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Education in Electrical Engineering and Emerging Technologies

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ABSTRACT: The paper presents the patterns and methodologies of imparting education in the discipline of Electrical engineering specifically, where it brings out the various phases of learning and instructing engineering scholars. It is a combination of various surveys and draws analogies from the past patterns of pedagogy and learning and points out the inefficient loop holes that prevail even today in terms of delivering information to electrical engineering students. Solutions to these problems have also been discussed and the paper intends to trace the life span of electrical discipline since its inception to present date. It throws light upon the fluctuations of education and development in this field with due course of time and discusses glimpses of the new emerging technologies which are likely to take over in near future.

Keywords : Pedagogy, Learning, Technologies

I. INTRODUCTION

The present scenario of the world is one which is constantly changing with time. Everyday a new technology is being proposed and innovations are the talk of the times. With the advent of science and technology, the status and styles of livelihood change, providing individuals with the access to user friendly day to day equipments and thereby making life easier. The root cause of innovation is learning, understanding, analyzing and thus reciprocating ideas into physical systems. Education is the backbone to learning, and inculcating a sense of understanding of various phenomena and processes that take place in daily life, forms an eminent part of a scholars life.

Electrical engineering is a discipline that traces its roots of origin to Physics as the main subject. This discipline of study deals with the analysis of electrons and their flow per unit time, electronics and the combination of electricity and magnetism. William Gilbert was the one who clearly distinguished magnetism and static electricity and is known for establishing the term Electricity.

Electrical energy forms the backbone of all major innovations today and is the form of reliable power that is used in all production houses and industries. Without power , the common on goings of life would come to a halt. Mostly everything today is based on electrical circuits and signals and hence this discipline forms a very important part of the engineering arena.

For generating power and then consequently developing devices that have its applications in operation, a skilled and trained force of scholars is required. Education is the key source of learning and thus Education in Electrical Engineering plays a major role in defining the quality of innovations and ideas.

The process of education generally relates to majorly teaching and learning and thus for effective education to take place, it becomes of utmost importance to analyze the styles of teaching and learning. Tracing the history of this discipline, it is seen that electrical engineering originated in the nineteenth century and became an eminent area of interest after World War II. All the issues that concern the area of learning in this discipline need to be understood and their probable solutions need to be analyzed. This paper deals majorly with viewing concepts of education particularly in the field of Electrical Engineering and enumerates the various new emerging technologies in this area.

II. EDUCATION

Education relates to the process of acquisition of information as a set of facts, principles, terminologies and data by means of phenomenal perception in ways of visualizing or catering to inculcate information by the help of our senses. Engineering is a diverse field and education in a system of systematic logical analogies pertains to learning the fundamentals of the subject. To understand the education in the arena of electrical engineering discipline, the primary focus is on the styles of inculcating data and receiving information by engineering scholars today. Researches show that there are many kinds of learning for engineering scholars , majority of which have been discussed below.

A. Methodologies in Learning

Numerous ways of learning [6] have been sourced in various surveys which consume learning by intuition, visualization, watching, hearing, concluding with analogies and making models of mathematical aspects of a phenomenon. Similar is the case of teaching. Demonstration can be one way while verbally lecturing can be the other, implications can be drawn by applications while methods such as following conventional principles can be an option. Learning is an aspect of a student that depends on his own capacity to retain and the ability of instructor to guide.

A two step process which involves reception and processing where reception means observing through senses and perception may relate to memorizing, both these account for the process of learning. Scholars today have been accounted to learn by various methods and styles. There are 2^5 (32) learning styles in the substantial framework of learning. Majority of the instructors are intimidated to implement these many styles of teaching but engineering education on the whole addresses mainly five categories of learning styles as auditory, deduction, sequential, reflective and intuitive.

Engineering graduates learn mainly by one of the following styles as discussed:

a) Sensing and Intuition

Carl Jung in his theory of Psychological Types describes that the major forms of perceiving information from the world is either by sensing or intuition. Sensing involves observing, gathering data through senses whereas intuition involves indirect perception by ways of unconscious imagination. Myers-Briggs Type Indicator developed by Isabel in 1940 is a type of measuring device that measure the degree to which any person is either preferring a perception by sensing or by intuition. Scholars that like sensing are ones who are biased towards facts, data, experiments while the intuitive are good for cramming concepts and deciphering languages. Most electrical courses except for laboratories focus on concepts which hamper sensor type scholars while favoring the intuitive ones.

b). Visual and Auditory

This category broadly classifies perception by scholars in three different categories as visual, auditory and kinesthetic. The visual perception relates to pictures, diagrams and everything relating to the optical senses, the auditory deals with sounds and words , kinesthetic relates to the sense of touch and feel. It is a matter of fact that people learn majorly from one of the three broad classifications. The auditory and visual components are related to specifically learning whereas kinesthetic pertains to both perception of information and processing.

c) Inductive and Deductive

Induction is an approach of reasoning that traces down from observations to laws and rules. Deducing relates to consequences rather than principles. Deduction is the natural style of human teaching where as the style of natural human learning is induction. Example of induction is when a baby throws a bottle and cries, he knows someone will come to pick it up- thereby inducing results.

d) Active and Reflective

The aim to learn with experimentation and actual physical touch is called active learning whereas the reflective learning aims to learn as a passive form where learning is conceived to be done without kinesthetic approach. The active should not be confused with sensors and the reflective with intuitive as it may happen that the sensor preferentially selects the available information but processes it either in an active way or in ways so it proves to be reflective.

e) Sequential and Global

The formal way of imparting education is by presenting the information in a predefined logical and ascending order which is related to the step wise procedure of learning. Scholars that learn by a series of perceptions are categorized as sequential, where as there are also scholars that pop up mid way and are still able to comprehend the on goings of the surrounding environment and thus come under the category of global learners.

Considering all the learning styles of engineering scholars, the teaching perspective is very important as it is repeatedly mentioned that the learning of an individual depends majorly on the instructors guidance. It is of utmost importance that the level and style of delivery of information on the instructors side is matched with the level of comprehending of the recipients.

B. Techniques of teaching covering major styles of learning

To have an effective learning the essence of utmost efficiency is necessary. Some of the surveys and experiments suggest that motivation is a key factor that helps to level the recipients and make them comfortable by addressing issues of the subject by relating them with the past and present happenings and with the experiences of the students (Inductive/global). An unbiased material for solving problems with practical (sensing/active) and fundamental approach (intuitive/reflective) can be implemented. Usage of schematics, block diagrams, graphs, pictorial representations (sensing/visual) and demonstrations (active) can be highlighted. Using computer assisted instructions (sensing/active), providing gaps within lectures (reflective) and activities such as problem solving and brain storming (active) are strongly recommended.

Teaching and learning dimensions.

Preferred Learning Style	Corresponding Teaching Styles
Sensory, Perception } Intuitive	Concrete, Abstract } Content
Visual, Auditory } Input	Visual, Verbal } Presentation
Inductive, Organization } Deductive	Inductive, Deductive } Organization
Active, Reflective } Processing	Active, Passive } Participation
Sequential, Understanding } Global	Sequential, Global } Perspective

Fig. 1. Table showing various styles of learning.

C. Problems of Education in Electrical Engineering

Electrical engineering being a substantial arena of the engineering is taken up by many young scholars and students . The problem arises due to the fact that majorly all the phenomenon and the parameters used in the field of electrical engineering are of a very abstract or insubstantial aspect i.e., do not directly relate to the physical world. These abstract parameters such as the voltage, current, potential, resistance, inductance are not directly observable and do not easily initially succumb to any individuals understanding . Being the basic parameters there is a strong need to understand their importance and characteristics. There are many systems such as systems of control or power electronics or MATLAB results that are quite complex and cannot be explained just on the board. Non linearities, phasor analysis, transformer saturation curves, circuit transients, complex transitions and systems, all need some computer softwares and animations. In spite of the usage of computer aided results, students at times are not able to cope with the complexities shown in the animations as the time duration of viewing is very limited due to the constraint of class hours. This often leads to students getting de motivated and dropping out and is a main reason for the society to lose some skilled prospective engineers of the future. The most bewildering aspect of current and voltages is their variations in time, changing polarities, their dependencies due to mutual interactions and their relations to the present circuit state. In complex systems of three phase, the systems become very complex. A probable solution could be the increase in the frequency of repetition of visuals.

Example of the problem described above is shown in the figure and is an example from control systems. The figure represents Smith compensator output to compensate for the dead time involved in any system. It is seen that if the transport delay used in the compensator is changed, the waveform changes its shape. The two figures show the change in the output observed due to change in parameter.

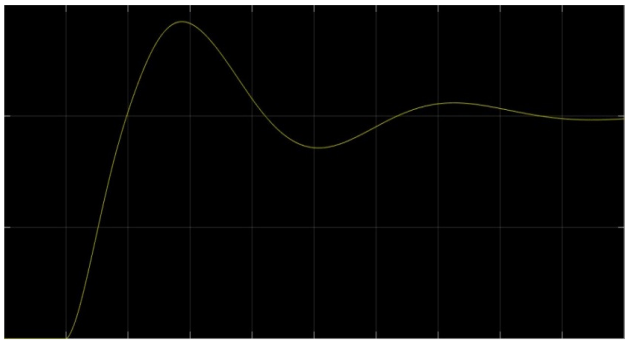

Fig. 2. Smith compensator output for dead time.

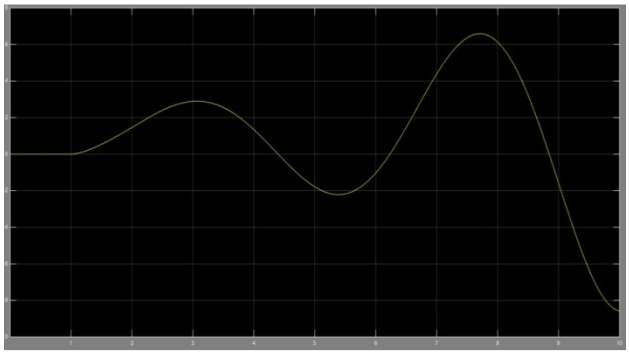

Fig. 3. Smith compensator output for delay variation.

To understand effectively how the change in parameters take place, the fundamental concept of e-learning comes into light.

D. Solutions Addressing the Problems in Education

a) E-Learning

Requirements of Electronic learning

- Appropriate instructions for usage of systems should be known.
- Systems must agree to self assistance in learning.
- The learning information should be accessible irrespective of time and place.
- Learning support systems [11] should be structured in ways that complexity should increase in ascending order with time.

- If multi dimension aspects are dealt with, there should be options of freezing the waveform, reversing or forwarding the output.
- The computer tools used for learning should also be combined with the insights to circuit properties. Thus with this in mind the developers have developed SAPWIN- a tool which has the ability to provide by means of generating approximate symbolic expressions for linear analog circuits and their corresponding manipulations in graphical terms.

Benefits of E-Learning

There are some benefits which this type of learning involves, which includes the high accuracy and easy visual displays, and is very suitable for handicapped students.

b) Remote experimentation learning in electrical engineering

The traditional ways of experimenting gives hands on experience to scholars to understand and perceive the process involved in any experiment. But , it is also noticed that with the fast changing scenario, it becomes impossible for scholars to have all the equipments available due to high financial limit of purchase and maintenance and also due to geographical barriers. A solution is the implementation of remote labs that allow access to various instruments over the internet. Laboratory working is supposed to be one of the finest ways to assimilate knowledge. Internet access today provides for virtual laboratories that enable experimentation from a distance. A laboratory at Blekinge Institute of Technology (BTH) [10] , Sweden provides for eight laboratories where each station has some hardware of desktop, a bread board and the link for power supply.

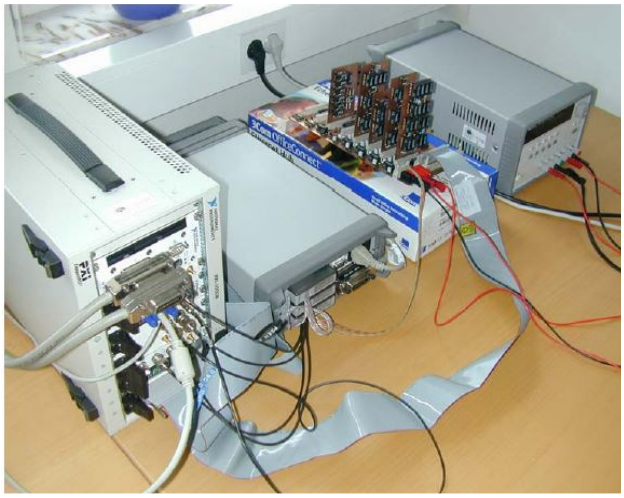

Fig. 4. Laboratory Server for experiments in Circuit Theory.

There is a remotely controlled switch matrix which makes all necessary connections in just milliseconds. In the diagram is shown a lab server enclosed room at BTH. In figure 4, left side shows a PXI (PCI extension for Instrumentation) which has a controller having oscilloscope , function generator and digital input output device board. There are data acquisition units and instruments setting is done by host computer.

c) Problem based learning

The practice of class room teachings [8] no longer does suffice to the new era of innovation and technology as a new form of skill set needs to be developed within scholars for them to be able to entertain the present days engineering requirements. A list of characteristics for engineering graduates is as below.

- Skills are required in communication and retrieval of information, computational ability and technological literacy.
- Ability to decide for the specific problem and their approaches towards yielding a solution .
- Competence in technological aspects.

The learning based on problem solving provides a platform in which the important characteristics can be developed. Learning is substantiated by a problem that is encountered, analyzed and understood , and then processed to yield a solution. Problem based instructions directly address many recommended challenges as :Critical thinking and analyzing, evaluation and approximation of learning resources and the intentions of working as a team.

Problem based learning cycle

This form of learning [3] traces back to the schools of medicine where small units of scholars combine under a guide and learn about problems. This approach is seen to have optimistic results when applied to hard core engineering .The basic concepts of problem based learning are:

- The scholars are given a problem (a paper of research, case studies, diagrams). Working in groups, scholars combine their ideas and knowledge from past to define the general broad aspect of the problem.
- During the cycle of undertaking the problem, questions are raised on the resources required to learn the major subject .
- The issues are presented in a series of order by their degree of importance.
- When the problem is completed, the resources prove to be helping hands for learners and they can add on to their previous knowledge.

In a research survey [9], around fifty five scholars under a given electrical engineering course at Midwestern University were taken into this experiment where they had to have normal teaching lectures and the problem based learning. Pre tests and post tests

were conducted and as a result it was seen that the results of learning from the problem based learning were twice as good as the normal learning by lecture technique.

III. BRIEF HISTORY OF ELECTRICAL ENGINEERING EDUCATION

The curriculum of education in electrical engineering dates back to the late nineteenth century [7] where the first glimpse of this discipline of engineering was seen in the United States in 1880's and had its inception from the major branch of Physics. Before the World War 1, focus was largely concentrated to A.C. and D.C. equipments. The initial stages of inception of electrical had only a handful or even lesser number of people undertaking this discipline and the presence of only a single individual with a doctorate degree in M.I.T. in the year 1925 justifies the same. The discipline exploded after the World War 2, as with war, there was formulation of new technologies like RADAR, microwaves and guided missiles. The first application of electricity was in telegraph and was developed by F.B.Morse and in 1876 Alexander Graham Bell patented the Telephone. The first educational program in the arena of Electrical engineering was designed in 1882 in M.I.T. in United States. This field witnessed in the last quarter century an exponential bombardment of individuals and learners as electrical engineering in its own has multiple disciplines of subject based substance that relates to mainly all walks of life directly or indirectly.

IV. EMERGING TECHNOLOGIES

a) Internet of Things: It is the combination of operation of various components such as actuators, physical devices with the help of network connectivity [2]. It aims to integrate the devices under operation in various fields with the addition of embedded software or electronic sensors. This technology allows objects to be sensed remotely with the backbone of an existing network, thereby recording, analyzing, estimating and storing data efficiently and accurately without human intervention. Internet of Things is an emerging field of technology and has an open platform for Electrical engineering. In the discipline of electrical , several motors, generators, transformers can be networked together for absolute perfection in operation.

b) Next Generation Robotics : A robot apart from its physical balancing, falls into mainly the discipline of Electrical engineering as on the whole it is a complete circuitry based system . Advancements in robotics tend towards making the collaboration of human-machine everyday working a reality[16]. Using better sensors and accurate control mechanisms help in designing more flexible structures that can work under real time situations. The emerging technologies employ GPS based robots and intend to make them work in areas where human working is hazardous . Some examples include robots being used as pest controllers, furnace maintenance works and nursing.

c) Space Based Solar Power : An emerging aspect of electrical discipline [13] is renewable energy and its extraction by sufficient methods from the sources. The Space Based Solar Power technology differs from the conventional form of solar energy tapping in terms of the fact that this method of collecting energy from the sun is limited to the outer earth spaces only. It proposes to set up solar panels in the satellites revolving around the Earth. This form of energy tapping includes benefits of more power absorption and lesser losses. The tapped energy is then converted to microwaves and then focused towards the earth to be collected by means of a receiver, which in turn would convert it into electrical energy.

d) Smart Grids : This type of technology is based on the intentions to completely automate the present power grids[12]. Grids include, substations, transmission, generation and many more classes of complex systems that combined together result in power to be received and consumed by consumers. Automating the systems would mean tracking of information and data completely on a digital platform without the intervention of humans. This would lead to accuracy, efficiency and reduction in the frequency of hazardous exposure of employees working on high voltages and faults. Smart grids would enable a direct two way communication between the electrical department and the devices by using sensors such as fault sensors, distance locating sensors and parameter sensors.

e) Sense and Avoid Drones: This form of technology is concerned with developing intelligent drones [14] in ways that they can sense and detect any obstacle and avoid it . The drones are intended to be unmanned and capable of flying at different heights and levels. They can be used for surveillance and filming. The key feature of these types of drones is their complete autonomy and sensing power.

V. CONCLUSION

Various types of learning and their corresponding appropriate styles of teaching have been analyzed and seen. The motive of the complete study is to understand clearly the importance of good learning and teaching methodologies related to the field of electrical engineering. The solutions that have been discussed relate to methods that should be applied in modern day instructing to produce better results. Recent technologies have been thrown light upon and the historical background of the complete electrical engineering discipline from its advent till date is summarized.

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