation to the matter at hand, specificity and social applicability. These concepts are closely related as they are positive desirable characteristics that are important in solving various challenges in the current dispensation that we are. Therefore, it is essential to understand how to achieve excellence and relevance in engineering education in the era of the fourth industrial revolution. To achieve excellence and relevance in engineering education in the era of the fourth industrial revolution, there are many things that need to be done to achieve that. Key amongst this include development of 21st century skills, overhaul in the curriculum, change in the teaching learning process, sustainability etc. All these has been opined on as key to achieving excellence and relevance on engineering in the fourth industrial revolution.



## VI. CONTRIBUTION OF NEW KNOWLEDGE

We are at the fourth industrial revolution now and this has immense opportunities for engineering education as a discipline. This paper contributed to new knowledge by building on excellence and relevance while also putting in perspective the fourth industrial revolution.

## VII. IMPLICATIONS

Engineering has been opined on as vital for socio-economic and sustainable development especially in developing countries that have not been able to leverage effectively on the opportunities embedded in it coupled with the massive benefits and potentials of the fourth industrial revolution. Encouraging engineering education in the era of the fourth industrial revolution is now key in guaranteeing development globally and acquiring the skills important in this era will help in the process. There is the need for new policy thrust on regional or local level to shape educational processes crucial to the fourth industrial revolution. There is a need for wide overhaul in educational processes especially in developing economies so as to encourage the development of skills crucial to the fourth industrial revolution and hence, there will be easy adoption of the various technologies that came with the fourth industrial revolution to influence structures, systems and processes. The paper therefore is crucial for policy makers in technology and educational line to have policies that will ensure excellence and relevance at the fourth industrial revolution. This is important in leveraging on the massive benefits that has come with the fourth industrial revolution while also intensifying effort on engineering education to proffer viable solution to the challenges of the society.

## VIII. CONCLUSION AND RECOMMENDATION

Especially in academic environment, excellence and relevance are common words associated with higher institutions of learning as it captured in some of their vision and mission statement. These are times of changes and excellence and relevance must be encouraged in all spheres which this study addressed. The fourth industrial revolution is a period of massive technological breakthrough along physical, biological and digital world which has immense influence on structures, processes and systems. It is therefore imperative to encourage excellence and relevance in the discipline of engineering education. This study therefore recommends that STEM education should be encouraged across board so as to develop the skills necessary in the fourth industrial age and also effort should be made at intensifying action on adopting some of the technologies that are emerging in the fourth industrial revolution especially in the developing countries.

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## AUTHOR PROFILE



**Dr. Kehdinga George Fomunyam**, Institute for Systems Science, Durban University of Technology, Durban, South Africa

