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Design Thinking as the Answer to the Question of Relevance in Engineering Education in Africa

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Abstract: ***Relevance occur in various forms and across various disciplines. More often, it is a property of applicability. Changes in information, conduct, context, processes are occurring at a fast pace compared to time past which begs the question if engineering education is relevant and applicable to proffer solution that suits these changes. This research therefore seeks to conceptualize design thinking as the answer to the question of relevance in engineering education in Africa. Findings from the study revealed that the question of relevance is somewhat puzzling and none has been able to give an in-depth exegesis of the concept. The design thinking concept is a complex cognitive process and in engineering parlance, it is a systematic, intelligent process which is used by designers to generate, evaluate and delineate concepts which will be applicable for devices, systems and processes whose form and function must be to satisfy users objectives or needs while satisfying specific constraints. The study recommended that effort be intensified on engineering education to ensure relevance and proffer solution to socio-economic disorders in Africa.***

Keywords: ***design thinking, engineering education, engineering, relevance, Africa.***

I. INTRODUCTION

Relevance occur in various forms and across various disciplines. More often, it is a property of applicability which canalso include keeping up with time. According to the Merriam Webster Dictionary (2020), relevance was defined as a relation to the matter at hand or practical and social applicability. This definition has in it the essence of a discipline having a bearing to a matter currently considered and its applicability. As time passes, there are changes in information, context, conduct, and processes in various disciplines which must reflect practical and social applicability. Hence engineering education as a discipline has evolved over the years and with the massive changes occurring lately and the pervasive breakout of various technologies, it has the impetus to influence the discipline. It is therefore necessary to understand if the discipline is applicable to suit current trends and hence the impetus for design thinking as a panacea to the question of relevance in engineering education in Africa. Design thinking is a design methodology that is applicable in providing a solution-based approach to solving problems (Rikke Friis Dam *et al* 2020: Brown 2008).

From their definition, the design thinking process is along five dimensions and it is important for understanding human needs (empathy), reframe problems in human-centric ways(define), create many ideas through interaction (brainstorming), adopting a hands on approach (prototyping) and lastly testing. This implies that the approach is critical for proffering solution which can contribute to the ideals of engineering education. Engineering education is a discipline that seeks to provide solution to various human challenges and elements of the design thinking process are applicable to ensure relevance in engineering education in Africa. Changes in information, conduct, context, processes are occurring at a fast pace compared to time past which begs the question if engineering education is relevant and applicable to proffer solution that suits these changes. Design is one of the peculiarities of engineering (Simon, 1996) and there have been various agitations for engineering programs to produce graduates that can design effective solution to various social needs (Sheppard S.D, 2003). Design thinking showcases the processes of inquiry and learning that designers perform in a systems context while making decisions as they continue to work collaboratively in a social process and communicating in various languages with each other. This research therefore seeks to conceptualize design thinking as the answer to the question of relevance in engineering education in Africa by first understanding the dynamics of engineering education in Africa, and deconstructing the concept of relevance in engineering education

II. THE RESEARCH GAP

With engineering education being pivotal for social and economic development in Africa (Matthews *et al*, 2012), Africa as a region has not been on the path of sustainable social and economic development. This is manifested in widespread poverty, hunger, dependence on primary sector of the economy, poor infrastructures, poor economic systems, social instability, and poor leadership. Much more than this, Africa has the potential for social and economic development but the region has not really kept pace with global development as a result of various factors. The widespread fertile land for agricultural production, the massive deposits of natural resource, freedom from natural disasters etc. confers much opportunity for social economic development in Africa. with this knowing, it is essential to question the relevance of engineering education in Africa.

Hence, there is a wide gap between engineering and socio-economic development which necessitates the need to question the relevance of engineering education in Africa. Relevance is all about applicability and it is important to note that Africa as a continent has serious issues to deal with as a result of changes in the environment manifesting as climate change,

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changes in the economy, shift in demography, changes in culture etc. which therefore necessitates the need to conceptualize design thinking as the answer to the question of relevance in engineering education in Africa. This research paper seeks to deconstruct the relevance concept in engineering education in Africa, understand design thinking and then conceptualize it as a panacea to the question of relevance in engineering education in Africa.

III. METHODOLOGY

The research methodology is an approach that seeks to showcase the pathway through which the research was conducted and Remenyi *et al* (1998) notes that research methodology is the logic of the development of the process used to generate theory or the procedural framework within which the research is conducted.

With the various concepts embedded in this research, evidences from relevant scholarly literature were considered to support the study. To guide the literature search, keywords such as relevance, design thinking and engineering education were entered as search terms. Relevant materials were identified from the search result and then thematically analyzed to identify patterns and similarities. Some of the sources include journal articles, research publication, websites, magazines and newspapers, evidences from international organizations, and government report. With the rigour of time and economic constraint associated with primary research, this study adopted a theoretical approach to review literatures pertaining to the concept of this study.

IV. LITERATURE REVIEW

Deconstructing relevance in engineering education in Africa

From the Merriam Webster Dictionary (2020), relevance was defined as a relation to the matter at hand or practical and social applicability. This definition emphasizes a connection to issues that are currently happening. This has in it a relation to time. It is of essence to understand what relevance is because it shows applicability and social acceptance. Any endeavor that will have meaningful impact must be characterized by practicality and social applicability.

The question of relevance is somewhat puzzling and none has been able to give an in-depth exegesis of the concept. Relevance has been termed a tyranny by social scientist Flinders M (2013) as a result of its ubiquity and multifarious nature.

The concept according to him has been constrained by an inability to draw any major theoretical reflection on what it entails. From evidence from literature, the question of relevance is an inquiry aimed at a problematic situation seen as a state of crisis which relates to societal challenges as a result of various processes which include social, political, economic, ecological, and technological effects of a globalizing world (Vinulus Declaration, 2013).

This implies that as a result of some externalities such as the social, political, economic, ecological, and technological effects of a globalizing world, there is the need to ensure relevance. Also, according to Edglosarry.com (2013) the term relevance in educational parlance has to do with learning experiences that are either directly applicable to the personal aspirations, interests or cultural expectation of the learners or that has to do with the larger society which include real-world issues, problems, contexts (life relevance).

With the various approaches to understanding relevance, concretizing what it entails holistically becomes challenging. With no general consensus on what relevance entail, I will make the case for social, cultural, political, economic, environmental and contextual relevance in engineering education in Africa.

In understanding the question of relevance in engineering education in Africa, there must be social, cultural, political, economic, environmental and contextual applicability. These dimensions of the human sphere will be briefly considered to understand the question of relevance in engineering education in Africa.

With humans being social animals, needing companionship and living together in a geographical space, the practice and conduct of engineering education must be that the social dynamic of humans is factored in and be made relevant to it. In demystifying the social dimension, there are various elements to it such as interaction and group dynamics, exchanges, culture etc.

The practice and conduct of engineering education must be that the multidimensionality of the social sphere is considered while also being applicable to them. Engineering education must be applicable to the culture of people, influence their interaction and shape their exchanges positively so as to ensure relevance.

In culture, take for instance, in time past, communication was informal where symbolic social tools were used in communication. The use of town criers with metal gongs, smoke in the bush for determining location and direction, sitting at night by the moonlight and listening to tales and folklores has changed as a result of some technologies that emerged from engineering such as better communication devices. This has influenced the social sphere positively and people across various geographical divide can communicate without any hassle. Also, the housing patterns in various areas reflect the culture of the people.

Take for example the housing system in the South and Western part of Nigeria in Africa.

The engineering processes in such country must consider the culture of people and take it into consideration to ensure that the discipline is relevant.

The output of engineering education in this context must consider the culture of people, their language, arts, dressing, communication, housing etc. to be relevant.

Engineering education in a clime must be relevant to the political atmosphere.

The political processes evoke the demands for some processes which engineering education helps to facilitate. The policies, directives and processes in a political clime is also predicated on engineering education.

Policies in production, education, legislation, trade and commerce are all influenced by the dynamics of engineering education and engineering education must be relevant to such process being applicable to them.

This also implies that engineering education must be politically relevant in the societies in Africa.

The question of relevance of engineering education in the economy cannot be trivialized. The economic systems of the world are one dependent on production, distribution, trade and consumption of goods and services by different people. A cursory look at these elements will reveal that they have in them a dimension of engineering which must be made relevant to encourage social-economic development in Africa. It has been revealed by Mattews *et al* (2012) that engineering is vital for social economic development of nations but this has not really been the case for countries in Africa. As a result of many factors, engineering has not been leveraged on effectively too culminate into social-economic development in the region compared to countries in the Global South that has highly developed technological infrastructures which has positively affected their social economic sphere. This then begs the question of the applicability of engineering education on the economy of Africa. Lastly, the environment is the sum total of all factors that affect humans and it is anything that surround humans. The environment is dynamic assuming changes as humans gained more mastery of it and as civilizations progressed, the environment has been influenced. With the import of engineering education on the environment, it has helped in shaping the environment and improving on it while also contributing negatively to it. We are now in an era of widespread environmental imbalances that has influence on the biodiversity in the ecosystem. The scourge of climate change which is manifested in various dimensions such as drought, flood, heat wave, desertification, erosion, proliferation of diseases, etc. requires the applicability of engineering education which is a question on the relevance of the discipline. The conduct and context in which events take place has also changed and this requires new approaches from engineering education to address these changes and hence the question of relevance.

V. UNPACKING THE DESIGN THINKING CONCEPT

The design thinking concept is a complex cognitive process and in engineering parlance, it is a systematic, intelligent process which is used by designers to generate, evaluate and delineate concepts which will be applicable for devices, systems and processes whose form and function must be to satisfy user objectives or needs while meeting specific constraints Clive L.D (2005). This definition captures some of the essences of the design thinking concept in that it is a smart process where there is the application of intellectual rigour to design, evaluate and specify concepts which will be useful for systems, devices and process to meet predetermined objectives and goals while also satisfying specified challenges. The concept emphasizes a thoughtful, intelligent, systematic generation of design concepts and specification to satisfy specific constraints (Dym C.L 2003: ,Dym C.L, 1994). It is different from creativity which is also important to engineering education and in it, there's a degree of intentionality, such that the designer has a client who also has a customer with a set of users in mind that will benefit from the design process and design tools been developed. In design thinking, some approaches and skills are vital to the overall design process such as questioning which has been labelled as an integral part of design. It is thus important to understand divergent-convergent dynamic to questioning in design thinking.

According to Dym C.L (2003), asking questions is the major step in any project or class in the problem definition stage. The educational content in today's engineering curricula is basically epistemological in which questions are asked systematically and proven principles are applied to analyze real issues and proffer testable, verifiable answers. The systematic questioning in the educational content in engineering curricula applies to the design context dynamic and some of the ways that have been reputed to aid designers include asking questions and proffering answers to the questions asked as the whole design process is unraveled. Basically, various kinds of questioning take place at various levels in the design process. Taking reference from Aristotle`s saying, the kinds of questions we ask are as numerous as the kinds of things we know (Aristotle, 1994). This emphasizes that there is much knowing in asking questions and in the process of providing answers, knowledge is built up. Though, the types of questions asked according to Aristotle's revelation must be ordered which reveals a procedural approach to the epistemological process. Evidence from literature suggests that the occurrence of a specific array of questions which were referred to as deep reasoning questions has positive correlation with student learning as shown by test score (Eris O, 2004). Systematic inquiry in the design process is somewhat related to epistemological questioning and the notion conceived is that there are specific answers for a given sets of questions and this highlights convergence, a situation in which the inquirer attempts to converge on and highlight facts. In the same vein, questions that arises in the design process, have various alternative known answers as well as various unknown possible answers. And the inquirer seeks to reveal the various known answers and to generate the unknown alternatives which is a characteristic of divergent thinking where the inquirer moves from tested, provable facts to various other possibilities that emanates and according to Eris O (2004), these types of questions are called generative design questions.

It is thus important to understand that convergent questions take place in the knowledge domain while divergent questions take place in the concept domain which typifies that design thinking is a continuous process of transformation from the concept domain to the knowledge domain and these questioning and thinking adds to the bank of engineering knowledge (Viventi, W.G (1990). It is thus essential to note that the revelation of deep reasoning questions and generative design questions has correlation with performance in designing solutions (Viventi W.G, 1990).

Thus, to ensure effective inquiry in design thinking, there must be a buildup if asking deep reasoning questions starting from systematically lower questions, convergent questions and a divergent dimension where generative design questions are applicable to create the basis for which the convergent component can act on.

Conceptualizing design thinking as a panacea for relevance in engineering education in Africa

With various changes taking place globally, ensuring relevance in engineering education is important so that the discipline will be applicable to such changes.

It has been revealed above that as a result of social, economic, environmental, technical, ecological changes, there is the need for relevance in engineering education.

To ensure relevance, the design thinking process encourages complexity in engineering products and systems which has the impetus to increase the number of components and their interconnectedness (Reynolds D *et al*, 2002).

Design thinking in engineering has been reputed to be a beneficial approach for proffering solution to some of the society`s complex engineering challenges (Blizzard 2013: Brown,2008).

This implies that by the apparatus of design thinking, it can ensure relevance in engineering education.

It was revealed by the National Academy of Engineers and major players in engineering education that having engineers who are design thinkers can help to solve complex, open ended and wrongly defined societal problems (Dym et al 2005: Brown, 2008).

These are huge testament to the efficacy of design thinking as the solution to the question of relevance in engineering education which will be considered.

Brown (2008) who is a major player in the global design company IDEO noted that design thinking is a human centered, creative, iterative and pragmatic approach to finding the apt solution to the world`s challenging problems. In his work with IDEO, he made the case for the popular design thinking process and the process include empathize, define, ideate, prototype, test (Brown 2008).

With various perspectives on design thinking, Brown (2008) definition of the concept and the process of design thinking will be conceptualized as a panacea for relevance in engineering education in Africa.

Taking a reference from Brown (2008) definition of design thinking, the concept is first a human centered one. To ensure relevance in engineering education in Africa, there must be a human centered approach to solving the challenges that stares the region in the eye.

Having a human centered approach to engineering education will ensure that humans are at the basis of any solution to prevailing challenges in the region which will ensure that their input in terms of intellection and cognition is factored into the whole mix.

The takeaway from this is that any engineering education process must first have it in mind that humans are the focal point of such agenda which in the long run can culminate in relevance for the discipline. It is important to note that devices, systems and processes are meant for humans and they at all-time should be first considered in any engineering intervention to ensure relevance.

Having a repetitive process can also ensure that things that were not seen before would be noticeable in the process. This is a dimension of iteration and basically it denotes repetition or frequentative approach.

Having an iterative approach to engineering education will ensure that the desired result is achieved by following a repeated cycle of process.

No solution is finite and this should be the goal of engineering educators. Any device, system and process can be made better and iteration as a constituent of the design thinking is important to achieve this.

This in the long run will ensure that the solution best possible is designed by engineering educators which guarantees relevance.

According to the Stanford encyclopedia of philosophy (2008), Pragmatism is a philosophical tradition which stipulates that all concepts should be tested by scientific experimentation and that such concept is applicable if it is only useful.

This definition emphasizes practical, workable solution to issues. Encouraging pragmatism in engineering education will ensure that workable and tested solution to issues will be provided which can contribute to relevance in engineering education.

Furthermore, creativity is also a major step in designthinking by Brown (2008). It is important to first understand what creativity is and how it can result in relevance for engineering education in Africa. creativity is not only confined to the arts but it has application in almost all disciplines.

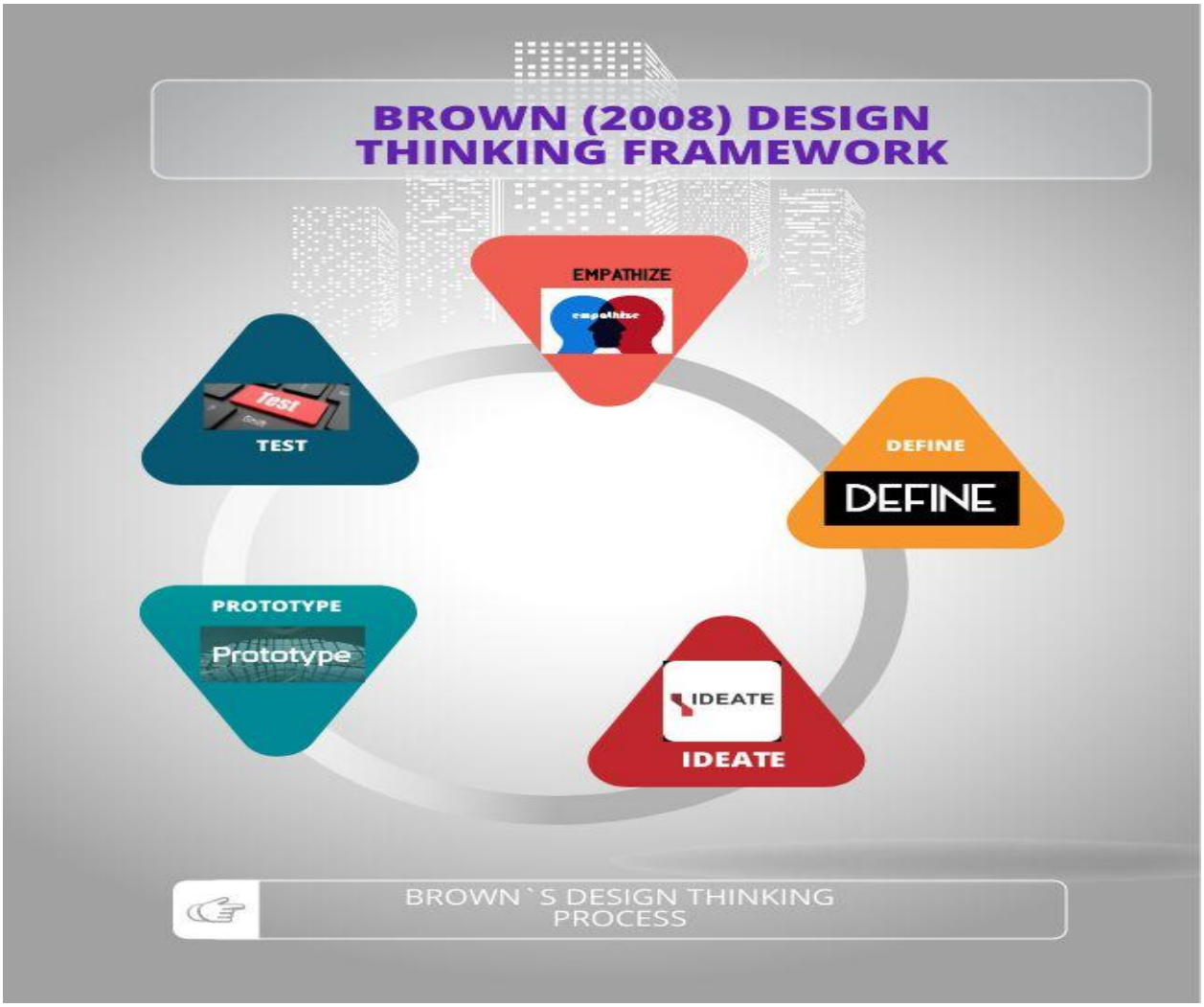
Creativity involves doing things in ways that are novel and effective in achieving desired result. This implies that a creative person finds new and effective ways to providing solution to various challenges.

Relevance in engineering education has a connection with prevailing issues. Any solution to be developed to solve a problem must be applicable to the current time and trend and by being creative, new and effective solutions are provided to engineering education in solving the problems of the society.

Having a new and effective approach to proffering solution as stipulated in the definition of design thinking will ensure relevance in engineering education in Africa.

To conceptualize design thinking as a panacea to the question of relevance in engineering education in Africa, the definition of design thinking and its processes by Brown (2008) was used in lending support to the argument. Brown's framework was considered because Brown is a leading figure in design thinking within the design industry (Brown, 2008).

Also, Dym*et al* (2005) had major influence on design thinking and his thesis were also considered. The popular process of design thinking by Brown (2008) include empathize, define, ideate, prototype, test.



Design thinking is a human centered approach and empathy is a major consideration in this context. The design of any system, process or structure must be that humans are first considered and to ensure relevance, there is a need to understand other peoples feeling as if one is having it personally. This will ensure that solutions to engineering challenges will not just be provided haphazardly. A thorough understanding of what people feels, their emotions and the ability to imagine what others might be thinking or feeling is considered in any engineering education process. Having this approach to the discipline is necessary for achieving human relatedness and interconnectedness which will also ensure that solutions are not provided apart from people, their emotions and their felt need hence, culminating in relevance for engineering education in Africa. At this stage a mass of data and information is collected which is applicable for use in the next stage to influence the process.

Your observation from the first stage in the design thinking process must be synthesized to define a problem. While defining, a problem statement must come to the fore. To define as a process in design thinking has the impetus to break down or in simple terms analyze concepts that are critical to the discipline. When you define, you try to understand concepts and problems so as to be able to better understand it and this is a major process in design thinking. Defining brings forward direction, clarity and focus in design thinking. Take for instance, in designing a solution for an engineering challenge, it is important first to define what the challenge is. In defining, the problem is solidified to better understand it. This will ensure that all elements pivotal to it are understood and comprehensible to all involved and this will ensure that appropriate solutions are provided to solve that challenge thus ensuring relevance in engineering education. At the define stage, evidences from various sources are organized, interpreted and used to create a piece.

With an understanding of the users of a system, process or structure through a human centered approach, information has been gotten to define what their problem is which will lead to the generation of new ideas. This will consequently lead to interaction among stakeholders on the need to think outside the box to identify solution to problem statement that was predetermined. Ideate is the third phase of the design thinking process and it involves generating new ideas through a process called ideation. Generating new ideas is applicable in design thinking because it depends on an avalanche of information gotten from having a human centered perspective to issues and then defining problems thus ensuring relevance because it helps in understanding the problem and how to solve it. Ideation is critical to better understand the opportunities that is inherent in solving a problem while also taking input from various sources to achieve better solution.

Prototyping implies that you create a graphical representation of the idea which can help boost the ideation process. In this stage, series of less expensive version of a product or features in a system, structure or process are produced to address the problems generated in the previous stage. In this stage also, visualization is important in engineering education and it helps to see how a solution will work, what are the processes to be followed in solving the problem, and also the outcome and feedback that can make the outcome better which has the impetus to culminate in relevance for engineering education. Solution to problems in engineering education thus must be provided within prototypes and then investigated to know which worked and which did not work.

Testing is basically the process of generating feedback as related to the prototype and gaining insight about the prototypes developed and having more understanding about the users. The complete product is ascertained by using the best solution identified in the prototyping stage. It is the last stage in design thinking and it is also iterative. The results generated in this stage is applicable in redefining the problems through a human centered approach. It can proffer insight that result in better solution to the problem. These processes have the capacity to ensure relevance in engineering education.

There are five key traits that contribute to a design thinking mindset: empathy, optimism, integrative thinking, collaboration, and experimentalism (Brown, 2008). These all when analyzed has more import in contributing to relevance in engineering education. Empathy ensures that other peoples feeling and emotions are considered in engineering processes, while optimism fuels the expectation that a process, system or structure will get better. Integrative thinking ensures following a holistic approach to understanding issues as it relates to engineering education which can then contribute to relevance while collaboration deals with having synergy between all important to the process and experimentalism introduces pragmatism to the approach.

Conclusively, with the need for engineering educators to widen their boundaries of knowledge to include environmental and social impact in their designed systems (Hastings D, 2004), design thinking can thus ensure relevance. With more skills pivotal to coping with complexity, it encourages much mastery of the social and environmental factors that affects humans. Design thinking also encourages thinking about systems dynamics and unraveling the unforeseen circumstances that might occur in multiple parts of a system. Having this foresight as a critical component of design thinking ensure relevance in engineering education in Africa. engineering education is a complex discipline that has in it lots of systems, process and structures and having a design thinking approach to it will ensure that systems dynamics are factored in. Dealing with uncertainties and making estimates in engineering education which occur as a result of a large number of variable and interaction necessitates a design thinking approach to ensure relevance in engineering education. According to Dym C.I (1994): Fleisher A (1992): Brown K.N *et al* (1995)the languages used in design can also influence design thinking and therefore ensure relevance in engineering education in Africa. languages are means of communication which influences processes and the essence is captured below as relates to engineering. These languages of design can ensure relevance in engineering education in Africa.

_Verbal or textual statements used to articulate design projects,
describe objects, describe constraints or limitations, communicate
between different members of design and manufacturing
teams, and document completed designs;
_ graphical representations used to provide pictorial descriptions
of designed artifacts such as sketches, renderings, and engineering
drawings;
_ shape grammars used to provide formal rules of syntax for combining simpler shapes into more complex shapes;
_ features used to aggregate and specialize specified geometrical
shapes that are often identified with specific functions;
_ mathematical or analytical models used to express some aspect
of an artifact's function or behavior, where this behavior
is in turn often derived from some physical principle(s);
and
_ numbers used to represent discrete-valued design information
(e.g., part dimensions) and parameters in design calculations
or within algorithms representing a mathematical
model

VI. FINDINGS AND DISCUSSION

Though relevance is a word used often by people, there is a dearth in the theoretical definition of the concept. Findings from the study revealed that relevance as a concept is somewhat puzzling and researchers have not been able to comprehensively address the concept. Few evidences from literature were considered to shed light on relevance as a concept. The Merriam Webster Dictionary (2020), defined relevance as a relation to the matter at hand or practical and social applicability. This further implies that as a result of changing conduct and context, the social, economic, environment, political, educational sphere is experiencing massive changes which necessitates having relevant solution to them.

Findings from the study also made the case for social, cultural, political, economic, environmental and contextual relevance in engineering education in Africa.

Findings from the study also revealed that design thinking has in it elements of creativity but they are different. It was found out that design thinking is a highly intelligent concept as depicted in the definition of Clive (2005) who defined design thinking as a complex cognitive process and in engineering parlance, it is a systematic, intelligent process which is used by designers to generate, evaluate and delineate concepts which will be applicable for devices, systems and processes whose form and function must be to satisfy users objectives or needs while satisfying specific constraints.

The process of design thinking according to Brown *et al* (2008) were conceptualized to ensure relevance in engineering education and the processes areempathizing, define, ideate, prototype, test. Also, the definition of design thinking by Brown (2008) contains in it vital elements such as human centered, creative, iterative and pragmatic approach where considered and conceptualized to ensure relevance in engineering education in Africa. some other evidence from relevant researchers in the line of design thinking were also considered to support this study.

Findings also revealed that with the design thinking process being iterative, it allows for flexibility and flexibility will ensure that dynamism in systems, processes and structures are considered which will ensure relevance in engineering education in Africa. It also allows an interphase of communication between designers and users which proffer ideas to real life challenges and how the real user of an intervention is affected.

VII. CONTRIBUTION OF NEW KNOWLEDGE

Engineering education is key to social and economic development in Africa and it must be relevant. This paper has considered design thinking as the answer to the question of relevance in engineering education in Africa. The contribution of new knowledge in this paper include addressing relevance through social, economic, environmental and technical dimension to engineering education in Africa. Secondly the paper built on the definition and process of design thinking by Brown (2008) and it was analyzed as a panacea to the question of relevance in engineering education in Africa.

VIII. RESEARCH IMPLICATION

With the design thinking process being built upon and its applicability to engineering education established, it can pave the way for more empirical and theoretical research on design thinking. The processes have been outlined by various authors and there is a need to ascertain its applicability and veracity across various disciplines which engineering education is a part of.

IX. CONCLUSION AND RECOMMENDATION

Engineering education over the years has been pivotal for building the world we inhabit and helping humans survive but as time passes, it is necessary to understand if the discipline is applicable to suit current trends and hence the impetus for design thinking as a panacea to the question of relevance in engineering education in Africa. This research conceptualized design thinking as the answer to the question of relevance in engineering education in Africa using.To conceptualize design thinking as a panacea to the question of relevance in engineering education in Africa, the definition of design thinking and its processes by Brown (2008) and Dym et al (2005) was used in lending support to the argument. the concept of relevance was examined in engineering education and various reasons to ensure relevance in engineering education was considered. Evidence from other scholars were also considered to understand and conceptualize design thinking for relevance in engineering education in Africa. It is of essence to understand what relevance is because it shows applicability and social acceptance.

Any endeavor that will have meaningful impact must be characterized by practicality and social applicability. In understanding the question of relevance in engineering education in Africa, there must be social, cultural, political, economic, environmental and contextual applicability. These dimensions of the human sphere were considered to understand the question of relevance in engineering education in Africa.

The study recommended that effort be intensified on engineering education to ensure relevance and proffer solution to socio-economic disorders in Africa.

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