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The Political, Social and Economic Dimensions of Engineering Education

Dr. KEHDINGA GEORGE FOMUNYAM
Durban University of Technology, Durban, South Africa
georgek@dut.ac.za

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ABSTRACT

The social, political, and economic structure of a society influences several aspects of the society, including the education sector and these three areas are often interconnected and affected by similar issues. Engineering, like other aspects of education is affected by policies and ideologies in a country and in turn, has an effect on the development of the economy. This paper shines a searchlight on modern day engineering education, focusing on its adaptation to economic and socio-political issues and changes, how they affect engineering education and its relevance in the face of evolving patterns and emerging trends in science and technology. This paper explores how these dimensions are being introduced into the engineering curricula-how engineering is taught and learned, changes that need to occur to maximize benefits obtainable from this linkage between engineering and the various aspects of society, how socio-political and economic content impact the field of engineering, and the contribution of engineering to these aspects of human life.

Key words: Socio-political, Economic, Social, Political, Engineering Education.

1. INTRODUCTION

Engineering helps sustain humanity and is a key basis of survival, it is also the foundation of societal development as well. It has transformed life and culture and continues to shape many aspects of society. Engineering education directly impacts growth and development in various sectors of any economy as the development and maintenance of infrastructure and essential innovations are entrusted to engineers, therefore a country lacking well educated engineers often encounters challenges in its growth agenda (Lewin, 1992), and the growth of the industrial economy requires well developed capabilities in engineering in order to respond to emerging challenges in structures, infrastructure, systems and innovations. Educational systems in numerous countries are plagued by problems stemming from unfavourable policies, belief systems and limited financial resources. These problems are majorly a reflection of deficient political, social, and economic systems educational institutions battle to overcome. Handicaps such as these negatively impact the ability of educational systems to produce effective graduates equipped with the necessary knowledge and skills to address societal needs and their ability to innovate or maintain technology, systems, applications, and inventions. Therefore engineers, to remain relevant must be politically, economically, and socially in tune to be able to identify, innovate and maintain relevant and essential technology and infrastructure in a society.

The question then arises; what impact does social, economic and political influences have on engineering education and conversely, how does engineering education impact the economy, politics and social order of a society?

In addition to political forces which play a dominant role in influencing and shaping the conduct of engineering education globally, engineering education has been influenced by power, social and economic factors, which have a huge impact in shaping its flow. Understanding the political, social and economic dynamics of engineering education will be the focus of this study as it aims at discovering how these institutions have influenced the practice of engineering education over the years, how they are being introduced into engineering curricula and how engineering education also shapes and affects these dimensions.

Rafindadi (2019) opines that, “engineering and technology are vital to the establishment of social amenities like quality education, healthcare and support infrastructures such as transport, power, water supply, and agriculture. Engineering activities are crucial to technical, political, economic and social systems, providing an essential impact on all identified development indexes. Engineers are at the centre of national development, as every nation requires the practice of engineering and technology for development to occur therefore according to Rafindadi “Integrating the engineer into the development process isa starting point to the development of our nation.”

Three potential avenues to integrate engineers into national development were broadly classified as policy formulation, programme development and project implementation (Rafindadi, 2019). Rafindadi further opined that "engineers are at the core of national development, as no nation can develop in the absence of flourishing practice of engineering and technology. The conduct of engineering education is influenced by laws and regulation, and this is vested in politics. All African countries have laws instituted which guides the practice of any discipline and these laws also apply to the practice of engineering education. Failure to adhere to the set laws and regulations such as safety regulations can badly deter the practice of engineering education (Odendaal, 2019). Evidently, the political scene in Africa has been significantly influenced by educational advances, dynamic attitudes and the impact of television and other media which is attributable to the advances made in engineering education. This sums up the interrelationship between politics and engineering education in Africa (Fomunyam, 2019).

With the right education policy reform and proper channelling of funds all focused on rethinking how higher institutions educate engineers, African engineers will be adequately trained to "address the complexities of the modern society's issues by innovating systems and processes (Ed Crawley). Ruth Graham (2018) posits that "Many political leaders outside of the U.S. are investing heavily in engineering education as it is viewed as a hotbed for entrepreneurs focused on technology". It is believed that in the near future engineering education via entrepreneurship will be at the forefront of economic growth across Africa.

A report by Ruth Graham identifies some major issues facing engineering education, and in some cases higher education as a whole, including streamlining government objectives and higher education, delivering student-centred learning to large numbers of students, and setting up faculty appointment and promotion systems that more effectively reward good quality teaching. A government or body of political actors that successfully brings about educational reform in addition to earning a tremendous amount of political capital which will be useful for future elections, will also gain the allegiance of the people which in its own self is valuable political currency to be used as a bargaining chip and ultimately steer public opinion in favour of the government or players.

2. STATUS QUO OF ENGINEERING EDUCATION ACROSS THE WORLD.

There is tremendous proof of the merits of engineering education across all sectors and industries, from smaller inventions that make everyday life liveable to innovations that have heralded economic development and transformed humanity's quality of life. Adegbuyi & Uhomoibhi, (2008) attributes most innovations that are recorded globally to the efforts of trained personnel in the field of engineering and technology.

Engineers continue to innovate numerous infrastructures, devices and processes that provide jobs, income, improved standard of living, save lives, detect, combat, and slow the effects of natural and man-made threats to man. Devices like computers, electric cars and solar energy, wind energy kites, solar balloons, lead recyclers, water generators, nuclear waste containers, solar mats - all vital for reducing environmental pollution, tornado-detectors, bomb-handling robots, machines that aid non-intrusive surgeries, space exploration, producing ships and aircrafts essential for ravel and trade, metal detectors, agricultural equipment for mechanized farming and large scale production and processing of food and commodities essential for sustenance and local and international trade which boost the economy, floating trains, super conductive materials, payment and identification devices, smart suitcases, etc. Engineers do extensive work in manufacturing and research and develop the physical infrastructure mankind depends on – inventions in aerospace and automobile, roads, bridges, water and energy supplies, waste management. They also build and maintain digital infrastructure essential for urban living. Businesses and workforce also operate more efficiently due to improved mobility and efficient internet connectivity (Forbes, 2016).

The healthcare industry has benefitted from engineering as well in battling the pandemic, with Chinese engineers and app developers designing mobile applications that alert users to the proximity of corona virus victims, and mobile shopping applications aiding compliance with lockdown and social distancing measures and 3D printing which was adopted in making face masks to combat corona virus globally. Despite the enormous amount of economic transformation engineering has brought and promises, many countries are faced with varying degrees of challenges and a close examination reveals that the majority of these challenges stem from how the political, economic, and social systems of countries are structured, especially in developing countries. Export-reliant Singapore is ascribing its problems to the US-China trade war, while damaging trade policies were blamed for the economic issues in the US in 2019.

The Washington post revealed that in 2019, most of the world, including the US, was hit with a manufacturing recession, with China reporting the worst manufacturing output in 17 years. Nine major economies were on the brink of recession, grappling with economic issues, including the Middle East. Lebanon, whose currency dropped by 70%, faces a 25% economic decline in 2020 along with Saudi Arabia, predicted to see a 5.4% contraction in 2020. Russia and Argentina are experiencing inflation and Italy faced a political crisis in 2019 - with speculation that a global economic slowdown could tip the US into an economic contraction even after cutting its interest rates along with South Korea in attempts to boost spending. Several countries suffered economic shrink in quarter 2 of 2019, the UK, Mexico and Brazil all saw a 0.2% drop, Iran's economy sank by 6.5% largely due to US sanctions, Singapore 3.3% while Germany reported a 0.1% economic drop as well. South Korea also saw a 0.4% shrink in quarter one. These are mostly

export-driven economies depending on exportation at a time of decline in global trade.

In 2020, the U.S. and Japanese economy are anticipated to shrink by 6.1%, Europe by 9.1%, East Asia, 0.5%, Latin America, 7.2%, Middle East and North Africa, 4.2%, Dubai and Abu Dhabi 6%, Oman, 10%, Iraq, 12%, Sub Saharan Africa, 2.8%, reflecting the disruptions associated with pandemic-control measures. Research by the World bank (2020) revealed that the corona lockdown threw the global economy into recession and landed between 88 - 114 million people into extreme poverty. The organization predicts a 5.2% global economic shrink in 2020, with developed and developing countries suffering a 7% and 2.5% drop respectively - the worst since World War two.

Pazarbasioglu (2020), reveals the World bank will focus on health, the economic emergency, unemployment, and poverty–all of which engineering education will play a big role in addressing, in terms of innovating processes, infrastructure and devices that will improve health, commerce, production, agriculture, transportation and trade.

Global growth is anticipated to rebound to 4.2% in 2021, but the chances are uncertain and there are major downside risks, including the possibility of a prolonged pandemic, financial crisis, and decreasing global trade and supply linkages. Poor socio-political and economic decision making impedes the proper functioning of education systems. From an economic perspective, these problems include recessions, fall in long-term investment, low income, a drop in tourism, trade, commerce, agriculture, unemployment, foreign exchange shortages, inflation, and hyperinflation, increasing poverty and low oil prices caused by a drop in demand as a result of a fall in production globally due to the lockdown. Political issues include poor international relations, trade policies and bilateral agreements, regional conflicts and unrest, poor policy formulation and implementation and government corruption. The virus has worsened strained political relations between America and China and some other countries, with economic consequences for many.

Social concerns include environmental challenges like nuclear waste generation and dumping, poor disposal of industrial waste, air pollution from automobiles and factories, soil erosion, extinction of certain species of animals, poor recycling habits, climate change brought about by global warming due to man-made environmental degradation, industrial pollution. A lot of these issue can be eased with provision of infrastructure, possible through practical application of engineering knowledge.

Australia is presently contending with an engineering skills shortage and has included chemical, mining and mechanical engineering among its migrant occupation on demand list, as less than 5% of 24-year-olds have engineering degrees. Research has shown that students view engineering as a difficult and boring course and are therefore reluctant to enrol for the study of engineering. Again, only 6 in 1000 females have engineering degrees in Australia, this is another example of a social problem in engineering as it is viewed as a male dominated career. South Africa is also facing a similar problem, as are other countries.

Matthews et al, (2012) postulates that unemployment among graduates in sub–Saharan Africa may arise due to foreigners being employed, which is a common occurrence in Africa where governments prefer to award construction contracts to Chinese engineering firms perceived as more skilled than their African counterparts, to the detriment of engineering education and practice in Africa. In Nigeria, almost all construction projects from road, bridges to rails are outsourced to the Chinese. It is also believed that jobs in other sectors like finance and governance are more luxurious and prestigious resulting in limited interest in engineering education (Matthews et al, 2014).

3. IMPACT OF THE VARIOUS DIMENSIONS ON ENGINEERING EDUCATION

As interconnected as these dimensions are in terms of an occurrence in one area affecting other aspects, they often display very individual and discernible patterns of relationships with engineering education. Socially, some human factors that impact engineering education include income, education, employment, community safety, and social supports influence engineering education. in the case where there is a large supply of engineers. Again, safety aids like scanners, metal, and bomb detectors, ensure safer living for all and are examples of the positive social impact of engineering education. Politically, government regulations, policies, laws, and legislations have always heavily impacted most aspects of life. Unfavourable education policies impede education thereby, limiting the supply of well qualified engineers, brain drain is a major issue in developing countries as most students that migrate for study end up remaining abroad, costing their countries much needed technical skills and expertise. Similarly, poor bilateral relationships between countries limits the acquisition and transfer of skills mostly obtained through student exchange programmes and mentoring programmes often obtainable in developing countries whereby engineers from advanced countries in the West and Asia, are contracted to teach local engineers modern techniques for construction of roads, railways, communication infrastructure and more. These strained relations also decrease international trade and reduces the production and acquisition of technology for exportation and processing of raw materials converted into products for local markets or exportation.

Economic occurrences affecting engineering education include high foreign exchange rates that limit the procurement and importation of technology needed by engineering faculties to teach students, unemployment and high inflation rate that results in brain drain of skilled engineers through migration, low demand for machines,

devices and skilled engineers which limits the enrolment of prospective engineering students and low supply of engineers which leaves gaps in the functioning of society. Inadequate budgetary allocation also impedes the effectiveness of engineering faculties in public institutions that depend on government funding. Limited funding leads to poorly trained engineers which inhibits proper productivity in a society.

Engineering is no longer an isolated field of activity in our society and engineering education is changing to reflect a greater concern about the social, political, economic, and financial issues of a society because these are often interconnected and impact on the study and practice of engineering. A comprehensive vision for the future of engineering education must, therefore, take these factors into consideration.

Engineering education, multinational corporations, social, economic, and political systems are interconnected in the current world. Engineering curriculum is linked to the science policy of a country while the political, social, and economic systems of the country influences education in turn. Political forces which play a dominant role in influencing and shaping the conduct of engineering education globally, politics through policy formulation and implementation, influences socio-economic factors that ultimately affect the conduct and content of engineering education.

Economically, income level of a family or individual income can determine if prospective students go ahead to study engineering, availability of funds will mean higher chances of young people signing on to study while a lack of funding will mean lower student numbers. This potentially affects the number of engineers in any society and has a similar effect on employment in the sense that a low turnout of engineers' limits innovation of new technology, this affects job creation as little manpower is required to operate and maintain the very limited technology (machines, infrastructure, devices and processes) available, employment level is low and vice versa Technological advancement has greatly improved mankind's quality of life. Technology, particularly through innovations in engineering through the ages majorly shapes and influences society, individual values, and the environment. Engineering has evolved from being an isolated field of mankind's activities and current and future aspects of engineering must account for ethical, social, cultural, political, and economic concerns as part of the technical dimensions of engineering education. Graduates in engineering are now required to be well rounded in not just the technical areas of the field but also the more complex human relationships that impact all areas of engineering. Society requires qualified engineers who are socially, economically, and politically aware to manage its technologically complex systems.

Society's belief system and attitude and an individual's environment also affects his perception and disposition towards education and the way the individual believes it should be taught and learned. The social dimension of engineering education is concerned with issues that relate engineering to human life and health, social dysfunction, human rights, and cultural issues. Engineering education should equip engineers to handle this dimension and an engineering treatment of social problems will reduce many of the unresolved issues and identify the major source of numerous issues.

4. MAXIMIZING THE POLITICAL, SOCIAL AND ECONOMIC CAPACITIES OF ENGINEERING EDUCATION

The ideology behind introducing these dimensions to engineering research and study is the belief that the application of appropriate measures to these dimensions in the practice of engineering will proffer solutions to related engineering and societal problems. Mazher (2003) posits that education is essential for protecting the social order of a society, supporting the fact that engineering education and practice has a major role to play in safeguarding the social order of society. Engineering curriculums are majorly concerned with producing graduates skilled at systems design and the analysis of processes, devices and components that can be used to improve the mechanisms of existing processes or innovate new ideas. The entrenchment of technical ability is prioritized, to the detriment of other aspects, including the social, economic, and political implications of engineering, science and technology. Engineering is streamlined to cater majorly to new technologies and industrial needs, both linked to corporations and the global market which also has an effect on engineering education. The advancement of industrialisation requires properly developed capabilities in engineering, and engineers, to remain relevant, must be in tune with these three dimensions to innovate and maintain technology and infrastructure, as these three aspects of society are interconnected. Thus, engineers can only be productive and remain relevant in the modern-day society if they can combine technical competence with economic and socio-political awareness in order to produce effective engineering graduates. In line with this thinking, these three aspects of science and technology have been included in the curriculum of many undergraduate science, engineering, and technology courses in developed countries.

Politics as a key player in engineering education can push policies that bring about educational reform which can transform the field through the production of well qualified engineers and an enabling environment and reasonable funding for research and innovation. This will ultimately result in economic, social, technological, and environmental development in the society. Cordial bilateral relationships between countries fostered through politics, provides opportunities for investment and transfer of skills, knowledge and technology from one country to the other. This transfer

will help propagate effective engineering education and grow the profession in African countries.

Policy decisions made by government on resource allocation, education, student and business loans, security, power supply, communication, transportation, importation taxes, tariff, subsidies, foreign exchange, local and international trade have an impact on company production, revenue generation and employee welfare, which affects the economy, society's quality of life, individual households and educational institutions teaching and learning methods- inclusive of engineering education. Unfavourable policies affect higher institution's ability to produce quality graduates, this has a ripple effect on the society and economy as such poorly trained engineers lack the knowledge and skills necessary for maintaining and innovating technology needed to run an economically viable society. No aspect of society can function in isolation and policies affecting one area has an impact on other areas, just like policies affect the quality of engineers' institutions produce and their inability to work effectively in turn has consequences socially, economically, and even politically as government then has to adjust policies to rectify these challenges stemming from engineering incompetence. Political forces have a huge impact on shaping the flow and influencing the conduct of engineering education globally and there are numerous cases to buttress this point. Ruth Graham (2018) reveals that "Many political leaders outside of the U.S are investing heavily in engineering education which is perceived as vital for entrepreneurs focused on technology. It is believed that in the near future engineering education through entrepreneurship, will be at the forefront of economic growth across Africa.

Many countries are also turning to engineering and technology to improve their economy. The University of Zimbabwe Dean of Engineering was in 2019 appointed as the new Waternet Board Chairman. A Mckinsey 2017 report revealed that South Africa is seeking to automate 60% of its processes by 2030. The Rwandan government is also seeking to be part of the fourth industrial revolution and is working hard to build skills needed to produce relevant technologies for Africa's innovators. Taking on this view has shaped the practice of engineering education in Rwanda (Ntirenganya, 2017). In 2019, there was an abolition of the dichotomy between university and polytechnic graduates by a house of representative bill in Nigeria (Enekwechi, 2019), to encourage inclusion of polytechnic graduates and this is another example of political influence on education which affects engineering (Akinnaso, 2016). President Buhari of Nigeria also recently signed the engineers ACT 2019, aimed at strengthening the Council for Regulation of Engineering in Nigeria (COREN) and holding engineering professionals accountable for building faults which lead to collapses. Rafindadi (2019) anticipates that the enactment of the COREN Amendment Act would ensure proper engineering regulation necessary for the enforcement of policies favourable to development of engineering in the country as well as ensure stability in the exchange rate and the entire macroeconomic environment. "The country should also witness a major improvement in economic performance, which should result, among others, in reduced importation of food items and refined petroleum products, improved power supply, improved transport infrastructure, expanded industrial production, improved competitiveness, greater availability of foreign exchange, improved job creation, reduction in poverty and greater inclusiveness in the spread of the benefits of economic growth". This regulatory act further emphasizes the link between politics, the economy and engineering education. A stalled 10-billion-dollar port building project between China and Tanzania to be executed by engineers is another example of how politics influences engineering education. Egypt, Ghana, Angola, and other African countries have or have had similar policy changes, laws, and business agreements affecting engineering education. China has at one point had political dealings or business partnerships with most African countries that influence engineering education majorly through construction and trade agreements.

Educational policies, from elementary schools to higher institutions need reformation that can be advocated for by political players. Possible areas of reform include; adoption of problem based research and learning methods, curriculum content restructuring, regulation of academic standards and engineering institutions accreditation processes to ensure maintenance of high standard, improved funding by the government for improved educational practices in higher institutions, technological and infrastructural improvement in engineering faculties to promote student learning, governments and the private sector should also create incentives to encourage students to embrace STEM subjects from an early age. With the right education policy reform and proper channelling of funds all focused on reshaping how universities educate engineers, African engineers will be adequately trained to address the complexities of the modern society's issues by innovating systems and processes.

5. CONCLUDING THOUGHTS REFLECTIONS AND RECOMMENDATIONS.

This study established that many aspects of a country's system are linked and often have a ripple effect on various sectors of the economy. A failure or impediment in one dimension or sector of a society has consequences for various aspects of the society, conversely efficiency in one area improves performance in other areas, for example, in politics, good education policies translate to better skilled graduates which enhances various aspects like production, transportation, agriculture, employment etc. Therefore, because all three dimensions highlighted in this study are interconnected, sometimes, countries regardless of how they are structured face similar political, economic and social problems arising

from inadequacies in a country's education system, the difference is majorly in the degree of severity of the challenge and techniques adopted in resolution, which is dependent on a country's policies, available resources and skilled manpower. Poor engineering education policies have implications for almost all areas of a society's system. In examining the common challenges engineering education faces in most countries, it is evident that the majority of the hurdles stem from defective government policies on education- the political dimension of education, so it is inferred that effective government policies on education, tailored to the needs of the society, will go a long way in transforming the way the course is taught and learned and consequently improve most vital sectors of the economy, directly improving the general quality of life in the country. It can be deduced from this study that a government that seeks to transform all sectors of the economy and enhance standard of living must invest in its education sector, both financially and through good policy decision-making and implementation, particularly in the areas of science, engineering, and technology education.

Again, engineering education can only produce graduates that will be productive in the society if they can combine technical competence with economic and socio-political awareness. This will enhance relevance in teaching, learning and technological innovation, all of which promote infrastructural and economic development of a country. The perception of engineering as just a course of study and of science and mathematics subjects at the primary or elementary level as difficult must be changed, because a country's economy is only as successful as it skilled manpower and material resources.

In order for higher institutions to produce well-rounded and effective engineering graduates, able to handle the expanding global market, engineering education and practice must be approached as part of a whole, it must be viewed as a multi-dimensional subject with far reaching 'branches' and studied in its entirety; technically, socially, politically, economically, environmentally and in its other aspects. Adjustments must be made to curriculums to include courses that study the social, political, and economic issues of a country from an engineering perspective and assess the impact of engineering practices on the society holistically. This is achievable by integrating all three dimensions with engineering practice and technical systems in higher institutions and industry. Also, an interactive feedback system, well represented by government and industry experts, engineering professional bodies, higher institutions, employers, the average citizen and other stakeholders in society should be put in place to monitor, evaluate and maximize engineering practice and its impact on various sectors of the society.

Students of engineering are expected to understand the more advanced concepts and ideologies, possess advanced skills, and familiarise themselves with integrated tools needed to deal with evolving knowledge in various economic sectors and aspects of engineering. The utilization of modern technology and analytical tools in higher institutions has advanced the study and practice of engineering in developed countries, evidenced by regular inventions and innovations they contribute to science and technology. Industries academic, political, economic, and social institutions must be restructured to be interactive and responsive to constantly evolving dynamics of a country's system. Industrial training across industries is also vital for students to observe first-hand, the effect of engineering decisions on sectors and vice versa. Curricula adjustments must be made to account for the various capacities of engineering and should be frequently updated to align with changes in the system. Students must be trained to resolve not only structural and technical challenges but to analyse and understand the effect of technical and engineering decisions on key aspects of the economy. Government allocation and policies must make proper provision for funding of education sector, curriculum content must be regulated and frequently updated to reflect society's situation. Educational policies must all be reviewed ensure elementary and secondary students are properly introduced to STEM subjects with incentives like scholarships, gamification, and innovative, interactive learning methods in place.

The exploration of new research and analytical tools by engineering faculties will further advance the course of engineering education through the use of virtual reality technology for simulation and predictive forecasting of the implications of engineering decisions and technology on the totality of human dimensions, this will ensure maximum utilisation of resources, minimization of negative impact on mankind and optimum output.

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