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Criticality of Computer Aided Design Packages in Engineering Education & Professionalism for the Developing Countries: Issues and Perspectives

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---***Abstract***---

Engineers all over the world are known for their creativity, innovations and ingenuity in harnessing the resources and forces of nature for the benefit of mankind. No doubt, engineers in some parts of the world have done so well in view of their giant and mind throbbing technological breakthroughs, while some other parts of the world are at the receiving end of the products of engineering technology. This paper underscores the importance of Computer Aided Design (CAD) in Engineering while calling for a wake-up and real-time embracement of CAD technology by the developing countries. The objective is to re-echo the indisputable fact that CAD represents the most critical part of modern engineering training curricula and by extension, the most important aspect of engineering professionalism. The need to step-up academic training of CAD systems users to better align and measure-up with continuing evolutions in modern day CAD driven engineering is summarily emphasized.

Keywords: *Computer Aided Design, Engineering Education, Developing Countries, Design Implementation*

1. Introduction

Computer Aided Design (CAD) refers to the application of computer systems in the design of components and assemblies. CAD is a very crucial industrial art used extensively in many fields and applications ranging from Architectural designs to very complex mechanical, electrical and mechatronics systems designs. CAD isn't just limited to the creation and modification of designs; but extends to rendering, analysis, optimization, animation and simulation of designs (Dassault Systèmes, 2014). It can also be employed in the planning of the entire production line. This means, CAD can be used throughout the engineering process from conceptual design and layout of products through strength and dynamic analysis of assemblies to definition of manufacturing methods and material specification. These extended capabilities inherent in most modern CAD software have been leveraged upon in revolutionalizing engineering graphics.

Engineering designs and graphics are the dominant means of communication among engineers in industry and academia. Even highly developed word languages are inadequate for describing the size, shape, and relationships of physical objects. For every manufactured object, there are engineering drawings/designs that describe its physical shape completely and accurately. With the introduction of Computer Aided Engineering (CAE), the boundary of engineering design has expanded because of various ways and manners in which the computer can be used to generate engineering graphics (designs, drawings or pictures) and in the handling of specific engineering tasks (Terence et al, 2018; James, 2005).

Computer Aided Design is always used alongside Computer Aided Manufacturing (CAM) because of the desirability to perform the "art-to-part" procedure. In other words, integrated system of CAD/CAM results when a CAD package is interfaced with manufacturing machines (Sharma, 2007). Designed components, tools, machinery, etcetera may be presented as 2D drawing or 3D Solid models. Benefits associated with CAD technology are numerous. They include: precision, lower product development cost and shortened design cycle; ease of storage, retrieval, transmission and modification of designs just to mention but a few.

According to O'Sullivan and Sheffrin (2003), a developing country (also referred to as less developed country, less economically developed country or underdeveloped country) is a country with a less developed **industrial base** and a low Human Development Index (HDI) relative to other countries. Worthy of note is the fact that the term "developing" describes a currently observed situation and not a changing dynamic or expected direction of progress. Although these countries are listed under the World Bank Country Classifications and based upon the United Nations Sources (http://data.worldbank.org/indicator/NY.GNP.PCAP.CD), a key benchmark factor used in the determining yardstick for classification is the robustness of a Country's industrial base. In view of the intertwined nature of industries with engineering professionalism, it stands to reason and rightly too that backwardness in engineering and technology is predominantly responsible for the underdeveloped status of most countries of the World. Computer Aided Design has been identified as the hub of modern engineering technology extensively used by the developed countries; hence its criticality in engineering education for the developing countries cannot be over-emphasized.

2. Nature of Engineering Designs

"Design" refers to the formulation of a plan for the satisfaction of a specific need or to solve a specific problem. The plan may result in the creation of something having physical reality, in which case the product must be functional, safe, reliable, competitive, useable, manufacturable, and marketable (Richard and Nisbett, 2011). Engineering design is a complex process, requiring many skills. Extensive relationships need to be subdivided into a series of simple tasks. For Mechanical engineers and technologists involved in designs, the skill and knowledge base must be extensive as mechanical engineering design involves all the disciplines of mechanical engineering. More so, the designer's personal resources of creativeness, communicative ability, and problem solving skill etc are key to effective designs as these must be intertwined with the knowledge of technology and first principles.

For the design of most Civil works with high structural integrity, the designer(s) must consider wide range of possible ***failure modes*** and at the same time pay attention to applicability of relevant ***theories of failure.*** Effects of corrosion, vibrations, high temperatures and stresses must be carefully weighed against the nature of materials specified for use (Obike et al, 2017; Okonkwo et al, 2018; Okokpujie et al, 2018; Nwoke et al).

Engineering design progresses from identification of a problem to solving a need as the flowchart in figure 1 below indicates.

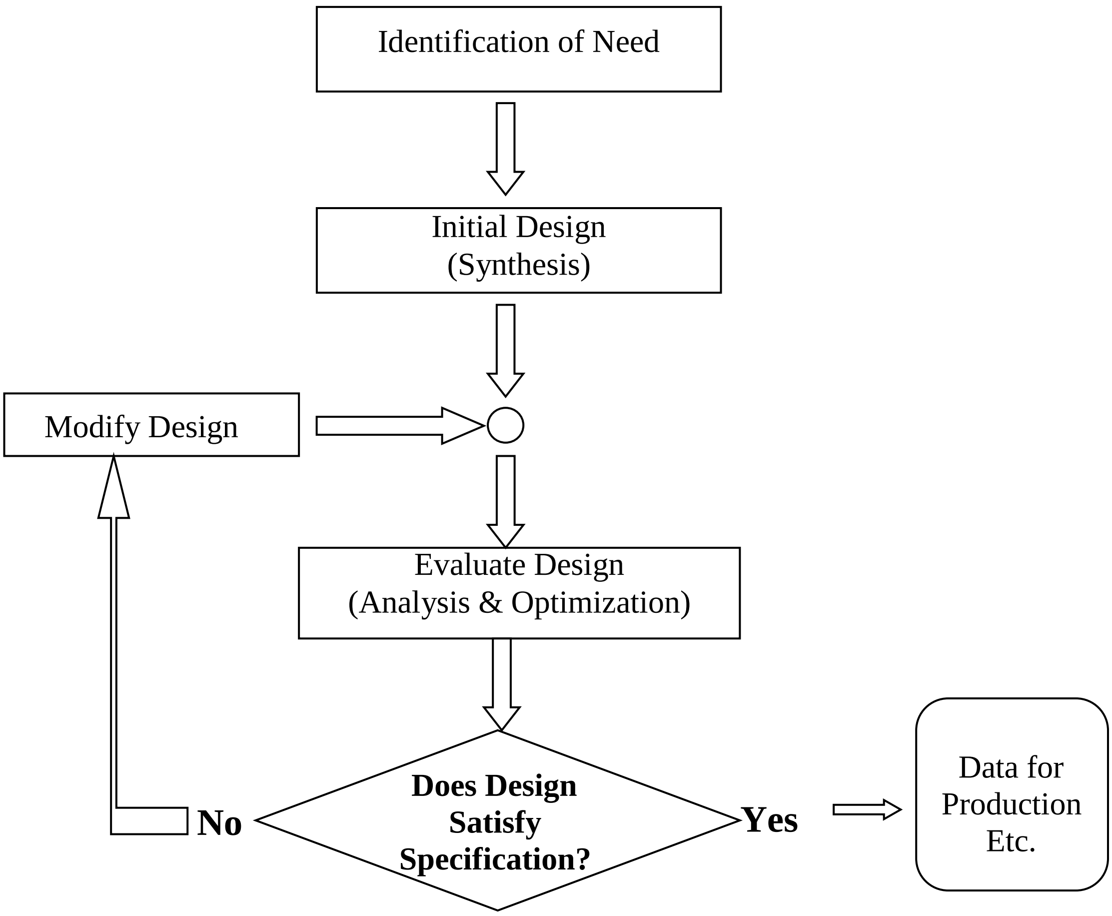

Fig.1: Typical Design Process Flowchart

There are many of such engineering design process models, each being accustomed to a family of engineering problems that are identical in nature (Massachusetts Science and Technology/Engineering Curriculum Framework, 2016). Design, as a process, is highly innovative and often iterative. It is a decision-making process. Decision has to be made sometimes with too little information, hence the engineering designer has to be personally comfortable with a decision-making, problem solving role.

Engineering problems and designs across the globe vary widely in their nature, degrees of complexity, and according to fields and applications. Thorough evaluation of the interaction of materials selection, design and manufacturing processes must be done if the engineering goal of manufacturing or production must be achieved. Implicit in this statement is the generation of parts from selected

materials, with internal structures and companion properties that have been optimized for the specific service condition and environment that the product must withstand. The 'ideal product' is one that is "just good enough".
Anything better will usually incur added cost through higher-grade materials, enhanced processing, or improved properties that may not be necessary. Anything worse and we may encounter product failure, dissatisfied customers, and possible unemployment (Ronald, 2012).

In the case of most developing Countries, there has to be steady and persistent inputs from stake holders of engineering professionalism towards the establishment of local technologies that would metamorphose into world-class standards. Continued over-dependence on the use of foreign technological products has remained the bane of most of the developing Countries. Coordinated under-study and reverse engineering of low and medium caliber technologies is a necessary step if the referenced countries must revolutionalize their engineering and technological base. This is where CAD comes in. However, it is the duty of every government (on one hand) to set out curriculum structures, enabling policies and environment for the engineering professionals to operate optimally. On the other hand, the engineers are duty bound to embrace varied nature and complexity of engineering challenges and problems. For most of the developing countries, lack of political wills, unfavourable policies, and negligence of indigenous professionals have been identified as some of the key factors which militate against optimal performance of career engineers.

2.1 CAD Resources

These are CAD packages, software, programs, and/or modules used both for CAD-related engineering trainings and professional practice. There are numerous resources and tools at the disposal of professional engineering designers to assist in the solution of design problems. Fundamental amongst these are the PCs, text books, manufacturers' brochures, handbooks etc. The list is much, so an attempt has been made here to mention but a few: AutoCAD design suite, Autodesk Inventor, CadKey, ProEngineer (also called Creo parametric), NX Unigraphics, Aries, Solid Edge, SolidWorks, SketchUp, JL Analyzer, Alibre Design Express, ArchiCAD, Revit, STAAD.Pro, EAGLE, Proteus, Altium, CADMATIC, Wind Loads on Structures 4 etc. Some computer software packages perform specific engineering analysis and/or simulation tasks that assist the designer, but they are not considered a tool for the creation of the design that CAD is. Such software fits into two categories: engineering-based and non-engineering-specific. The former might be integrated within a CAD system. Examples include Finite Element Analysis (FEA) programs (ANSYS, Algor, MSC/NASTRAN), Computational Fluid Dynamics (CFD) Programs (Fluent, CFD++), and Programs for Simulation of dynamic force and motion in mechanisms (Working Model, ADAMS).

Non-engineering-specific computer-aided applications include software for word processing, Spreadsheet software (Excel, Lotus, SPSS and MiniTab) and mathematical solvers (MathLab, MatCad, Mathematica).

The developed countries have gone past the stage of mere ‘usage or application’ of the CAD software packages. In addition to high-level professional usage, they have so many companies that are into computer aided engineering software development. The developing countries are battling with the use of some of these software packages, thereby losing sight of the need to venture into CAE software development. This makes the whole difference we see between the two sets of Countries: Developed and Developing. Majority of engineers in the developing countries may not be fully aware of architectural and engineering-technology types of CAD software. A very important aspect in teaching CAD is the choice of software (Asperl, 2005).

3. Impact of Engineering Education Curricula

The teaching of Computer-Aided Design (CAD) is such a broad field of study that there is no consensus about what to include in the curricula, since these differ depending on the degree and on the level and age of the CAD learners (Asperl, 2005). Furthermore, some studies emphasize the importance of continuing evolution in the training and educational needs of users of CAD systems (Field, 2004). From the point of view that today’s student is tomorrow’s engineer, descriptions have also been put forward regarding what CAD curricula should be like depending on the role CAD will play in the student’s future (as a user, an application developer, a software developer or a CAD manager).

Interestingly however, curriculum structures of the engineering profession have played vital roles in the modeling of accomplished engineering personnel across the globe. Yet, there are still gaps which need to be filled in the development of engineering curricula especially for the developing countries.

3.1 Fundamental Issues of Concern with Engineering Education in Developing Countries

There is variance in the educational and training needs of users of CAD systems when juxtaposed against industrial demands. This poses an ongoing challenge for educational and industrial institutions to meet. This mismatch is a pointer for the need to harmonize academic curricula on CAD using industry-based schemes.

In the definition of engineering, lots of opinions and thoughts have formed and various definitions have been made by different people. Engineering is based on scientific knowledge which contributes to the development of civilizations by leading economical and social forces through the demand of humanity. Intrinsic in the above definition is the need for sound scientific background. Well structured curriculum has its role in addressing fundamental issues of concern bordering on engineering education in developing countries. Relevance of engineering curricula and academic research works (thesis and dissertations) to contemporary industrial challenges must be highlighted here.

Challenges faced by engineers in most developing countries have been underscored by many as the major factor militating against Engineering Design Implementation Issues. These cogs in our wheel of development are summarized hereunder as they are part of the issues that needs to be resolved:

- Our society seems not to be fully aware of the job of the engineer. Most of them think that the engineer's job is mainly to repair and maintain; the actual engineers' job of ***design and conception*** are not recognized.
- There are no Design laboratories in most of the Universities. Other engineering laboratories and workshops are either nonexistent or poorly equipped. Even where they exist, Lecturers and university authorities show no regards to practicals. In fact, the practical aspects of the student engineer's course which ought to cover at least 60% of his syllabus are usualy relegated to logically unacceptable levels. Excessive theorizing in engineering education, now a norm in our universities, hasn't made a difference in the real world of engineering.
- Engineers are not optimally encouraged and challenged. There is not enough room for internship; there are very few production factories and other innovative institutions where the young engineer can develop in his

profession. His theoretical knowledge gained from the university is not quickly translated into practical production.

- Most of the developing countries are poor; there are no entrepreneurs who are interested in engineering designs. Professionals who are good in design have their good designs end in prototypes. No motivation for research and development. In developed countries, entrepreneurs buy patents for good designs and this encourages the engineer. Engineers are given special grants and enabling environment to research in their chosen areas of specialty and bring out lasting solution to technological needs and challenges in the Country. Most times, a blue-print or master plan is provided by the government to give direction to researchers, designers, and companies who then key into the plan.
- There are no engineering development plans put forward by government of these countries. Most of them are simply uninterested in such moves as to plan and pursue vigorously blue-prints for the establishment of manufacturing plants for (say): Light and Heavy Duty Vehicles; Light and Heavy Military Hardware; Telecommunications Equipment; Air Vehicles; Sea Vehicles, Ocean Liners, and Submarines; equipment and components for Chemical Plants and Oil Refineries etc. Under this arrangement, a country develops a master-plan which defines time frame within which certain inventions or innovative technology would emerge. The vision is then followed up through high-level coordination between relevant government agencies, private partners, and professional bodies. No past or present government of most of these countries has addressed technological advancement of their nations with sincere seriousness it deserves.

There are numerous other factors that undermine engineering education and technological development in the referenced countries. Most of these factors are interwoven. But the worst of them all is **lack of will-power to pursue *engineering development* through enactment and implementation of policies, programmes, and blue-prints that will envision and enthrone equipment building facilities.**

4. The Way Forward

For any developing country to record meaningful progress, her government must as a matter of necessity:

-Develop the Right Policies and demonstrate strong Will-and-Political Power towards full harnessing of engineering potentials: The truth is that most of the mediocre countries still rated as "underdeveloped" have good numbers of smart people with special talents and innovative minds whose stellar performances are recorded in the developed countries. Just recently, Jelani Aliyu was appointed by President Buhari as the director-general of the Nigerian Automotive Design and Development Council (NADDC). Aliyu is a Nigerian designer who designed a globally renowned electric car, the Chevrolet Volt. It is interesting to note that his talent was discovered and harnessed by the general motors, an American multinational corporation. It is also noteworthy that the General Motors came into being through right policies and strategies.

-Develop the engineering sector through investment on Equipment Building Facilities and manufacturing/production plants; right motivation and conducive environment: Sound technical frame-work goes a long way in inspiring creative mind-set, and provides the platform for the exercise and development of engineering skills and talents. Full development of the automotive sub-sector, Steel manufacturing Plants and allied industries would go a very long way in boosting engineering education and professionalism, design proficiency and creativity (Okoli et al, 2017).

-Implement *righ*t Educational Empowerment: Essentially, much funding is needed to enable engineering education effectively play the role of developing the high-level technical capacities that underpin economic growth and development. While most of the developing countries have programs in place pursuant to this objective, corruption and wrong implementation strategy are key factor which have continually marred their dreams. According to the Nigerian National Bureau of Statistcs (2014), one of the interventionist agencies in Nigeria, TETFUND had spent N619.091 Bn between 1999 and 2014 on the Nigerian Tertiary Institutions (Oraka et al, 2017). Other agencies like the PTDF have been making their contributions aside direct and statutory interventions from the Federal Government of Nigeria. The question of whether these interventions into the public tertiary institutions are sufficient or not is still a subject of rhetoric. The question of whether there are commensurate realities in terms of visible developmental projects within the education systems still beckon for answers.

-Nip in the bud corruption and corrupt tendencies, especially among the political elites and leaders: If corruption has become ingrained as is the case in most of the developing countries, then stiffer penal strategies must be invoked. If corrupt practices can be effectively pinned, national development of most of the referenced countries would become rapid.

5. Conclusion

The engineering profession has been contributing to global development and civilizations by harnessing the resources of the world for the benefit of humanity. Utilization of computer technology and application is not just a redound factor that facilitate engineering education but has become critical in the development of schemes and programs that are employed in the continued transformation of both the Earth and Space. CAD, CAM, CIM, CAE etc evolved as part of the said developments in computer programs and revolution driven by societal needs.

Technological backwardness of most of the developing countries has been traced to lack of basic facilities for training and practice. This issue must be addressed holistically if fast and steady development is envisioned. These countries must acknowledge the fact that developed foreign nations do not encourage and can never guarantee their technological independence. They want continual patronage of their finished products. The critical roles of engineering in addressing the large-scale pressing challenges facing each developing country must be widely recognized and adequate steps taken to develop the county's technological-base.

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