Electrical Engineering Education In Under Developed And Developing Countries

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Abstract:

Transfer of Technology in the classroom and/or the laboratory for engineering education in underdeveloped and developing countries lags far behind developed and industrial countries. Personal computers, interactive multi user mainframe computers, engineering software for simulation purposes like CAD, IDEAS, MATLAB, PSPICE are not available. The most available tool is probably the hand held scientific calculator or an obsolete IBM main frame computer. The crème of the crop of outstanding students in physics and mathematics compete to join the engineering program. Qualified professors with terminal degrees are not always available in the engineering schools. A handful of students who are able to join graduate schools of engineering in the US have adapted to the flood of the new technologies. An effort is under way, from alumni, to open a channel of an open line of communication to enrich some underdeveloped and developing country's engineering school with continuos transfer of technology of computer aided design (CAD) tools.

I. Introduction

Some African and Asian countries were once colnoies of the British Crown, and therefore most of the education system was organized based on the British system of education and in particular at the College level in Science and Engineering. In the country of Sudan, students who would like to major in science and engineering, attend two years of intensive courses in mathematics, physics and chemistry, known as the preliminary and intermediate years. The best students are selected to join the College of Engineering. The intermediate level in science is equivalent to the 'A' level in the British system of higher education. An external examiner from the University College London is regularly invited to verify and approve the examinations as well as the results in the intermediate year.

The curriculum in the College of Engineering consists of four years of intensive theoretical and experimental study in engineering in addition to the intermediate level degree. In the first two years, the students attend classes in all disciplines of engineering. Engineering students attend unified introductory courses in civil, electrical and mechanical engineering. Civil engineering courses and laboratories consist of hydrology, surveying, building material technology, and strength of materials. Electrical engineering classes consist of electrical circuit theory and electrical machines. Mechanical engineering courses consist of engineering drawing, metallurgy,

thermodynamics, machine tools, water pumps, and foundry. In addition, all students attend engineering mathematics courses. This particular curriculum was enforced at the time because in some cases engineers may work in projects that require more than one discipline in engineering. This allows engineers to understand and interpret one another drawing, designs, and reports.

The courses that the student attends in the physics department, during the intermediate degree, expose the student to voltage, current, Ohms law, electrostatic forces, magneto-static forces, electromagnetic fields and waves, inductance, and capacitance. The background in physics and mathematics allows the student to enroll in electrical engineering. The background in mathematics, hydrology, surveying, engineering drawing and strengths of material, allow the student to enroll in civil engineering. The background in mathematics, engineering drawing, thermodynamics, heat transfer, machine design prepare the student to enroll in mechanical engineering. The background in mathematics and chemistry allow the student to enroll in chemical engineering. By the end of the second year the student is exposed to various disciplines in engineering coupled with a practical experience during two summers. The students had to attend three months during the summer as an engineer trainee. This takes place in the largest maintenance workshops in the country of Sudan Railways. In the second summer students work as an engineer's assistant in an engineering firm, or a Government engineering department depending on the discipline the student intends to pursue. The last two years are intensive major courses in separate groups in civil, electrical, chemical, and mechanical engineering. During the third summer the students are required to obtain an engineering experience outside the country in Europe or Egypt. A comprehensive final design project is required for all majors at the end of the fourth year.

The textbooks in engineering are in English, authored by British or American professors in engineering. The language of instruction is English and this has helped the students to become proficient in English and has provided an easy transition to join graduate programs in England and the USA.

There is no state of the art equipment in the college of engineering laboratories. All computations are made using the slide rule, logarithmic and trigonometric tables. During the 1970's a British computer company donated a main frame computer for the College of Science, that uses a language called "ALGOL". The computer was strictly for research and all data entry was through a punished tape. The hand held calculator came along, but it was too expensive for the average student to own. The University is supported financially by the State Government, and the majority of the students are supported by the State. Textbooks are provided by the State, including the slide rule.

At the time, computers or computer aided design (CAD) tools to enhance and enrich the engineering's students ability to higher levels of design and simulation did not exist. The professors as well as the students depend solely on their mathematical background to analyze and design their projects with very limited experimental set up. Some laboratories have some equipment. For example, the electrical engineering laboratory has two Tecktronix oscilloscope, Ohm's meter, voltmeter, and ampere meter for DC and AC measurements using the analog dial technology. There are electric components such as inductors, capacitors and resistors. Locally made wooden boxes with sockets and banana plugs are used in lieu of the present day

breadboard. The slide rule and the logarithmic tables are the only helpful tools for large computations. Therefore numerical technique analysis for functions that can not be written in a closed form are rare. This has limited the student's ability to perform analytical projects or design final senior projects that require little or no computations. In this paper we shall limit the discussion to the electrical engineering discipline that the authors have chosen to pursue.

During the end of the third year all engineering students must attend a practical training in an engineering company or join an on going project outside the country. The majority of the students attend this training in Egypt because of the continuous and neighboring relationship that exists between the two countries (Sudan and Egypt). Both countries have joint projects and continuous agreement in the distribution of the river Nile waters. The Union of Egyptian Engineers has taken the responsible to arrange all training sessions and locations for the students. They provide summer jobs at government's engineering departments and locating all the engineering students to different companies and engineering projects in Egypt. When I attended the summer training during 1967, the High Dam was under construction. The Consultant engineering company, The Arab Engineer's company, responsible for construction of the Dam, provided the students with a comprehensive and enlightening tour to the High Dam. It was an experience to remember.

II. Electrical Engineering Curriculum:

The last two senior years, the students who choose electrical engineering major, attend courses in power systems, power generation, transmission lines & distribution, electrical machines, electronics, linear system, control systems, and telecommunications.

Engineering Drawing and Drafting

All engineering students are required to take engineering drawing and drafting. The tools required to complete this course are: a T-square, a French curve, an accurate measuring ruler, a set square, a protractor, a compass, pencils, erasers, and lots of paper and time. Today, there are many computer software that can do a better and faster job in engineering drawing using a PC. The most recommended software is IDEAS [1,2]. Underdeveloped and developing engineering schools need to be introduced to these advanced tools in engineering drawing and drafting. This will eliminate a lot of frustration and time, and provide accurate, presentable, and faster results to enhnace the student learning.

Basic Circuit Theory Course:

The introductory courses in theoretical physics and laboratories provide excellent fundamentals to electrical circuit analysis theory for DC and AC circuits. Resistance in series and parallel, current divider, voltage divider, pulse circuits, and various techniques to analyze DC or AC circuits are emphasized. Circuit analysis problems are solved using paper and pencil and a slide rule. Today, SPICE [3] pioneered by the University of California, Berkeley, has provided an outstanding tool to accurately analyze both DC and AC circuits at all USA universities. This tool was strictly for use on the mainframe IBM computer, but now PSPICE can be operated using a desktop or a laptop personal computer. This tool can be purchased with a license and used for

educational institution in the US as well as in other countries with permission from the vendor. It would be of gigantic step for under developed and developing countries in engineering schools to acquire and use the state of the art CAD in circuit analysis and design like PSPICE [2]. Some companies allow limited and free down load of software from their home page in the Internet. This is a good but limited opportunity for developing countries to surface the Internet and down load available software in CAD that can facilitate and enhance their engineering education.

Electrical Machines

Electrostatic forces, magneto-static forces, and electro-dynamic fields and waves are the fundamentals for an introduction to DC and AC motors and generators theory and operation. The following topics: motor speed control, DC and AC generators, single and three phase transformers, require a sound background in circuit analysis, physics, electrodynamics, and mathematics. At the same time, experimental operation and measurements in electric machine require the state of the art experimental set up modules. Various companies today specialize in introducing a scaled module that can be used for experimental purposes to study electrical machines and transformers. Such modules can be used in underdeveloped and developing countries to enhance the engineering student concept in electrical machines.

Electrical Power generation, transmission, and distribution

In the countries of Sudan and Egypt, there are huge hydroelectric power generating stations like, Damazin Hydroelectric and High Dam respectively. There are two main hydroelectric power generation stations in the Sudan. They are located in the Blue Nile near the towns of Sennar and Damazin cities. The 220/110 KV transmission lines stretch a distance of 300-350 miles to the capital city, Khartoum as well as other cities. The study of hydroelectric power generation by mechanical engineers and electric power transmission and distribution by electric engineers have been very intensive and focussed in both the Sudan and Egypt. This area of electrical engineering is relatively up to date and there are graduate studies conducted in this area. The first author studied a master degree in electrical engineering at the University of Khartoum, Sudan, in this area with a thesis title of “Corona Power loss in transmission lines” due to environmental changes in weather conditions [4]. The Sudan is a semi dessert and therefore there are sandstorms that may affect the corona power loss sometimes. The first chairman of the electric engineering department had written a book in power systems and transmission lines and the same book was used for teaching in the department. The majority of the graduates in electrical engineering work for national electric power transmission and distribution power companies. The standard of electric power distribution used in Sudan is similar to the British standard of (3 phase/ 1 phase) 415 V/240 V, or 380 V/220 V with 50 cycles per second frequency.

Today numerical techniques and computer models for symmetrical components, non-linear functions analysis, power transmission and distribution, and transient analysis can be used to model transmission lines. These tools can be used to predict the worst case scenario in power transmission. Power analysis software to predict the various changes in voltage surges or switching transients would enhance the engineering education in electrical power system in under developed and developing countries.

Electronics

At the time the authors attended college, the main electronic devices were the vacuum tubes. Mainly the Triode, and pentode that were used as amplifier and oscillators in electronic circuits. The textbooks were the only sources to grasp and learn electronics. Limited experimental laboratories such as amplifiers or oscillators were conducted using triode and pentode with the help of two oscilloscopes and hand made breadboards. Most of the AC and DC ammeters and voltmeters were the analog dial instruments. Car batteries were used as the source of DC voltages. Locally built boxes are used as component holders for electronic components. All laboratory reports are hand written and all diagrams were drawn by hand using a straight edge. The transistor started to replace the vacuum tubes during the late sixties and was called the solid state device. But was never studied as part of the curriculum at the time in the department. Consumer products started to use the transistor and the transistor radio became very popular followed by the TV set.

With the influx of the state of the art breadboard, stripped wire connection, digital multi-meters, high frequency digital dual oscilloscopes, frequency and voltage generators, diode, transistors, field effect transistor, the electronic courses lectures and laboratories can be enhanced to accommodate the state of the art educational resources. The revolution made by SPICE and PSPICE [2] as a tool for analysis and design provide excellent opportunity to the electronic engineering courses enhancement. The virtual laboratory or experiments can be conducted using modern tools and equipment. This transfer of technology is required today for under developed and developing countries.

Today solid state devices are used in integrated circuit that had reached sub-micron dimensions and speed of the electric signal transmission is in hundreds of Mega- Herdz. The study of design, analysis, layout, verification, and simulation of integrated circuit is not available in under developed and developing country's engineering school. These courses can now be taught without the sophistication of integrated circuits processing. There is software for VLSI [5] that can be used to design simple devices and electronic circuits to provide a vivid example to what actually happens during processing of integrated circuits. Other design software using CAD like VHDL [6,7] and Verilog [8,9] that can be used for design & synthesis, and simulation of prospective design ideas. Some textbooks have student's version software that has limited use for educational purposes. These textbooks are highly recommended for developing countries engineering schools.

Telecommunications

This is one of the main core courses in electrical engineering because it is widely used in telephones distribution lines, radio communication, and microwaves. The theory of small signal transmission in telecommunication transmission lines is similar to the theory of high voltage transmission lines. The microwave radio signal transmission and the availability of satellite have opened new doors for the application of telecommunications. Today it is faster and easier to call by telephone from the USA to Sudan than to call between two cities in the country of the Sudan. This is due to the over loaded and out dated telephone telecommunication cables and transmission lines available in the Sudan. This area of electrical engineering is vital to the

economy of the Sudan and Egypt. The opportunity to locate an engineering job in telecommunication is very good in both countries.

The course introduces analog communications using the traditional amplitude and frequency modulation. This depends on strong background in Laplace and Fourier transforms as well as linear system. Today digital communications and optical communications are introduced at the undergraduate level in electrical engineering education. There are no laboratories in communications at the time. Today there are modern laboratory equipment strictly made for communications, with software for signal processing. The telecommunication education in developing countries can be enhanced using the PC, MTLAB [10], DSP, and ELINAX [11] software. These are excellent examples of tools that can enhance the telecommunication engineering education in under developed and developing countries.

Numerical Techniques

Engineering students must be able to write program codes using high level languages such as FORTRAN, C, C++ [12], and PASCAL. These programming languages are now available and can be used in a PC. It is essential that all engineering students should be able to write program codes to solve any complex equations that can be written in a closed form. Some hand held calculator can be used to obtain graphical solution to some simplified equation. MATLAB and mathematical software can be used to solve matrix equations, is highly recommended for engineering schools. Some textbooks come with software packages enclosed. Such textbooks are highly recommended for engineering students that allow them to have limited use or student version of the software.

Summary and Conclusion

Under developed and developing countries engineering schools, although they have a strong background in mathematics, physics, and engineering core courses, they lack far behind with respect to experimental setup, software tools for analysis, design, and simulation. Basic courses like engineering drawing need to be replaced by CAD tools like IDEAS. Programming languages like "C" and "C^{++}" must be introduced by using PC based computer programming for numerical techniques. MATLAB can be used for linear system, control, Digital signal processing, telecommunications, and signal analysis. PSPICE can be used for electric circuits, electronics, analog and digital circuits. ELINAX can be used for telecommunications and digital/analog signal processing as well as analog/digital filters. The majority of these softwares are becoming less expensive and in some cases vendors donate the software for educational institutions or allow limited use of these software can be down loaded from the home page of many vendors for free. It is necessary that under developed and developing countries with alumni that are pursuing graduate programs in USA or working permanently in USA to communicate with their schools. All alumni are in excellent position to provide services in engineering education that can enhance the engineering curriculum in their alma mater schools.

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"Electrical and computer engineering" redirects here. For contents about computer engineering, see Computer engineering. Field of engineering that deals with electricity, electromagnetism, and electronics.Â 4 Education. 5 Professional practice. 6 Tools and work.Â By 1800 Alessandro Volta had developed the voltaic pile, a forerunner of the electric battery. 19th century[edit]. The discoveries of Michael Faraday formed the foundation of electric motor technology. 2.1 Developments and Status of Engineering Education in Germany. Education in Germany is not part of the federal government politics but it is the duty of the. federal states (States in USA) to take care of education. Since Germany is divided into 16 federal states, , it has the effect that there are around 16 different school systems.Â Engineering in Germany developed rapidly in the 19 th century along with industrialization. Before that time engineers were usually scientists studying physics or mathematics and there focusing on their special interest.Â Engineering is usually divided historically into mechanical, electrical, electronic and information engineering (which form own faculties and bodies of research and teaching staff) and subsequently specializations. Secondary education in developed countries has become, with few exceptions, universally available. In East Asia, the Middle East, and Latin America, secondary-education enrollment rates ranged from approximately 60 percent to 70 percent at the beginning of the 21st century. South Asia and Africa had the lowest enrollment rates, at approximately one-half and one-third of the age-group, respectively.Â By contrast, in the most industrialized and developed countries, higher-education enrollment as of 2005 reached approximately half of the age group, with rates of greater than two-thirds in North America and western Europe and nearly three-fifths in Oceania. Electrical Engineering is one discipline that was hot in the past and is still hot till date. The discipline has remained relevant to technology advancement and will continue to stay relevant. For this reason, there are scholarships for undergraduate students in developing countries to study electrical engineering abroad in developed countries. Letâ€™s show you what you need to know about these undergraduate scholarships for electrical engineering students in developing countries. About the Undergraduate Scholarships for Electrical Engineering. Scholarships in electrical engineering are one of t