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Chapter

Introductory Chapter: Theorising STEM Education in the Contemporary Society

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1. Introduction

In their bid to strengthen the fields of science and mathematics, the National Science Foundation (NSF) of the United States Department of Education constituted a government policy that will challenge Americans to become leaders in science, technology, engineering and mathematics. This happened right after the launch of the Russian satellite, Sputnik, into space which charged the spirit of the Americans. Originally called SMET (science, mathematics, engineering and technology), this acronym was changed and reintroduced as STEM in 2001 with the plan to completely reform and renew the educational sector with focus on STEM fields [1]. Science which is the first of the four fields improves the human understanding of the physical world while developing research, experimentation and collaborative skills [2]. Science is based on observation, experiment, measurement and laws and its values include independence of thought, creativity, tentativeness, subjectivity, testability and cultural and social embeddedness [3]. Second is technology, which is the satisfaction of human needs and wants using knowledge and skills needed to interface between science and the real world. It is an orchestration of phenomena, programmed for a useful purpose. Third is engineering which involves solving real-life problems using scientifically designed products and processes. Lastly is mathematics which is packed with skills needed to interpret and analyse information, simplify and solve problems, assess risk, make informed decisions and further understand the world through modelling both abstract and concrete problems. Mathematics is concerned with the study of number, shape, space, quantity and their interrelation [2, 3]. Field-specific definitions like his are static as definitions of STEM transcends disciplinary lines. These disciplines are taught in isolation, but STEM education involves a cross-disciplinary approach thereby somewhat blurring their boundaries [4]. This implies that these fields are integrated and the knowledge and skills from two or more fields can be applied to real-world problems.

STEM education is defined differently by different people and groups and has become top priority for education, business and governments. According to Breiner et al. [5], the NSF defines STEM fields broadly, including not only the common categories of mathematics, natural sciences, engineering, computer and information sciences but also social behavioural sciences such as psychology, economics, sociology and political science. For [1], STEM education is a teaching field based on constructivism and constructionism, while Caparo [6] defines it as a teaching composite of any two or more fields of science, technology, engineering and mathematics, which may occur as a result of duplicity of real-life and problem-based learning.

STEM is commonly used to reference a set of educational and occupational fields related to science. It is the purposeful integration of the science, technology, engineering and mathematics discipline in solving real-world situations [7].

These disciplines can be taught and applied either in a traditional and discipline specific manner, or through a multidisciplinary, interconnected and integrative approach [2]. Mitts [8] and Bruce-Davis et al. [9] support the critical analysis of STEM education using two approaches. For them, the first approach is the integrative approach which is a composite of major disciplines integrated into one. The second is the multidisciplinary approach, an approach that integrates knowledge from several disciplines. These approaches use problem-based learning, project-based learning or inquiry-based learning as strategies to produce results. Both approaches are outcome-focused and aim to solve real-world challenges [2]. STEM education and training establishes relationships between the four disciplines with the objective of expanding peoples' abilities by supporting technical and scientific education with a strong emphasis on critical and creative thinking. These are skills vital for existence in today's world which is at the brink of a technological revolution.

2. The era of the fourth industrial revolution

In the past, several revolutions have defined the world and according to the World Economic Forum, the fourth industrial revolution is here already [10]. The first industrial revolution saw the introduction of the steam engine which transformed industries; it was a revolution that changed most agrarian societies to industrialised ones as the world discovered and began to rely on steam power and machine tools [11]. The second industrial revolution was based on combustion engines [12] and associated with new technologies for manufacturing that used electricity. This era witnessed the transition to electricity, the development of transport, communications and the development of high-tech industries. It was a period of growth for pre-existing industries as science, technology, engineering and mathematics (STEM) were brought into factories leading to advancements in education [11]. The focus of the third industrial revolution was on the paradigm shift from a society based on conventional fossil fuel to a society based on renewable or alternative energy. This was a revolution inspired by information technology and linked to web-based interconnectivity and computerisation [12]. Often referred to as the digital revolution, it involved the transition to telecommunication technologies, automation of production and rapid development of services [13].

Currently, the world is on the brink of another revolution that will alter the way we live, work and relate with one another. Lee et al. [13] state that the fourth industrial revolution has been in progress since the beginning of the twenty-first century and is a concept triggered and based on recent diverse technologies. This revolution is characterised by the convergence of breakthrough technologies such as advanced robotics, artificial intelligence, virtual reality, wearables and additive manufacturing that will transform production processes and business models across all industries [14]. Usually referred to as 4IR, the fourth industrial revolution has continued to gain momentum, influencing every sphere of human life. According to [12], twelve disruptive technologies reshaping the world in the era of 4IR are renewable energy, advanced materials, 3D printing, energy storage, genomics, advanced oil and gas exploration, Internet of things (IoT), cloud, advanced robotics and autonomous vehicles. This is a revolution characterised by a fusion of technologies, blurring the lines between the physical, digital and biological spheres.

3. Projections of 4IR

The World Economic Forum in 2015 defined a set of tipping points by which the technologies of the fourth industrial revolution will become widespread, such that it will create significant societal change. These points are the proliferation of the fourth industrial revolution technologies to levels where they make remarkable impacts on our lives and require shifts in education and employment. A survey of 800 high-tech experts and executives determined a series of dates by which these tipping points would be reached. They state that by 2025, implantable cell phones will exist. 2023 will see 80% of people in the world digitally present and 10% of reading glasses connected to the Internet. By 2022, 10% of people will be wearing internet-connected clothes, and 90% of the world population will have access to the Internet by 2024. The year 2023 will see 90% of the world population using smart phones, and over 50% of Internet traffic will be directed to homes and appliances by 2024 [10]. 3D printed cars will exist by 2022, and by 2024, there will be transplants of 3D printed organs such as the liver. Many other predictions suggest extensive integration of artificial intelligence in the twenty-first-century workforce. This will lead to the loss of 75 million jobs by 2022, but 133 million new jobs will be created by new technologies for people trained to work with machines and data [14]. In fact, 65% of children entering school today will eventually work at jobs that do not currently exist.

Statistics show that as of 1950, the world population was 2.5 billion, and this increases to 5.3 billion by 1990 and 7.3 billion by 2017. It has been projected that by 2050, the world population will be 10 billion. Increasing population coupled with the loss of arable land, as a result of global climate change, will require an increase in food production efficiency of more than 50% by 2050, thereby placing an imperative on industry 4.0 technologies to develop groundbreaking new sources of food production. Environmental threats arising from a buildup of Co_2 as well as other greenhouse gases are also expected, and according to [12], there will be an increase in temperature to more than 10°C. Global warming could make the earth uninhabitable in which case, the result would be widespread crop failures, subjecting large fractions of the world's populations to heat exhaustion and potential death. The predicted rise in temperature will lead to a great reduction in agricultural productivity by as much as 15% for every degree of warming. New technologies in this era could attenuate global warming by absorbing excess carbon dioxide using both bioengineered organisms and new materials within buildings.

According to Professor Klaus Schwab at the World Economic Forum, this "transformation will be unlike anything humankind has experienced before. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving stakeholders of the global polity, from the public and private sectors, to academic and civil society" ([10], p. 5). Educational responses to 4IR would be to retool STEM institutions and curriculum to provide new departments and science programmes in new interdisciplinary fields in a bid to provide more efficiently trained workers to help advance and accelerate the development of ever-more sophisticated artificial intelligence, biotechnology and nanotechnology. The education system is adopting these new changes, and STEM education has been identified as a new approach to be used in the education system globally.

4. STEM education responses for the contemporary society

As stated by [16], the implications of 4IR for education is twofolds with the first being required research and interventions from scholars and scientists on making intelligence not just an industrial tool but also useful in the direct service to society. The second implication affects the teaching and learning process including the curricula. Considering the dynamic changes in society, education has to change, and a revolution in teaching and learning methodologies is necessary so as to adopt a type of learning outcome based on competencies, blending academic and vocational education to answer the market need. Teaching and learning should now reflect edutech services, lifelong learning pathways, digital fluency and STEM skills [15].

Today's educational system is tasked with preparing this generation and the next to thrive in the face of these projections that would change the world, and STEM education is the answer. A relationship between STEM education and 4IR should be fostered so as to produce scholars with twenty-first-century skills that can solve real-life problems such as collaboration skills, communication skills, critical thinking skills, problem-solving skills and all-round creativity. To achieve this, STEM education must be fully integrated into the school curriculum such that regardless of the course of study, each individual is prepared for the future workplace. Exponential growth and rapid change give the curriculum an imperative to update its content to match the rapid tempo of scientific and technological advances. The jobs of tomorrow are rooted in STEM; therefore integrated instruction should focus on STEM fields so as to create critical thinkers and empower the next generation of innovators [16].

The foundations for STEM education should be introduced to children early on so as to pique their interest and get them curious. This can be achieved through hands-on multisensory and creative experiences as it helps children develop curiosity, critical thinking and problem-solving capacities. In the long run, they become interested in STEM fields and are more likely to undertake one of these fields as a major. This era also demands that students are trained to be entrepreneurial so that their thoughts will be diversified, to not just technical education. Developing an enquiring mindset and attitude will ensure that they function adequately in the dynamic and flexible workplace of today [15–17].

All these point to the criticalness of STEM education in the current dispensation and attest to the need of this volume. This book is therefore a timely addition to the scholarship on STEM education and provides valuable insight in the teaching and learning of science, technology, engineering and mathematics. It also provides insight to the scholarship in these fields as they relate to each other and the broader STEM field.

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