Work In Progress: Remaking of Introduction to Engineering Course

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Abstract: - The primary objective of introduction to engineering course is to excite students about engineering and give them a glimpse of engineering profession early in their education. School of Electrical and Electronic Engineering in our institution offer various diploma courses at the polytechnic level with a total intake of more than eight hundred students in each academic year. Introduction to engineering course is traditionally taught by a team of faculty members where all the students from different diplomas given the same project in order to maintain uniformity in assessment and course material. However, a major shortcoming of this approach was the inability of the course in instigating students’ creativity. This paper presents our efforts in remaking and redesigning introduction to engineering course together with our preliminary evaluation results and observations.

Key-Words: - Introduction to engineering, engineering education, curriculum design, student motivation

1 Introduction
Introduction to engineering course offers students an authentic learning experience of engineering at the beginning of their study. In many institutions, introduction to engineering course is also used to expose students to engineering which helps them to decide engineering as a career path as well as about the field they would like to concentrate on (See for instance [1] and [2]). The first year of polytechnic education is a critical time for our students who are contemplating a career in engineering. It is also the right time to excite them about being an engineer and invoke their interest in the field that they are studying. In our institution, we took a new approach to introduction to engineering course. We intend to introduce not only technical aspects of engineering but also other relevant skills needed to fit in today’s industry. Since this subject is taught in the first year, we also attempt to make it a fun experience and stimulate students’ creativity.

The first year of conventional engineering curriculum lays the fundamental mathematical and electrical engineering foundations which are necessary for later studies. Likewise, the following years are also highly concentrated on technical abilities and do not provide a meaningful insight into what engineering is about. Nowadays, industry requires engineers with not only good technical skills and but also proficient intrapersonal and interpersonal skills [3][4]. Social skills, communication skills and emotional intelligence are as important as technical skills. However, as mentioned traditional pedagogy in engineering education is focused on delivering technical knowledge and skills and it does not significantly address students’ social skills. As a result we now intend to enhance not only the technical skills of our students but also other key attributes such as autonomy, innovation, communication and team work in order to prepare them for the challenges ahead.

A major shift in the mind-set in today’s industry is the need for greater innovation, which is no longer at the domination of large corporations. With fast prototyping and manufacturing tools, such as 3D printing, becoming available, future of engineering and manufacturing is highly dynamic and innovative. Innovation is now the key differentiator in various industries[5]. The job scope of engineers therefore is not limited to delivering products that fit in the specifications or making incremental improvements on them. They also need to develop innovative products and services [6]. Consequently, it is important to inculcate a culture of innovation and making in our students.

The concerns discussed above led us to rethink the methods and pedagogy that we were employing. Introduction to engineering course which expands to two semesters in the first year of engineering education suits well to implement our pedagogy initiatives. Traditionally, all the students were given same project and thought the some basic hands on
skills such as soldering, using testing tools and equipment and so on with this project. Considering the large student cohort and the large team for faculty teaching this course, such uniformity was suitable in order to maintain some standard in the assessment and the content. Inherently, this approach had shortcomings in stimulating students’ creativity.

It is important to note that introduction to engineering course is offered to students of five different diplomas. They are Diploma in Aerospace Electronics Engineering (DASE), Diploma in Common Engineering Programme (DCEP), Diploma in Computer Engineering (DCPE), Diploma in Electrical & Electronic Engineering (DEEE) and Diploma in Energy Systems & Management (DESM).

This implies that students of these diplomas already have some idea or expectation about the field of engineering they are interested in. We consider this factor when we redesign the course so that students can pursue a project not only provides opportunity to stimulate their creativity but also related to the field they are interested in.

2 Details of the Course and its Structure

Introduction to Engineering is a year-long course that spreads into two semesters as “Introduction to Engineering 1 (IE1)” and “Introduction to Engineering 2 (IE2)”. Both IE1 and IE2 courses are laboratory-based and students are involved in a project.

IE1 provides a platform to teach students literacy, skills and an attitude for creativity in conceiving new products and services. It also introduces project design and fabrication activities that not only impart project prototyping skills like PCB layout planning, strip board fabrication, soldering, circuit assembly and troubleshooting but also integrates technical knowledge and provides practical applications for courses they are taking such as Principles of Electrical and Electronic Engineering (PEEE) and Digital Electronics (DE). Students design, test and build a range of real world electronic circuits such as level alarm, alphanumeric display and level indicator. Through these mini projects, students are exposed to a range of generic process skills such as creative and critical thinking, teamwork and communication. For instance, students go through interviews and final presentations throughout the project. They also present their project in Team Work and Communications skills course which is offered to all first year engineering students.

In IE2, students from different diplomas are assigned to projects that contain elements of their diplomas and every diploma is given a different theme to provide a diversity of projects within a diploma. For instance, current theme for students in Diploma in Aerospace Electronics Engineering (DASE) is airplane taxiing. Theme for students in Diploma in Computer and Programming Engineering (DCPE) is Sumo Robot game. Students in Diploma in Electrical and Electronic Engineering (DEEE) given the theme of celebrations and they develop gadgets for celebrations and entertainment. Theme given to students of Diploma in Energy Management Systems is green environment (DEMS). These project ideas aim to stimulate creativity as well analytical skills of our students. It also provides an environment to apply the knowledge they acquired from courses such as PEEE (transistor switching circuit, relays, LDR, etc) and DE (Counter Circuit, Flip-Flops, etc).

At the beginning of this course, student teams, made of 3 to 4 students, are formed. Each group is given some of the common circuit boards and components. Students solder components to the circuit boards, test and understand the working principles of them. The group is then required to design and build an additional board which is integrated with the common circuit boards given to achieve certain objectives of a working prototype.

In addition to electronic parts, students also develop mechanical parts and pieces for their project mainly utilizing 3D printers. These parts can be part of a model plane or target boards for mounting of sensors and so on. Students develop these parts using Sketch-Up or Autodesk 123D. This part of the activity excites the students, and spurs them to think out of the box and come up with different designs for their projects. The use of this new technology also helps them polish their designs and creative thinking skills.

As mentioned earlier, we emphasize developing the communication and team work skills of our students as well as their technical skills. These efforts spread into two semesters. All the students take a formal course named team work and communication which is offered by the faculty of school of communication, arts and social sciences. Furthermore, during the introduction to engineering courses students are required to make several presentations about their design ideas, their progress
and their final project to their classmates and faculty members. Through these practices and working as a team, we hope to inculcate a better social and communication skills in our students.

2.1 Projects

**DASE – Prepare Aircraft Take Off**
The purpose of this project is to design and build a circuit to taxi a model plane forward to a designated station by counting markers on the taxiing path, stop and wait for a signal to take-off. The take-off is simulated by its propeller running, moving forward and activating its flight controls (i.e. Ailerons, Elevators and Rudders).

The students need to build and integrate the following circuits on a model plane:
- Light Dependent Sensor Circuit - to detect the station.
- Counter & Display Circuit - to display the station number on the 7-segment LED display.
- Motion Control Circuit - to activate the motor and move the model plane forward.
- Voltage Regulator Circuit.
- Servo Flight Control Circuit - to activate the servo motors controlling the primary flight controls (i.e. Elevators, Ailerons and Rudders).

The students are required to conceive ideas using the above completed circuit boards and guiding materials provided online to design a Count Limiting Circuit that is able to enable, integrate the above circuits and move the model plane forward to any station and then activate the flight controls to certain angles automatically. The Counter and Display Circuit are to be activated at each station along the way forward.

Each team is given a random station (from 2-9) that their model plane needs to taxi from station 1 before take-off. Fig. 1 shows an example project developed by students. In addition to the basic functions, students add features to their model plane to make it unique.

**DCPE – Robot Sumo**
This is a well-known and very popular robotic game where two robots try to push each other out from the competition ground. Students are provided with an Arduino-based mobile robot and they are required to

- Program the Arduino to perform various tasks.
- Add infra-red sensors to detect the edge of the platform.
- Add ultrasonic sonar sensors to detect opponent robot.
- Use 3-D printing technology to create parts for the robot.

Students are given opportunity to add additional features to their basic robot in order to make it unique from the rest such as displaying the distance, making sound effects etc. Fig. 2, shows a snap shot of student at development process and the final project.

Fig. 1. IE project of Diploma in Aerospace Electronics Engineering.

Fig. 2. IE project of diploma in computer and programming engineering program.

**DEEE/DCEP – Marksman**
The purpose of this project is to build a fun-fare game where a laser pointer is used by one player to get the counter to count up while another player tries to get the counter to count down. The students are required to build and integrate the following circuits in this project:

- Target Sensor Circuits – to detect shots from laser guns.
- Counter and Display Circuit – to count up/down and display the scores on the 7-segment LED display.
- Motion Control Circuit – to control forward and reverse directions of the motor.
- Additional Circuits - to be designed by the students to achieve certain effects of the game.

Students may design additional circuits to achieve some special effects for the project such as a circuit to move target forward or reverse randomly, a circuit to cheer /boo when a player wins/loses. Fig. 3 shows one of the successful student projects.

**DEMS– Sun tracker**
The purpose of this project is to build a solar tracking device that enables a solar oven to track the light and point to the direction of the sun. Students
are given the following circuit boards to assemble and test.
• Light Dependent Sensor Circuit – to detect a desired condition.
• IC 556 Astable Multi-vibrator Circuit.
• Motor Interface Circuits.

Fig. 3. IE project of diploma in electrical and electronic engineering.

Fig. 4. IE project of diploma in energy management systems is green environment.

The students may design additional circuits to meet certain objectives of the working prototype. Fig. 4 shows picture of a student project.

2.2 Assessment
There are two major component of the assessment: individual and team work. Their distribution in final grade is 60 and 40 per cent consecutively. There four main areas that students are assessed. They are individual competencies, presentation and final project work. Student expected to demonstrate good teamwork, technical knowledge, analytical thinking and systems thinking skills. These individual competencies assessed via interviews and students performance during class. In the final project work, the following points taken into consideration:
• Workability of common circuit boards.
• Ability to analyse the schematic diagrams
• Understanding the working principles of circuits and being able to integrate the common circuit boards.
• Ability to design and build circuits to meet the given specifications.

• Overall workmanship of the completed project (ie good solder joints; components and cables are neatly laid out and connected).

3 Results and Discussions
A feedback session was held with students at the end of the semester. Using a student questionnaire, we try to find out how this course benefitted them in enhancing the abilities as well as their understanding of what engineers do. In the following, the term ‘module’ corresponds to ‘course’ which is a commonly preferred term in our institution. The evaluation form included the following rating type of questions where a scale of 5 represents very much the case for the student and 1 represents not at all the case for student.

Q1. The module has helped me to manage my own learning better.
Q2. The module has increased my confidence in learning independently.
Q3. I can take multiple perspectives when solving problems.
Q4. I have developed a better understanding of engineering.
Q5. I am able to use various types of tools for prototyping/fabricating engineering projects.
Q6. The module has developed my ability to think creatively.
Q7. I feel more motivated to take on new projects ideas.
Q8. I feel I am able to communicate my ideas more effectively.
Q9. The various assignments help me improve my ability to use technical language when presenting.
Q10. I am better able to work effectively with different personalities when doing team-based projects.
Q11. I feel more confident in helping the team to meet its objectives.

Approximately, a quarter of students from a cohort of thousand responded to the survey. A quick observation from the average response, shown in Fig. 5, is that students benefitted well in improving their communication and team work skills, independent learning skills, as well as understanding engineering tasks. Moreover, response shows that they have gained considerably in hands on and practical skills. However, they were not as positive as expected in being motivated to take on new projects.
3.15
3.2
3.25
3.3
3.35
3.4
3.45
3.5
3.55
3.6
3.65
3.7
Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11
average student response

Fig. 5. Average response of students to rating type of questions.

Fig. 6 shows student response in more detail. From the Fig., we observe that 38.3% somewhat agreed, 32.83% agreed and 15.28% strongly agreed that the module has increased their confidence in learning independently. A similar pattern observed in their response to the question if they better understand what engineers do. From the response, we see that about 51.24% somewhat agreed, 45.27% agreed and 23.38% strongly agreed that module achieved one of its key objectives which is developing hands on skills of our students. Only a minor 3.48% disagreed. From the results, we also observe that students’ confidence in team work and their confidence in contributing to team work are higher than their ability to communicate effectively. An unexpected observation was that a significant, approximately 20%, of the students disagreed on being motivated to take up new projects. This requires further investigation on the students concerns and further improvements of this module.

4 Conclusion
This paper presented our initiative for redesigning introduction to engineering course to our first year students. A major challenge was to choose right themes, or projects, which can provide opportunities for creativity and innovation. At the same time, we can deliver necessary practical engineering skills and implement our pedagogical aims. Our observations from the first run of this course are that students benefit significantly developing their practical and hands on skills and they have a better understanding of an engineering process. Further improvements on the course will be made based on the feedback gathered from students, as well as our observations made during the first trial of this course.

References:

Survey included some open response questions. Students’ responses to “What are the most useful aspects of the module for you?” were almost unanimously practical skills they have gained, working in team and the opportunity given to be creative. Students’ response to “what are the least useful aspects of the module for you?” indicated three problem areas: lack of time, lack of knowledge, and the work load. In summary, further improvements on the module, to address above discussed issues, are needed. These would be a better time management and proper work load given to the students.