A Comparative Analysis of the Mechanical Engineering Curricula of Two International Universities

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Abstract – *The availability of the Internet has led a movement that continues to advance the "globalization" of the engineering curricula in which two or more universities on different continents collaborate in exposing students to diverse approaches to teaching and learning. A number of papers presented at conferences of the ICEE report on such collaborations; the Partners for the Advancement of Collaborative Engineering Education (PACE) organization promotes such collaborations and has been very successful in linking its members of 50 universities and industry sponsors to collaborate on virtual design projects with heavy reliance on internet tools and commercial CAE software. Although most universities in the western countries have taken advantage of the opportunities available to "globalize" their curricula, very few universities in the developing countries are participating in global opportunities to enhance their engineering curricula.*

In this paper, the Mechanical Engineering curricula of two universities, Howard University in the USA, and the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana, West Africa, are compared in terms of their curricula content as prescribed by the Accreditation Board for Engineering and Technology (ABET), design experience, teamwork and the preparation of students to pursue life-long learning including the pursuit of advanced degrees. The intent of this paper is to describe the commonalities of the two curricula and to identify areas in which the two universities can improve in order to make their products desirable to employers not just locally but anywhere in the world. Following a brief introduction of the two universities and their historical missions, descriptions of the curricula are presented using ABET curriculum categories to guide the presentation. To conduct a fair comparison of the two curricula, the paper describes the employment opportunities in the two countries as a major factor in the evolution of the two curricula. In the case of the KNUST, the recent discovery of major sources of oil and gas has provided the impetus for the faculty and the university to conduct a critical review of the curriculum in order to adapt to the needs of the local economy. The paper concludes with recommendations for the two universities to implement in making their curricula more diverse in which opportunities exist for students to obtain training that makes them productive citizens of the global village. One such recommendation is for KNUST to form collaborative partnerships with other institutions in and outside of the West African region and for the Mechanical Engineering department at Howard to enhance the research experiences of its students.

INTRODUCTION

Engineering education has been transformed very much in the last decade with the availability of the internet and the use of broadband resources to enhance the teaching and learning through the conduct of problem-based learning experiences. However, the resources of the internet are not widely available uniformly in all regions of the world and could also vary greatly in one country. In light of the disparities, the intent of this paper is to examine the effectiveness in which two universities on two continents are using resources to enhance the teaching and learning in their respective mechanical engineering curriculum and in particular what each department is doing to advance the "globalization" of the curriculum. The two universities with curricula in mechanical engineering that are analyzed in this paper are the Kwame Nkrumah University of Science and Technology (KNUST) in Ghana, West Africa, and Howard University (HU) in Washington, DC, USA. The two universities produce graduates of mechanical engineering in a four-year degree program.

The KNUST (www.knust.edu.gh) began as a College of Technology in January 1952, with the transfer of 200 Teacher training Students from Achimota School to form the nucleus of the new College. In October, 1952, the School of Engineering and the Department of Commerce were established and the first students were admitted. From 1952 to 1955, the School of Engineering prepared students for professional qualifications only. In 1955, the School embarked on courses leading to the University Of London Bachelor of Engineering External Degree Examinations. As the College expanded, it was decided to make the Kumasi College of Technology a purely science and technology institution.

In pursuit of this policy, the Teacher Training College, with the exception of the Art School, was transferred in January, 1958, to the Winneba Training College, and in 1959 the Commerce Department was transferred to Achimota to

form the nucleus of the present School of Administration of the University of Ghana, Legon. In December 1960, the Government of Ghana appointed a University Commission to advise it on the future development of University Education Ghana, in connection with the proposal to transform the University College of Ghana and the Kumasi College of Technology into an independent University of Ghana.

Following the report of the commission which came out early 1961, Government decided to establish two independent Universities in Kumasi and Legon near Accra. The Kumasi College of Technology was thus transformed into a full-fledged University, Kwame Nkrumah University of Science and Technology by an Act of Parliament on 22nd August, 1961. The university was named after its first president, Kwame Nkrumah, who led Ghana into independence from Britain on March 6, 1957. Other departments, such as Pharmacy, Agriculture, Architecture, Town Planning and Building were added in expanding the course offerings of the University.

The University name was changed to University of Science and Technology after the Revolution of 24th February, 1966. The University of Science and Technology was officially inaugurated on Wednesday, 20th November, 1961. However, by another act of Parliament, Act 559 of 1998, the University has been renamed Kwame Nkrumah University of Science and Technology, Kumasi. The university has grown into six colleges, Agriculture & Natural Resources, Architecture & Planning, Arts & Social Sciences, Engineering, Health Sciences, and Science; the academic departments of the various colleges are supported by a number of research and technology transfer centers.

Howard University (www.howard.edu) was created by an act of the United States Congress. In November 1866, shortly after the end of the Civil War, members of the First Congregational Society of Washington considered establishing a theological seminary for the education of African-American clergymen. Within a few weeks, the concept expanded to include a provision for establishing a University. Within two years, the University consisted of the colleges of Liberal Arts and Medicine. The new institution was named for General Oliver O. Howard, a Civil War hero who was both a founder of the University and, at the same time, commissioner of the Freedman's Bureau.

The University charter as enacted by Congress and subsequently approved by President Andrew Johnson on March 2, 1867, designated Howard University as "a University for the education of youth in the liberal arts and sciences." The Freedmen's Bureau provided most of the early financial support of the University. In 1879, Congress approved a special appropriation for the University. The charter was amended in 1928 to authorize an annual federal appropriation for construction, development, improvement and maintenance of the University.

Today, Howard University is one of only 48 U.S. private, Doctoral/Research-Extensive universities, comprising 12 schools and colleges with approximately 10,500 students enjoying academic pursuits in more than 120 areas of study leading to undergraduate, graduate, and professional degrees. The University continues to attract the nation's top students and produces more on-campus African-American Ph.D.s than any other university in the world. Since 1998, the University has produced a Rhodes Scholar, a Truman Scholar, six Fulbright Scholars and nine Pickering Fellows.

The College of Engineering, Architecture and Computer Sciences was created by the August 1997 merger of the School of Architecture and Planning and the School of Engineering. In the course of the merger, the names of the schools were changed to the School of Architecture and Design, and the School of Engineering and Computer Sciences.

The undergraduate programs in both schools were instituted in the early 1900s, with the exception of chemical engineering and the computer science programs, which were inaugurated in the 1970-1980 era. It was during the period of 1907-1910 that the two-year programs in architecture, civil, electrical and mechanical engineering were introduced into the curriculum of the School of Manual Arts and Applied Sciences. By 1911, a four-year curriculum leading to the bachelor's degree was established and a separate building was constructed and equipped to house the School. Eight years later, the School of Manual Arts and Applied Sciences was reorganized into the College of Applied Sciences, which included under its umbrella the departments of architecture, engineering, art and home economics. In 1934, the School of Engineering and Architecture was established as a separate unit of the University--appropriate to the recognition of distinct and important role of engineering and architecture professions. In 1970, the School of Engineering and Architecture was divided into two schools--the School of Engineering and the School of Architecture and City Planning. Thus, after 27 years, the programs of both Schools were reunited under one organizational umbrella on 1997. Traditionally, the College has been dedicated to educating well-qualified engineering and architecture graduates who have assumed productive roles--often of national and international prominence--in industry, government, academia and the professions.

MISSIONS AND OBJECTIVES

The mission of the department of mechanical engineering department at Howard University is "to provide mechanical engineering majors a high-quality engineering education and to contribute new knowledge through research in mechanical engineering and allied disciplines. In addition, the department seeks to maintain recognition through scholarly work and service to the college, the university and the external community." To achieve the mission of the department of mechanical engineering, the faculty of the department, with input from other constituents, established the following Undergraduate Program Educational Objectives:

- Graduates of the Mechanical Engineering Program have acquired knowledge in mathematics, science and engineering and have developed problem solving skills necessary for productive careers in mechanical engineering and other professions and to pursue graduate, professional and life long education.
- Graduates of the Mechanical Engineering Program have acquired concentrated knowledge in at least one area in mechanical engineering. Areas of concentration may include aerospace, applied mechanics, energy engineering, and manufacturing and robotics.
- Graduates of the Mechanical Engineering Program can design and conduct experiments, analyze and interpret data, and effectively use modern technology in communication, research, and problem solving.
- Graduates of the Mechanical Engineering Program have the ability to formulate engineering problems and design a mechanical system or component to meet desired needs.
- Graduates of the Mechanical Engineering Program have developed teamwork, leadership and communication skills to effectively solve engineering problems.
- Graduates of the Mechanical Engineering Program are exposed to issues dealing with people in relation to themselves, society and the environment and understand the need for social, professional and ethical responsibility in engineering practice.

The aim of the Mechanical Engineering program at the KNUST is "to provide broad-based education and training in mechanical engineering sciences and their applications that will enable graduates to meet the challenges of the engineering profession in a rapidly changing environment such as exists in a developing country like Ghana. These challenges require the ability to apply existing knowledge in new ways thereby creating new systems and opportunities as well as adapting existing technology to local production conditions. They require the ability to manage and service, maintain and improve upon existing as well as new systems. The programs and courses are therefore guided by these concepts". Specific objectives that must be met by each of the graduates of the program include the following:

- Design, manufacture and assemble mechanical components and systems.
- Solve engineering problems by analysis and empirical methods, including application of the computer.
- Install, commission, operate, maintain and service plant / machinery, tools and equipment,
- Prepare and read engineering drawings.
- Prepare and present engineering reports.
- Apply relevant social science principles to manage engineering organizations and maintain cordial human relations.

DESCRIPTION OF THE CURRICULA

Both mechanical engineering departments run on the American style semester system. In the engineering program at Howard University, students are required to complete a minimum of 128 credit hours and a minimum grade point average (GPA) of 2.0 in order to receive the degree, Bachelor of Science (BS) in Mechanical Engineering. Prior to the year 2002, the requirement ranged from 143-145 credit hours depending on the selected technical elective. The curriculum is structured into four main core threads: a social science/humanities thread; a thread involving mathematics and engineering science; a thread with a focus on laboratory experimentation and a thread that involves the integration of design in the curriculum.

The Table 1 shows the scheme by semester based on a four-year completion period that is used by the department to guide students through matriculation in the program. The scheme requires students to take a minimum of 23 credits in social sciences/humanities, 68 credits in mathematics and engineering science, 9 credits in laboratory experimentation; and 22 credits in courses that focus on engineering design. To give students room to pursue interests in preparation for graduate school or to enhance their entrepreneurial skills, students are given the chance to obtain 12 credit hours in a combination of technical electives (selected from the mechanical engineering curriculum) and "free electives" for which departmental guidelines exist for the selection of such courses.

YEAR 1				**YEAR 2**				**YEAR 3**				**YEAR 4**			
FIRST SEMESTER		**SECOND SEMESTER**		**FIRST SEMESTER**		**SECOND SEMESTER**		**FIRST SEMESTER**		**SECOND SEMESTER**		**FIRST SEMESTER**		**SECOND SEMESTER**	
ENGL-002 FRES. COMP I		ENGL-003 FRES. COMP II		ECON-001 ECONOMICS I		MATH-159 DIFF. EQUATIONS		MATH-189 PROB. & STATISTICS		AFRO-AMERICAN STUDIES		SOCIAL SCI./ HUM. ELECTIVE		SOCIAL SCI./ HUM. ELECTIVE	
SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE

MATH-156 CALCULUS I		MATH-157 CALCULUS II		MATH-158 CALCULUS III		MEEG-203 PRODUCT DEV II		MEEG-307 FLUID MECHANICS		MEEG-306 APP. THERMODYN		MEEG-403 HEAT TRANSFER		SOCIAL SCI./ HUM. ELECTIVE	
SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE
CHEM-003 GEN. CHEMISTRY		PHYS-013 PHYSICS I LEC.		PHYS-014 PHYSICS II LEC.		MEEG-204 SOLID MECHANICS		MEEG-309 MATERIAL SCI.		MEEG-311 MECH. DESIGN II		MEEG-415 EXP II		MEEG-417 EXP III	
SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE
EGPP-101 INTRO. TO ENGR. I		PHYS-023 PHYSICS I LAB.		PHYS-024 PHYSICS II LAB.		MEEG-205 THERMODYN		MEEG-310 MECH. DESIGN I		MEEG-313 SYS DYN & CONTROLS		MEEG-441 SENIOR PROJECT I		MEEG-442 SENIOR PROJECT II	
SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE
MEEG-103 ENGR. GRAPHICS		MEEG-102 INTRO. TO ENGR. II		MEEG-202 PRODUCT DEV I		CIEG-302 DYNAMICS		EECE-310 P.O.E		MEEG-315 EXP I		MEEG-XXX TECHNICAL ELEC.		MEEG-XXX TECHNICAL ELEC.	
SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE	SEM	GRADE
PHYSICAL EDUCATION		SYCS-165 ELEM. COMPUTATION		CIEG-202 STATICS				EECE-208 INTRO. TO ELEC. ENGR. LAB				FREE ELECTIVE		FREE ELECTIVE	
SEM	GRADE	SEM	GRADE	SEM	GRADE			SEM	GRADE			SEM	GRADE	SEM	GRADE
		PHYSICAL EDUCATION													
		SEM	GRADE												

EXP-Experimentation
P.O.E-Principles of Electronics
COMP-Composition
THERMODYN-Thermodynamics
HUM-Humanities
ELEM-Elementary
SYS-Systems
ELEC-Elective/Electronic
SEM-Semester (Spring/Fall/Summer)
Dev-Development

TABLE 1
DISTRIBUTION OF COURSES BY SEMESTER AT HOWARD UNIVERSITY

The mechanical engineering program at the KNUST requires students to complete a minimum of 140 credit hours with a minimum Cumulative Weighted Average (CWA) of 45%. The students must also complete a minimum of 14 weeks in a supervised industrial environment to acquire practical knowledge. Similar to the curriculum at Howard University, students must complete a minimum of 12 credits in social sciences/humanities, 85 credits in mathematics and engineering science, 4 credits in laboratory experimentation, and 23 credits in design related courses. In addition to the required core courses, students have the option to specialize in one of three engineering areas, Applied Mechanics, Design & Production, and Thermofluids & Energy Systems Engineering, and must take enough courses within the department to meet the requirements in the area of the chosen specialized area. The required courses in the KNUST mechanical engineering program are listed in Table 2.

Year ONE Semester ONE

Course No.		T	P	C
MATH 151	Mathematics I	4	0	4
ENGL 157	Communication Skills I	2	0	2
ME 157	Introduction to Information Technology	1	2	2
EE 151	Applied Electricity	2	2	3
CE 155	Environmental Studies	2	0	2
ME 159	Technical Drawing	1	3	2
ME 195	Engineering Technology I	0	5	2
		12	**12**	**17**

Year ONE Semester TWO

Course No.	Course Title	T	P	C
MATH 152	Mathematics II	4	0	4
ENGL 158	Communication Skills II	2	0	2
EE 152	Basic Electronics	2	1	2
ME 160	Engineering Drawing	1	3	2
ME 196	Engineering Technology II	0	5	2
ME 162	Basic Mechanics	3	1	3
ME 174	First Year Design Project	0	5	2
		12	**15**	**17**

Year TWO Semester ONE

Course No.	Course Title	T	P	C
MATH 251	Mathematics III	4	0	4
ENGL 263	Literature in English I	1	0	1
ECON 151	Introduction to Economics I	2	0	2
ME 259	Applications of Computer Graphics	1	2	2
ME 281	Mechanical Engineering Materials I	2	0	2
ME 255	Strength of Materials I	3	0	3
ME 295	Mechanical Engineering Laboratory I	0	3	1
ME 251	Fluid Mechanics I	3	0	3
		16	**5**	**18**

Year TWO Semester TWO

Course No.	Course Title	T	P	C
MATH 252	Mathematics IV	4	0	4
ENGL 264	Literature in English II	1	0	1
ME 270	Manufacturing Technology	2	2	3
ME 262	Theory of Machines I	3	0	3
ME 296	Mechanical Engineering Laboratory II	0	3	1
EE 252	Electrical Engineering Machines	2	1	2
ME 266	Thermodynamics I	2	0	2
ME 274	Second Year Design Project	2	1	2
		16	**7**	**18**

Year THREE Semester ONE

Course No.	Course Title	T	P	C
MATH 351	Statistics	2	0	2
ME 363	Automatic Control I	2	0	2
ME 365	Thermodynamics II	3	0	3
ME 355	Strength of Materials II	2	0	2
ME 395	Mechanical Engineering Laboratory III	0	3	1
ME 361	Theory of Machines II	3	0	3
ME 373	Machine Design I	2	2	3
	Elective (see courses below and select one)	2	0	2
		16	**5**	**18**

Year THREE Semester TWO

Course No.	Course Title	T	P	C
MATH 352	Numerical Analysis	2	0	2
ME 392	Industrial Engineering and Ergonomics	2	1	2
ME 374	Machine Design II	2	1	2
ME 352	Fluid Mechanics II	3	0	3
ME 366	Heat Transfer	3	0	3
ME 362	Dynamics of Machinery	3	0	3
ME 396	Mechanical Engineering Laboratory IV	0	3	1
	Elective (see courses below and select one)	2	0	2
		17	**5**	**18**

Year Three Electives

MUS 153	Keyboard Skills I	2	0	2
MUS 159	Introduction to Sound Engineering	2	0	2
PAA 151	Traditional African Dance and Dance Forms	2	0	2
PE 125	Jogging and Fitness	2	0	2
ECON 152	Introduction to Economics II	2	0	2
CACS 116	Introduction to Drums	2	0	2
CACS 124	Introduction to Ghanaian Dances	2	0	2
CACS 126	Performing Arts in Traditional Africa	2	0	2
	TOTAL CREDITS UP TO YEAR 3	***89***	***49***	***106***

TABLE 2
DISTRIBUTION OF COURSES BY SEMESTER AT THE KNUST

Final year students in the fourth year are required to specialize in one of the following options: Applied Mechanics, Design & Production, and Thermofluids & Energy Systems Engineering. The students are expected to choose at least two core courses from their area of specialization and then take any of the courses offered in any of the other areas, including those listed as electives, to bring the minimum credits per semester to 17 and also ensure the minimum of 140 credit hours required to graduate. Students are encouraged to consult their academic supervisors in the selection of their area of specialization as well as the courses.

For comparison purposes, Table 3 is derived to show the number of credit hours required in each of the discipline skill areas as a percentage of the total credit hour requirement. Except for some disparities, the curricula of both departments appear to have identical weighted allocations of credit hours to the various core/elective areas. The curriculum at the KNUST has more than seven per cent of credit hours allocated to mathematics and engineering science whereas more weighting is allocated to Experimentation courses at Howard University than at the KNUST. The

allocation of credit hours to the design stem of each curriculum is practically identical. Although Howard University allows students to take four electives (two in the discipline, and two from other disciplines) for a total of 12 credit hours, the program at the KNUST allows students 16 credit hours of elective courses that are for the most part discipline focused and are taught as mechanical engineering courses.

	Howard University		KNUST	
Core/Electives	# of Credit Hours	% of Total	# of Credit Hours	% of Total
Social Science/Humanities	23 (includes 2 hours of PE)	18.0	12	8.5
Math/Engrg Science	68	53.0	85	60.7
Experimentation	9	7.0	4	2.9
Design	22	17.2	23	16.4
Electives	6 (Free Electives)	4.7	16	11.4
Total Credit Hours	128		140	

TABLE 3
CREDIT HOUR ALLOCATION IN CORE AND ELECTIVE SUBJECTS

FINAL YEAR PROJECT COURSES

Each of the departments in the two universities provides what is generally referred to as a capstone design experience for the students. The experience in the form of a two-semester project course, a total of six credits, that requires students to apply their knowledge of fundamental principles learned in earlier courses to design, build and test a product that meets certain specifications and subject to other constraints. Whereas the capstone project at Howard University as described by Thigpen et al [1-8] is taught by a team of faculty members working with student teams on industry defined projects, the practice at the KNUST follows the "independent project" model. Each student team at Howard, composed of about 3-5 students, carries out the project beginning with the production of a technical proposal early in the first semester followed by a mid-term progress report and a final report that is defended by the student team at the end of the semester. In addition to the three written reports per semester, the student teams provide oral updates to the faculty on a weekly basis in addition to the three formal presentations that are required soon after the submission of a written technical report. Students are assessed by faculty evaluation in addition to a confidential evaluation by team members.

The conduct of the capstone project experience at the KNUST is different from the process at Howard University. The capstone project work on an approved topic is carried out under the supervision of a member of the academic staff. The project topics cover a broad range of areas including experimental work, design and manufacture of machines, writing of software, computer simulation, conduct of feasibility studies and survey research. Students either work individually or in groups depending on the nature of the project. The entire project work is completed in two semesters. Unlike the capstone project at Howard, students are assessed on a semester report and a presentation by the student.

GLOBALIZATION OF THE CURRICULA

Within the last decade or more the word "Globalization" has become a buzz word at international conferences on engineering education. Globalization is described as "the development of an increasingly integrated global economy marked especially by free trade, free flow of capital, and the tapping of cheaper foreign labor markets" [9] . One purpose of this paper is to compare the mechanical engineering curricula of the two universities and to determine what elements of the curricula that could be considered as indicators of globalization. Relating the definition of globalization to engineering education would simply imply that a curriculum must prepare its students to take advantage of the globalization of the economies of the world and be able to adapt to various working conditions so that they can be effective as team players in advancing the goals and objectives of their organizations which for the most part are for-profit multinational corporations. Some elements [10] of a globalized curriculum are the following:

- Part of graduation requirements could be fulfilled through a period of study abroad.
- Implement faculty and student exchange programs to clarify the global views of the engineering practice.
- Inclusion of extended periods and/or close cooperation with industry while enrolled in the engineering program.
- Conducting joint projects/research among various departments (multi-disciplinary) and among different universities in different geographical locations and countries.

- Engineering curricula must include languages and cultural studies.
- Engineering programs accreditation must be made global and subject to international quality standards that address industrial expectations
- Ensure that engineering students are educated in how to develop their critical thinking abilities, innovation and problem solving by offering projects at various stages of their years within the program of engineering and not just at the end of the program

To infuse global awareness into the engineering curriculum at Howard University, students have the option to take a global course that is offered as a technical elective. The notion for the course was conceived when Howard University became a member of the Partners for the Advancement Collaborative Engineering Education (PACE) in 2004. With the encouragement of colleagues at Virginia Tech, Howard joined a team of other PACE institutions in creating a technical elective global course on Product Data Management. This global course is taught among five universities in four countries: Virginia Tech and Howard University in the US; ITESM, Monterrey in Mexico; Shanghai Jiao Tong University, China; and Technische Universität Darmstadt in Germany. The course is taught by video conferencing and extensive use of Internet resources such as Skype for communication by students working in teams on assigned design projects. To take advantage of cultural diversity in enhancing learning and effective teamwork, each student team is formed with students from each of the countries represented in the course. Most of the technology needs to connect all the five universities are provided and managed by the Virginia Tech CAD Laboratory.

Although the capstone design course at Howard is not designed as a global course, some of the assigned design projects are designed by companies that work in different parts of the world. Until the recent economic downturn, the department of mechanical engineering at Howard had a partnership with General Motors and students were assigned automotive design projects in which they had to take global perspectives in proposing solutions that meet social, political, environmental and geographic constraints. Results from such projects have been prepared and presented by student representatives at international conferences [11, 12].

ACCREDITATION

The two mechanical engineering programs are accredited by each country's established accrediting body. The mechanical engineering curriculum at Howard University is accredited by the Accrediting Body for Engineering and Technology (ABET). The learning outcomes as stipulated by ABET and tailored for the mechanical engineering program at Howard University are listed below:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
(l) an understanding of issues related to minorities and gender diversity, society and culture, and an historical awareness of Africa and its Diaspora
(m) a knowledge of chemistry and calculus-based physics with depth in at least one
(n) the ability to apply advanced mathematics through multivariate calculus and differential equations
(o) a familiarity with statistics and linear algebra
(p) the ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems

The learning outcomes must be measured and documented for presentation during each visit by external evaluators. An assessment plan that is documented and executed with results used as feedback to improve the program is one of the elements of the ABET accrediting process. In addition to the mechanical engineering program accreditation by ABET, the university as a whole is also accredited by a regional board, the Middle States Commission on Higher Education (MSCHE) , that reviews the university from a holistic perspective unlike ABET which focuses on specific programs in engineering.

The program at KNUST is accredited by the National Accreditation Board (NAB). As a unit under the Ministry of Education, its purpose is to review and recognize an educational institution for meeting satisfactory standards in performance, integrity and quality. The function of this body is similar to that of a regional accrediting body such as the

MSCHE in the US. Like the MSCHE, the process of accreditation as implemented by NAB begins with the completion of a questionnaire, the submission of a self-evaluated report, or a business plan, by the educational institution and a visit by a team of evaluators. On completion of its work, the evaluating team communicates their decision which can be appealed to the Minister of Education if not favorable.

SUMMARY AND RECOMMENDATIONS

This paper describes the mechanical engineering curricula of two international universities, one in the United States and the other in Ghana, West Africa. In spite of the fact that the goal of the programs is to train students who can become productive citizens upon graduation, the program at the KNUST puts more emphasis on the needs of local industries, whereas the program at Howard University strives to produce graduates who could potentially pursue career and advanced educational paths that may not include mechanical engineering. As **a** graduate of the mechanical engineering program at the KNUST, one is expected to handle civil, metallurgical and electrical engineering problems or any engineering problems that one my encounter in industry. Consequently, the program at the KNUST requires students to acquire training in machine shop operations unlike the students at Howard University which partially explains the disparity in the total number of credit hours required for graduation. As four-year degree granting programs, there are similarities, particularly in the number of weighted credit hour allocations in the areas of Mathematics, Engineering Science and Design. Each program has flexibility for students to pursue areas of further interest in the form of (free) electives; however, whereas the electives can be selected from disciplines outside engineering at Howard University, the elective credits must be selected from a list of mechanical engineering courses at the KNUST.

The extent to which "globalization" is being incorporated into the learning process at the two universities is revealed by a comparative analysis of the two curricula. Comparatively, the program at the KNUST appears to offer very little on globalization. As a program that is designed to produce graduates for the local (national) market, there is very little interaction with the outside world at the curriculum level, although some faculty may be engaged in collaborative efforts with external colleagues in the execution of various engineering projects. There is no evidence that such experiences have any impacts on the teaching and learning of engineering principles. As an institution with the only mechanical engineering program in the country, an effort must be made to align with global organizations such as PACE in order to produce graduates that meet the needs of multi-national corporations who may wish to invest in the country. Although the mechanical engineering curriculum at Howard University includes a global elective course, more needs to be done to expose students to the globalization of engineering education. As a profession that also strives to generate new knowledge, there is little evidence that students are engaged in the conduct of research. The mechanical engineering curriculum at Howard University has an option for students to pursue six credit hours of research over a two-semester period. There is little evidence that this is a popular option among the students. Every effort must be made at the two universities to involve students in research in which new knowledge is generated and to further prepare students to enter graduate schools to obtain advanced training that is crucial to any vibrant and productive economy.

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