

Theory or Practice? the Search for Value for Money in Engineering Education

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Abstract: Engineering education was predicated on two sources. One on trade apprenticeship where people that are trained locally under the tutelage of someone are engaged in further studies to broaden their theoretical and practical knowledge. The other source of engineering education was within the four walls of the educational institution which has in its core natural sciences and it emphasizes specialization in a specific aspect of engineering. This study seeks to understand if value for money in engineering education is in theory or practice. Value for money is one of the measures of quality of education. Value for money as a concept that has been defined by various authors and the World Bank defined value for money as the effective, efficient, and economic use of resources, which requires the evaluation of relevant costs and benefits with the assessment of risks and of non-priced items and/or cost of life cycle. The objective of this research is to determine if the search for value for money in engineering education is a theory or practice. Findings from the study revealed that engineering education is one of foundation for the development of the society. By engineering education, the dynamics of life has been influenced and also human culture giving more substance to civilization and politics. It was also found out that value for money is not only a financial marker but it has with it various economic, social, physical dimension. In engineering education costs are expended and this thus necessitates the drive for value for money. This study recommends that there is a need for better measures of value for money in engineering education and there is a need to advance knowledge on the theories of engineering to ensure relevance in this changing era.

Keywords: engineering, engineering education, value for money, search for value for money, theory, practice.

I. INTRODUCTION

As revealed in the work of Booth (2004), engineering education was predicated on two sources. One on trade apprenticeship where people that are trained locally under the tutelage of someone are engaged in further studies to broaden their theoretical and practical knowledge. The other source of engineering education was within the four walls of the educational institution which has in its core natural sciences and it emphasizes specialization in a specific aspect of engineering. The evolution of engineering had kicked off since the existence of man and this is exemplified in various dimensions. This became the foundation for the development of the society. By engineering education, the dynamics of life has been influenced and also human culture giving more substance to civilization and politics.

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Taking a retrospective look at some notable giant edifices built in the old ages such as the pyramids of Egypt (2500BC), King Goujian's Bronze Sword (500BC), Dujiangyan water engineering project (300BC), and the great walls of China (206, BC).

It all attest to the constant need to satisfy human curiosity while not undermining the search for value for money. Value for money is one of the measures of quality of education. Value for money as a concept that has been defined by various authors and the World Bank (2016), value for money was defined as the effective, efficient, and economic use of resources, which requires the evaluation of relevant costs and benefits with the assessment of risks and of non-priced items and/or cost of life cycle. This typifies that value for money does not only contain with it price and other financial attributes but all processes where resources be it economic, social, human, financial and physical are expended. In businesses, costs are expended and this begs the need to justify the value for money. So, also it is in engineering education. Davidson A *et al* (2008) also defined value for money as the educational value added per pound of educational expenditure. This implies that for any expenditure in educational activity, what is the value gained. The objective of this paper is to analyze the theory and practice of engineering education and its basic tenets and to determine if the search for value for money in engineering education is a theory or practice.

II. METHODOLOGY

The methodology of this research is a review of relevant literatures in line with the topic under consideration. Relevant literatures were consulted and reviewed to make inferences and draw conclusion for this research paper.

Delineating between theory and practice in engineering education

Engineering education has evolved over the years and with it there are changes. The desire to have the best in the discipline necessitates a clear framework. The answer lies within two choices which are the theory based and practice-based dimension to engineering education. The theory of engineering education will be conceptualized as the content(curriculum) and the mode of delivery of elements in the discipline. The theory of engineering education has with it some concerns such as using 20th and 19th century curriculum to teach in the 21st century (Grasso and Burkins (2010). The requirements for the 21st century engineers are numerous and they are predicated on technical competence, global sophistication, cultural awareness, innovation and entrepreneurship, nimbleness, flexibility and mobility (Continental, 2006b).



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This shows there has been a change generally and the curriculum must change so as to remain relevant. It is important to note that the problems of the previous centuries are different from what we have now and there is a need to have a body of knowledge that relevantly addresses it.

There are more challenges emerging now even from the various technological development of the 21st century and this include issues bordering on privacy and security which has become commonplace recently. Worthy of note is the need to ensure confidentiality whilst not undermining security which has been threatened by widespread development in technologies that came with the 21st century. The curriculum in engineering education is changing as a result of the impetus to meet up with current realities, there has been an overhaul. Until the world war II, the engineering curriculum in most universities was practical and they emphasized engineering design and other practical skills. With the impact science and technology had on the war, there was an overhaul in the curriculum in engineering education as it moved from developing practical skills to a strong foundation in science, mathematics and the engineering sciences (eg thermodynamics, materials, solid and fluid mechanics). This gave more impetus for recruiting applied scientists with strong interest in basic research.

Teaching and learning is important any higher education discipline and what distinguishes a higher education institution from others is teaching and learning (Holz-Clause, Guntuku, Koundinya, Clause, & Singh, 2015). Teaching and learning are theoretical in nature and it has in it the main goal of imparting people with the requisite knowledge needed to be professionals in their fields. Holz-Clause et al (2015) defined teaching and learning as real action time or period of imparting knowledge, skills and attitude to students by an adult facilitator. This definition highlights the major aim of any teaching-learning interaction and that is to impart knowledge. Fomunyan (2016a) opined that teaching and learning is all about imparting skills necessary to become adept in a particular discipline and to do that knowledge must be constructed, stimulated, directed and the teacher must guide the learner to evaluate the outcomes of the process. The ultimate aim of teaching-learning process is that there must be a change in the learners (2017a). Apart from the curriculum changing, there are new competencies delineated along hard and soft skills to ensure that engineers are relevant in the 21st century. The technical competence is not the only reason for their demand now and there are now 21st century competencies such as problem solving, design and analytical thinking, communication, creativity are important as elements of theory in engineering education. What necessitates the demand for these skills (Obama, 2011) is the emergence of various technologies from the fourth industrial revolution and the necessity of benefiting from the numerous technologies. These lend more credence to the development of STEM skills which President Obama was a major champion of. What this means is that there must be more effort intensified on developing STEM skills in the 21st century to encourage the theory and practice of engineering education. The practice of engineering was defined by the US department of labour as the application of theory and principles of science and mathematics and develop economic solution to technical programs which

links perceived social need and commercial application. It is important to note that the theory of engineering education is in its teaching while the practice of engineering education is the application of what was taught. By mastery of a specialized body of knowledge, engineering education practice is done. The practice of engineering education has been shaped by the both new technologies and the mega systems in contemporary societies which requires a crop of engineering team that are intellectually sound within such discipline. It has been reported that the practice of engineering education is pivotal for ensuring economic prosperity, security and social well-being and the practice of engineering education must shift from the traditional solving towards innovative solution. As a result of a technology driven world, the practice of engineering education has been shaped. What gives impetus to this is the various industrial revolutions and the dawn of the fourth industrial revolution lends more credence to it. As a result of the evolution of technologies, there is also difference between countries of the world. For instance, the evolution of high-quality engineering services in some countries like china, India, eastern Europe raises eyebrows about the global viability of the United States engineer. There has been global development in various countries of the world and this is dependent on the level of investment made into education which will consequentially influence the practice of engineering education. It is important to note that the United States has made heavy investments in engineering education and it has been reputed as one of the top destinations for the practice of engineering education. This is manifested in various technologies evolving from the practice of engineering education in the country which has been a critical factor that has placed the nation on a high pedestal on indices of technological development. The practice of engineering in the society has not been at par with other disciplines such as medicine and law. Take for instance, in some societies, specialties like medicine and law are held in high esteem and this might probably be because the curriculum is more of an evolution from a servile form rather than a natural philosophy. In history, engineering education stemmed from trade apprenticeship and from the academic institutions (Booth, 2004). In trade apprenticeship, knowledge of the discipline is transferred from someone superior in knowledge to apprentice. The quest for supremacy in terms of discipline questions the credibility of each discipline as each discipline is peculiar in its own ideal and delivery. One of the factors that also affected the practice of engineering education is the stereotypical outlook of the industry about the discipline. Engineering education professionals are viewed as consumable commodities that can be discarded when their skills are obsolete and cannot keep to time again. Also, in developing countries, there is shortage of skilled manpower (Royal Academy of engineering, 2012) in engineering education and the bank of qualified professionals that are present there are replaced with cheap labour from abroad. The practice of engineering education has changed with time take for instance the 20th and the 21st century.



In the latter half of the 20th century, the practice of engineering shifted from a Fordist model otherwise referred to as Fordism to customized and new models of production called post-Fordism.

This Post-Fordist era requires people to collaborate with others in sciences, aesthetics, entrepreneurship, ethics, finance, marketing, politics, project management, psychology and technology. The 21st century came with amazing technologies and the fourth industrial era. With this, there is the emergence of automation and robotics, advanced information systems and big data. This has rapidly influenced the practice of engineering education as there are now new technologies to deal with in the discipline. With the shift in the practice of engineering education in the 21st century, there are also new challenges to deal with because of the complexity of the changes happening now. The practice of engineering in the 21st century has been under attack as a result of the various technologies emerging from it and most people have opined that there is the looming danger of job losses and job reduction as a result of the various labour replacing machines which have come to shape the practice of the discipline.

Understanding value for money as a concept

Quality has gained importance in higher education and it has been measured in various dimensions. A research paper by Harvey L (2006) conceptualized quality using five different elements which are excellence, consistency, fitness for purpose, value for money and transformative. In educational parlance, value for money is one of the conception of quality as opined by Harvey L (2006). According to Erlendsson (2002) value for money is a term to determine whether an organization derived maximum benefits from the goods and services it acquires and provides from the resources allocated to it. This implies that value for money judges the quality of outcome against the costs and resources that are expended to achieve it. Quality as value for money also sees quality as return on investment. Ensuring quality in engineering project is important and the value for money is a major avenue for measuring quality.

Value for money has been defined by various authors to suit various contexts. In any endeavor, money is involved. In general terms, value for money refers to a product or service being worth the amount of money spent on it. Like I opined earlier, for every product or service used, you expend money on it and it is important as a user to justify the amount spent on it. Just like utility as a concept in economics, satisfaction must be derived when you spend money on a venture. Apart from the satisfaction derived from the use of a product or service, value is inherent which appeals to the person who spends the money. The concept of making good use of money is not new and in engineering projects, huge financial investment is made. Right from the primary stage of production to the tertiary stage, money is spent. This necessity to spend money must be met with value for so as to realize the maximum benefit from any engineering project. Engineering is as old as humans and It will be as long as human existence is, with this realization, designing engineering projects must factor in value for money. According to (Jackson, P. 2012) value for money is often used as a synonym for cost-effectiveness. This in economic

terms implies that maximum satisfaction must be derived from lower cost. This is what a wise entrepreneur will consider for maximum profit. The value for money concept in international development field is broad and it has in it elements such as economy, efficiency, effectiveness in addition to cost effectiveness (Jackson, P. 2012). The different elements mentioned here are different and they add to the mix of cost effectiveness. According to the Merriam Webster Dictionary, economy include thrift and efficient use of materials resources and it includes frugality in expenditures. Efficiency literally means the extent to which project resources (time, people, materials, money) have been used for maximum benefit while efficiency is the extent to which activities have contributed to the delivery of service (Barnett C, Barr J, Christie A, et al. 2010.). These elements embedded within the conception of value for money are important in understanding it. The organization for economic cooperation and development defines value for money as the optimum combination of whole life cost and quality to suit the needs of the users (Jackson, P. 2012). This definition has in it the cost-quality nexus which must be achieved in any project. A particular amount of satisfaction in terms of quality must be derived from expending a cost on any project. Take for instance, a road in a neighborhood being constructed by an engineering company, when done it has the potential to influence the quality of life in the neighborhood. Movement is eased from one place to another, commerce is boosted, production takes a positive turn, neighborhoods are opened up to other communities etc. these are elements of quality which must be derived from expending a certain level of cost in any engineering project. This exemplifies the cost-quality nexus in engineering projects. The national audit office in the United Kingdom sees value for money as the optimal use of resources to achieve predetermined goals (Treasury HM, 2004). Any endeavor is done with the aim of achieving a predetermined outcome. In engineering projects, the outcome is usually visualized with the aid of architect and an end in mind is developed. To achieve this end, resources are utilized and not only utilized, they must be utilized optimally. In economics, an optimal state is when cost is minimum and profit is maximum. The resources meant for the project must be optimally utilized to achieve the predetermined goal which is another dimension of understanding value for money as a concept. According to the United Kingdom department for international development, value for money is the use of resources to achieve intended sustainable outcomes and impact (DFID, 2011). This definition showcases various elements embedded in value for money whilst emphasizing sustainability. Sustainability in project is important as it ensures that the present needs at the moment are met without jeopardizing the ability of future generations to meet their needs. Sustainability is a major factor in projects and it must be considered in any developmental project.

Theory or Practice? the Search for Value for Money in Engineering Education

It is important to note that value for money is not a tool or a method that must be followed but it's an approach for understanding and providing evidence for proper resource allocation and use (Jackson, P. 2012). With this, work processes and structures are positively influenced. This gives impetus to the Royal Academy's definition of engineering as a discipline that seeks to make systems, processes and structures better.

Search for Value for money in engineering education: Theory or practice

With the various concepts critical to this topic discussed above, it will serve the purpose of understanding if search for value for money in engineering education is in theory or practice. Clearly emphasizing whether theory or practice confers value for money in engineering education might be challenging as both offer value on its own terms depending on context. From the theory of engineering education, there is value for money and in the practice of engineering education, there is also value for money, these two will be analyzed. It is important to first note that engineering education is the application of scientific theories to proffer solution to real life problems. This implies that theories culminate in practice and also influences it.

Like I opined earlier that the theory of engineering education is in its content (curriculum) and delivery. This two-pronged approach to understanding the theory of engineering education typifies that what comprise the theory of engineering education is along two dimensions and both might be within the educational institution. In the educational setting, content and curriculum might be seen along two divides, tangible and intangible. The knowledge of engineering education is intangible and it is accumulated over years and the lecturer demonstrates mastery of the discipline by passing the knowledge to students who must at all-time be ready to learn. Whilst delivering the knowledge, the curriculum might be spelt out in books which is tangible to all. With the delivery of knowledge in engineering education, it influences the practice of engineering education as the skills and competencies needed to become professionals in the skills are transferred to those that are willing to learn. This implies that theory influences practice of engineering education. The theory of engineering education is also in its teaching while the practice is in the workplace application to solving real life problems. It has been remarked in a definition by the Royal Academy of Engineering that engineering uses mathematical and scientific principles to create, design, build and make systems, processes and structures better. This typifies the many functionality of engineering education and through the knowledge of the discipline problems can be better understood and visualized using scientific perspectives, when this is done, the potential to create meaningful solution to those challenges increases and this ensures that processes and streams are made better by providing better alternatives. Not one approach is finite in solving problems and engineering education through its dynamism looks for better approaches to solving problems and make systems better. The practice of engineering education consists of series of elaborate socio-technical performances that are remarkably similar across various disciplines. According to

Blandin, 2012: Itaba-Shi Campbell and Gluesing, 2013, the series of performance in engineering include informal teaching and learning, informal leadership, technical coordination, gathering human resources, project management and technical problem solving. The practice of engineering education has received massive boost with the dawn of the fourth industrial revolution and there are now many subspecialties within it. With this realization is the impetus to have desirable technical and nontechnical skills that can facilitate leveraging on the discipline. With various problems coming to the fore, engineers are always in a position to provide solution to the various challenges of the society. Engineering practice is a problem-solving activity and this is done after mastery of the discipline is gained (theory). With engineering being a problem solving and specialized knowledge, it is applied towards the realization of a meaningful end which guarantees value for money. When problems are solved through the help of engineers, there must be value for money.

Theory without practice might be futile and knowledge gained from engineering theory must be applied so as to ensure value for money. The engineering educator in his practice causes change in systems and structures with an intended goal in mind to make the systems and structures better. While doing this, it ensures that there is value for money manifested in optimal utilization of resources and costs. The need to ensure change might be driven by time, old processes, civilization and sudden happenings. In a bid to keep up with the tide of events along the line of production, there must be changes made to systems and structures so as to ensure that value for money is guaranteed. Between theory and practice are engineers that applies the theory to solve real life problems. Along the line of their work, they meet with various challenges that must be solved. They therefore deploy the theory learned into meaningful practice which confer many benefits on processes and systems by guaranteeing quality which value for money is a part of. Theories might be useless without it being applied to solve problems hence the need to encourage practice of engineering education which ensures that value for money is realized for processes. As students are being imparted with various theories critical to their learning of the disciplines, there must be avenue for them to practice what they have learned and this cannot be possible without practice. To even make the learning complete, there must be opportunity to cross fertilize ideas between the higher education institute of learning and the industries so as to have professional competent hands in the field of engineering education. When this is done, and theory transits to practice in engineering education, there is value for money. Value for money is an approach to ensuring that quality is guaranteed from minimal expenditure of costs and resources in projects. It is important to bear in mind that theory is the basis for practice. Though, I have opined that theory is intangible, it is the major knowing and it is needed to create, visualize and build solution to various challenges and complex issues of life.



take for instance in building an electrical masterpiece that provides solution to a challenge. It is first important to know from scientific evidence the theory behind how to solve the challenge using the electrical masterpiece and this will influence the actual creation (practice) of the device.

III. FINDINGS AND DISCUSSION

Findings from the study revealed that engineering education is one of foundation for the development of the society. By engineering education, the dynamics of life has been influenced and also human culture giving more substance to civilization and politics. It was also found out from the study that value for money is one of the measures of quality of education. Value for money as a concept has been defined by various authors and the World Bank (2016), defined value for money as the effective, efficient, and economic use of resources, which requires the evaluation of relevant costs and benefits with the assessment of risks and of non-priced items and/or cost of life cycle. Findings from the study also revealed that value for money is not only a financial marker but it has with it various economic, social, physical dimension. In engineering education costs are expended and this this necessitates the drive for value for money. So, also it is in engineering education. Davidson A et al (2008) also defined value for money as the educational value added per pound of educational expenditure. This implies that for any expenditure in the practice of the discipline or its educational activity, what is the value gained. It was also found out that theory without practice might be futile and knowledge gained from engineering theory must be applied so as to ensure value for money. The engineering educator in his practice causes change in systems and structures with an intended goal in mind to make the systems and structures better.

IV. CONCLUSION AND RECOMMENDATION

This article engages the topic theory or practice: The search for value for money in engineering education and it attempts to delineate whether value for money in engineering education is in theory or practice. The discipline of engineering education has evolved over the years and with it there are changes. The desire to have the best in the discipline necessitates a clear framework. The answer lies within two choices which are the theory based and practice-based dimension to engineering education. The theory of engineering education was conceptualized as the content(curriculum) and the mode of delivery of elements in the discipline. While, quality in education has gained importance in higher education and it has been measured in various dimensions. A research paper by Harvey L (2006) conceptualized quality using five different elements which are excellence, consistency, fitness for purpose, value for money and transformative. In educational parlance, value for money is one of the conception of quality as opined by Harvey L (2006). Understanding the interplay between theory and practice will help in making the argument for determining if value for money in engineering education is in theory or practice. It is well known that theories provide structure and order for guiding and improving professional

practice, teaching and research. As well, frameworks can be studied, evaluated and evolved to makes better sense of new situations. Theory in engineering education culminate into the knowledge of the discipline. With the curriculum, its elements and mode of delivery appropriately tailored to meet the needs of learners, it has the impetus to encourage and build knowledge in students of engineering education and this knowledge consequentially, influences the practice of engineering education. Theories in engineering education have their basis in mathematics, sciences and technology. This study recommends that there is a need for better measures of value for money in engineering education and there is a need to advance knowledge on the theories of engineering to ensure relevance in this changing era.

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Theory or Practice? the Search for Value for Money in Engineering Education

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