

CONVERGENCE AND DIVERGENCE IN ENGINEERING EDUCATION IN AFRICA

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ABSTRACT

Engineering education is the process of teaching and learning engineering which has the capacity to make systems, processes and structures better. But in solving problems, there has been the case for having a finite appropriate solution or a plethora of solutions known as the convergence-divergence nexus. The convergence-divergence complex has been at the front burner of issues since the beginning of the 1950s and various scholars have argued for both in addressing challenges. This study unraveled the engineering education dynamic while also trying to understand convergence and divergence in engineering education in Africa. findings from the study revealed that Findings from the study revealed that convergence-divergence has been at the front burner of issues for long and various authors have made the case for each of the concepts as a result of their defining peculiarity and applicability. It was found out that it is important to understand both processes so as to ensure the selection of the best approach to issues and it was thus important to analyze both. This study, therefore, recommends that there must be synergy between convergence and divergence to ensure appropriate solutions to challenges in engineering education.

KEYWORDS: Convergence, Divergence, Engineering, Engineering Education, Africa

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INTRODUCTION

The basis of engineering is creativity which is a process that transforms using innovation (Boccarda, 2006) while engineering education is the process of teaching and learning engineering which has the capacity to make systems, processes and structures better. Engineering educators work by imparting the knowledge and skills needed to practice engineering and this, in turn, helps in proffering solution to the problems of the society and thus contribute to socio-economic development. Engineers create and innovate as a result of their thorough understanding of concepts in mathematics, science, economics etc. But in solving problems, there has been the case for having a finite appropriate solution or a plethora of solutions known as the convergence-divergence nexus.

The convergence-divergence complex has been at the front burner of issues since the beginning of the 1950s and various scholars have argued for convergence as a thesis based on so many factors like similarity of organization, technology, operations and planning across nations and cultures (Harbison & Meyers, 1959; Galbraith 1967) but evidence has shown that as a result of strong differences in cultural norms, convergence at all levels might be unlikely (Hofstede, 1991; House *et al* 2002). It is therefore important to have a thorough understanding of these complex issues so as to be able to comprehensively tackle the crux of this research.

Going forward from this revelation, there have been various attempts to explain the convergence-divergence theses and this has been seen across various disciplines. Taking a look first at the literal definition, Merriam Webster Dictionary (2020) defines convergence as moving towards union or uniformity or the independent development of similar characters (as of bodily structures or unrelated organisms or cultural traits)

which is associated with similarity of habits or environment while divergence was defined as a drawing apart as of lines extending from a common center or a deviation from a course or standard. According to Guo (2015) convergence relates to the creation of similarity in thinking, values, attitudes and behaviour of individuals which occur as a result of the emergence of a common belief system/logic. This definition showcases a congruency and alignment of values in individuals which is predicated on a common system of belief. On the other hand, divergence showcases individuality and from the thesis, it was revealed that individuals within a territory will maintain their specific choices, thinking, mindsets, values, attitudes and behaviour as time passes (Katz & Darbishire, 2000; Brewster *et al*, 2015). Consequentially, this study will critically unravel the engineering education dynamic while also trying to understand convergence and divergence in engineering education in Africa.

METHODOLOGY

Methodology as a key constituent in research plays a significant role. It is a method that showcases how the researcher carried out his study. This paper examines convergence and divergence in engineering education in Africa by adopting a theoretical review of relevant literature. The search engine was employed to identify relevant potential articles that could be used in understanding the crux of the study. Full text searches were done using the combination of the following keywords: convergence, divergence, engineering education, engineering education in Africa, convergence-divergence. Relevant literature were identified such as journal articles, thesis, government reports, white paper etc.

RESEARCH GAP

With engineering education being crucial to solving a variety of problems in the society by transferring knowledge of the discipline to the students in higher institutions of learning, having the right approach to it is important. Thus, the dilemma is now going from the specific to the general or going from the general to specific in engineering education which is the convergence-divergence nexus. Moving towards uniformity by having the best applicable solution and also generating a variety of ideas or information becomes puzzling which necessitates convergence and divergence in engineering education in Africa. It is thus essential to understand each dimension to ascertain the best approach to engineering education in Africa.

ENGINEERING EDUCATION DYNAMIC IN AFRICA

It has been noted that between now and 2050, there will be a massive increase in the population of the world to about nine billion and eight of those nine billion will inhabit the less developed countries of Africa, Asia, Latin America which are characterized by poor economic growth. This statistic typifies that there will be various challenges along many dimensions such as economy, environment, culture etc. Thus, it is important to have a solution that meets the technology, economy, environment and social demands of the society. Hence, the need for new knowledge that will help in providing the needed solution. The problems that plagued us in time past and the current ones we have now will be more inimical as a result of the changes occurring globally which requires a body of knowledge that is responsive to these changes.

There is therefore the need to increase creativity, innovation and out of the box thinking in the higher engineering education domain so as to have a learning environment where there is a diversity of thoughts and subjective interpretations are encouraged. The traditional conception of engineering has changed and there is a need to replace these styles and skills with modern means of delivering knowledge in the teaching learning domain. The era we are in is one of massive technological breakout which has the capacity to influence all areas of human endeavor and to leverage on it effectively,

there must be new knowledge.

It has been observed by stakeholders from academic institutions and the private sector and other notable stakeholders in the educational sector that current engineering graduates do not have the critical skills necessary to thrive in the 21st century which is constantly being influenced by various information explosions and massive shifts in science and technologies. It is important to note that more than ever before we are in a period of massive information spread across various domains which have been influenced by the emergence of various technologies that have aided and made the communication process more effective.

Globalization and digitalization have a massive influence on the engineer of today as a result of global, cultural and business constraints which require new sets of skills and competencies to deal with these global challenges. According to the National Academy of Science (2010), it was observed that there are five essential skills that are important in the 21st century and these are adaptability, complex communication/social skills, non-routine problem solving, self-management/self-development and systems thinking. These skills are needed to deal with the challenges of the now and to provide much flexibility in the labor force so that people will be able to adapt to dynamic changes easily and then culminate in innovation, productivity and competitiveness. Deficiencies in these skills have consequences globally and some of the consequences include the inability of companies to innovate, grow and deliver products on time, inability to meet quality standards, poor consideration for the environment and the lack of the social requirements needed in the country in which they operate. Hence, the need to have a change in the educational pattern from the traditional science model to one that conforms with the 21st century and the fourth industrial era which focuses on solving real world problems.

The need to have a change in the engineering capacity in Africa has immense benefits for the region such as encouraging rapid infrastructural development to meet up with its growth trajectory. If Africa will develop and become a region of prosperity there must be investment and provision of roads, bridges, buildings, airports, waterways etc. without the necessary infrastructures put in place, realization of socio-economic development in the region will be impossible. When infrastructures are put in place adequately, it has the impetus to culminate in industrial development notably in manufacturing so that Africa will become a massive importer of manufactured goods. It is important to note that Africa as a region has a comparative advantage in primary production which includes agriculture and mining.

Primary production is the basis of all economic production and must be encouraged for sustainability. An instance where there are adequate infrastructures like roads, bridges, electricity, airports and waterways, it will encourage industrial activities as we already have the bulk of raw materials to use for manufacturing. Hence, the need to develop the infrastructures in Africa, encourage industrialization and focus on socio-economic development in the region. With abundance of natural resources vital for economic production, there is a need to increase energy and overcome power shortages which will influence industrialization massively. Major natural resources are present in Africa and it ought to confer a status of nobility on the region if well harnessed but the reverse has been the case. There is a dire need to encourage control and usage of these rich natural resources especially oil and gas and other minerals. With a population that has been speculated to increase massively before 2050, there is a need for Africa to ensure that adequate steps are taken to ensure that current needs are met without jeopardizing the ability to meet future needs called sustainability.

UNDERSTANDING CONVERGENCE AND DIVERGENCE

Creativity is important in engineering and it is a process that has features of novelty and appropriateness within a set of

circumstances. Engineers demonstrate creativity in the conduct and practice of their discipline while proffering solutions to the many challenges of the world. A look at the various massive architecture and technologies brought about by the mastery of engineering has in its creativity. Engineers are creative individuals and they have the dynamic ability to create solutions to various challenges of the world. There are processes essential to creativity which is major in engineering and these processes are divergence and convergence which will be analyzed below.

The word convergence has its root in the Latin word “*convergens*”. From the literal meaning as defined by the Merriam Webster dictionary (2020) convergence was defined as the act of moving toward union or uniformity. Other authors have defined convergence and divergence and some will be considered in this research. According to (Wilson, Leslie Owen, 2006) convergence is the ability to apply logical and evaluative thinking to critique and narrow ideas to ones best applicable and suitable for context or situation. It is crucial for decision making and by the use of logic, it evaluates a series of ideas and the best applicable that suits a situation is chosen. The daily activity of man revolves around questions and we are faced with lots of decisions each day. This is also applicable in engineering education as a series of ideas on how to solve a problem crops up which necessitates the selection of the best possible solution that addresses the challenge. Engineers are constrained with the burden of solving challenges and in the process, various ideas come to them which by logic and evaluation, the best applicable idea is chosen.

In the same vein (Cropley, David H and Cropley, Arthur J, 2006) defined convergence as finding the single most applicable answer to a standard problem in the shortest time. Issues of choice is one that puts people in dilemma while deciding. This definition has in it time which is important in projects generally. For instance, engineering projects are time bound and there is a timeline to adhere to when engaged in any project. Finding the single most appropriate answer to a problem in the shortest time has a massive benefit on projects in that time is expended judiciously, resources are utilized efficiently and standards and regulations are adhered to when addressing a challenge in engineering education. In finding solutions, curiosity is stirred in people which brings to their consciousness a list of solutions both applicable and non-applicable but what convergence does is that it applies logic and evaluates all the solutions to select the most applicable solution in solving a problem. With engineering centered around creativity, ideas about solving a problem must be entertained but not all might be applicable hence, the importance of convergence in selecting the best, appropriate solution to a problem in engineering.

Cropley, Arthur J (2006) stressed that convergence is a feature of speed, accuracy, logic and it focuses on gathering information, observing the familiar, reapplying set techniques and keeping the already known. This attempt at defining convergence showcases three elements crucial to the process and these are speed, accuracy and logic. Speed has in it time while accuracy recognizes appropriateness while logic sound reasoning which is important in gathering information and then observing patterns in it.

Divergence, on the other hand, is like the opposite of convergence and it was defined by Wilson, Leslie Owen (2006) as the ability to generate a variety of complex or complicated ideas from a single idea or from simple ideas. Divergence is crucial to creativity as it ensures the creation of multiple ideas from one idea. Multiple ideas can prove helpful to solving problems in that series of solutions are provided and the problem is seen attacked using multiple solutions. It can be likened to triangulation in which multiple referents are used to address a situation. Take for instance to solve an engineering issue, many ideas are generated which has the possibility to influence solving the issue.

Divergence is important in problem solving by proffering various solutions, making unexpected relations, applying the known in ways unusual and this manifest in unexpected implications. There are many engineering problems that can be solved by convergence and divergence. What's vital is the solid understanding of both and selecting the best applicable in situations.

Basically, divergence is the process of aggregating various solutions for a given challenge while convergence is the critiquing and evaluation and selection of an accurate solution predicated on constraints and other factors (Liu, Zhiqiang, and Dieter J. Schonwetter., 2004: Cooperrider, Bryan, 2008:, Basadur, Min, *et al*, 1990) Both are needed cognitively to proffer new solution to problems and as revealed in ABET guidelines, it is also one of the vital skills to design an engineering solution to a given open problem.

Convergence and divergence are also related to creativity and it will be explored broadly. It is also important to understand that engineering has as its basis creativity which can be facilitated by thoughts hence convergent and divergent thought. Convergent thinking is also known as logical, conventional or vertical thinking which explores the possibility of a unique answer as the correct solution to the problem in knowing the solution. Divergent thinking on the other hand is the generation of various solutions to a problem using different perspectives. It is noteworthy to bear in mind that most amazing engineering discoveries and masterpieces were gotten through causal observations, accidents, mistakes and mood (Vidler, 1974). In creative production like in engineering, convergence and divergence are important as one first allow multiple ideas across and then the ideas are evaluated narrowed and refined through convergence. It is thus important to understand both divergence and convergence and how to navigate through the two for achieving predetermined goals and purpose (Basadur, 1990)

In engineering disciplines, the focus is on proffering solutions to various challenges of the world and in doing this, engineers utilize processes like engineering design, requirement gathering, analysis, design and implementation. In doing this, both convergence and divergence are important thus enhancing creativity and the quality of the outcome. This underscores the importance of convergence and divergence in engineering education in Africa. This is more important as the region is plagued by various challenges that will be more inimical in the future. This is manifested in various dimensions like extreme poverty, dependence on primary production, poor infrastructures, poor health, backwardness, poor leadership, insecurity and violence. Thus, the distinction between the developed countries of the world along Global North and Global South dimension with major comparison between the two dimensions revealing various indices of development and underdevelopment.

CONCEPTUALIZING CONVERGENCE AND DIVERGENCE IN ENGINEERING EDUCATION IN AFRICA

As it has been noted that the basis of engineering education is creativity which is important in proffering solutions to the challenges of the world. With the happening that is occurring in various parts of the world, regions and cities will be more predisposable to vulnerability and poor ability to address the challenges. This is more prevalent and it will occur at a scale different from the previous epoch because of globalization which has encouraged interconnectivity. This requires solutions along with the technological, economic, environmental and social spheres in solving these challenges. To understand and solve these challenges, the dilemma is choosing between convergence and divergence which is simply choosing from the most appropriate solution to a problem or series of alternative solutions. This, therefore, necessitates a look at convergence

and divergence in engineering education in Africa.

Engineers are critical in solving problems and one of the basic definitions of engineering revealed that it is the study and application of science and technology to solve problems and satisfy human needs using ingenuity predicated on techniques, models, methods, design etc. while engineering education is the process in which the knowledge of engineering is being transferred to students. To solve the challenges that occur in the world and to meet human needs, the dilemma is now in choosing between convergence and divergence which offer different approaches to issues. Patterns of convergence and divergence focus on the study of how to plan and organize resources and knowledge (Baskerville, Pawlowski, & McLean, 2000), using a single approach or varieties of approaches.

Taking a reference from convergence first, it focuses on the logical, conventional solution or unique solution to problems. This attempt at providing a solution to problems only considers the best alternative. In doing this ingenuity, logic and other cognitive approach comes to play here in consideration of the multiple options. Selecting the most apposite alternative doesn't just come by in engineering education. It has its own rigor and mental exertion so as to guarantee that the most optimal choice is considered. With convergence tilting towards the union of two or more things, consensus, integration and agreement are important. Also, from convergence, the focus is on selecting the single most applicable solution which also has its drawback such as not allowing lateral thinking, brainstorming and engagement that can generate other divergent ideas to then tilt towards convergence in selecting the best applicable idea based on judgment. Meaning, interpretation and principles.

Divergent thinking is pointed out by various authors as a generator of different solutions to a problem. It is important to note that perspective influences decisions and actions to take in addressing them and diversity is vital in this context. Take for example, in engineering, getting to a height in a building can be achieved using an elevator or the staircase is a problem that must be solved. As engineers proffer solutions to challenges, making the decision to choose between the elevator or staircase becomes a dilemma. This bi-directional approach to solving problems is good as it allows for consideration of options. In divergence, engineering education problems are seen from different directions. Hypothetically and from a logical standpoint, one can select the elevator because of the speed, comfort and luxury it guarantees while another might select the staircase for reasons such as to exercise and burn calories, enhance nervous coordination and muscular reflex and some other reasons.

Also, evidence from some authors revealed that divergence generates a large number of ideas with a focus on quantity and not on quality (Liu *et al*, 2004: Cooperrider, 2008: Basadur, 1990). This has a consequence on engineering education as the focus is on solving problems. While convergence has a connection with critical thinking, systematic decision making based on judgment. This distinction between the two showcases what the outcome of both convergence and divergence will look like. One focuses on large numbers while the other focuses on critical thinking and sound decision making.

Homogeneity and heterogeneity can also be used in understanding convergence and divergence in engineering education. Convergence offers a narrow single perspective to engineering issues while divergence relies on a multiplicity of ideas in addressing engineering issues. What becomes a challenge now in convergence is the ability to determine the best alternative out of multiple options which might be subject to people's interpretation and elusivity. Perception is king in decision making to select the best option from a variety of other competing options and this is predicated on individual interpretation. What's A to someone might be B to another person when subjected to mental rigor and perception which

makes converging towards homogeneity herculean in engineering education. Heterogeneity on the other hand offer multiple approaches to addressing engineering education issues and with multiple approaches, there are multiple challenges to face which can include which of the multiple approaches will be applicable in addressing an engineering challenge. The problem of choice in each dimension is a valid one and this depends on a variety of factors that I have stated about such as individual perspective and interpretation, logic, and other cognitive elements that influences the decision making. With the need for creativity which is crucial in engineering. Convergence and divergence are important which can help in generating new or innovative solutions to various problems of the world. This is in line with ABET guidelines which revealed that convergence and divergence are important thinking skills that can help in developing engineering design competency. This is necessary because students need to have an engineering solution or product by coming up with various potential solutions from multiple perspectives and having a thorough judgement and evaluation of the solution. The problems in computer science and engineering education require convergence and divergent thinking skills which are crucial in software engineering, computer network etc where a solution is needed to solve a problem.

Conclusively, having considered convergence and divergence in engineering education, each has its own uniqueness and peculiarity which must be known before addressing issues. With creativity crucial in engineering education, both convergence and divergence are important in engineering education. There is therefore the need to integrate convergence and divergence in proffering solutions to challenges. This supports the argument of (Howard et al, 2008) who maintained that the fusion of divergence and convergence in each phase of the engineering design process can culminate in enhanced creativity and quality of the product designed. This is necessary because to solve a problem, there might be an infinite number of solutions to it but when addressed holistically, only one might be applicable and this ensures that new knowledge is provided and then divergence culminates and tilts towards convergence which makes the process bi-directional.

FINDINGS AND DISCUSSIONS

The life of an engineer each day is one poised with the need to answer various questions that seek to better human life. The world of an engineer is one where answers are provided to various challenges through innovation and creativity by applying the principles of mathematics, sciences and design. Each of the amazing masterpieces and technologies are seen in everyday engagement and interaction of humans were birthed as a result of curiosity of some people and the need to make systems, structures and processes better. As a result of time, these masterpieces and technologies are being built upon and more mastery of surrounding conditions has made them better but in providing solutions to challenges, the dilemma is in finding an appropriate solution or applying multiple solutions which is the convergence-divergence nexus.

Findings from the study revealed that convergence-divergence has been at the front burner of issues for long and various authors have made the case for each of the concepts as a result of their defining peculiarity and applicability. Most authors made the case for convergence as a result of similarity of culture and conditions ((Harbison & Meyers, 1959: Galbraith 1967) but it was refuted by some due to the impossibility of having convergence at all levels (Hofstede, 1991: House *et al* 2002). It is important to note that convergence might be impossible as a result of various conditions.

It was found out that it is important to understand both processes so as to ensure the selection of the best approach to issues and it was thus important to analyze both. It was found out by Merriam Webster Dictionary (2020) that convergence is moving towards union or uniformity or the independent development of similar characters (as of bodily structure or unrelated organisms or cultural traits) which is associated with similarity of habits or environment while

divergence showcases individuality and from the thesis, it was revealed that individuals within a territory will maintain their specific choices, thinking, mindsets, values, attitudes and behavior as time passes (Katz & Darbishire, 2000; Brewster *et al* 2015).

With various events happening in various parts of the world, it has been revealed that cities will be more vulnerable and predisposed to various challenges. This will come at a scale and pace unprecedented in history as a result of the technologies that are emerging with the new epoch, we are in an era known as the fourth industrial revolution. As a result of the fourth industrial revolution, it has given more impetus to globalization through improved interconnectivity. This necessitates provision to various challenges along technological, economic, environmental and social sphere using single solution or various methods which has been discussed above.

IMPLICATION

The impetus to address and solve issues necessitates the application of a single appropriate solution or multiple solutions to prevailing challenges. This comes as a puzzle to those in the know of proffering solutions to issues which is the purview of engineers. Thus, evidence provided in this discourse has shed light on the peculiarity of convergence and divergence and the reasons for applying a single appropriate solution to issues, or multiple solutions to issues. This is important to policymakers on production and design and in solving various issues which relate to engineering education.

CONTRIBUTION OF NEW KNOWLEDGE

This study has built on the evidence from various authors on convergence and divergence and the impetus for the application of each was considered. The purpose of this discourse is to bring in a new argument for the peculiarity and application of convergence and divergence in proffering solutions to engineering issues. It was also found out that there is the need to string convergence and divergence to ensure an appropriate solution to challenges.

CONCLUSION AND RECOMMENDATION

Divergence and convergence are important in open problem solving and finding appropriate solutions to problems. The life of an engineer is centered around proffering solutions to problems as revealed in the study above. Light has been shed on convergence and divergence and the applicability of each in providing solutions to issues has been considered. In proffering solutions to engineering issues, no solution is finite and the dilemma is on selecting between convergence and divergence which has been considered in this study. This study, therefore, recommends that there must be synergy between convergence and divergence to ensure an appropriate solution to challenges in engineering education.

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