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AN EFFECTIVE METHODOLOGY TO TEACHING ELECTRICAL AND ELECTRONIC TECHNOLOGY TO SECONDARY-LEVEL STUDENTS

Marcus Lloyde George
Ultimate Virtual Market Limited, San Fernando, Trinidad and Tobago
marcus.george99@yahoo.com

ABSTRACT
This paper presents an effective methodology to teaching the UNIT 1 Caribbean Examinations Council's advanced level Electrical and Electronic Technology (EET) subject to students of Presentation College, San Fernando, Trinidad and Tobago. The paper also serves to compare the performance of students under this new effective methodology with previous methodology implored in the 5 years this subject was offered to students of the college. In conclusion, the new methodology offers an increase in the performance of students when compared to the previous methodology.

KEYWORDS:
Electrical and Electronic Technology, Electrical Engineering, Electronic Engineering, Electrical Technology, Electronic Technology, Teaching Electrical and Electronic Technology.

INTRODUCTION

Level 6 students at Presentation College, San Fernando are offered an advanced Electrical and Electronic Technology (EET) course. Students commence this course with no previous knowledge and skill of electrical and electronic technology. Secondary level education in electrical and electronic technology must not only provide students with a strong foundation in the area but must also provide a precursor to the Electrical and Computer Engineering degree program at the university level. This EET programme should also provide students with some level of practical experience in real world engineering issues.

[1] presents an overview of the Partnership for Engineering Education in the Rookies (PEER) programme for teaching electrical engineering material to high and junior high students. According to [1] the introduction of concepts and practices of engineering to these students via the PEER systems presents a good reason for the students being required to study core science material. As such this will assist students prepare for more difficult engineering material to be undertaken in the future [1]. PEER request advice on curriculum requirements from industry. Hence incorporating these materials into the curriculum is supposed to make student more marketable, according to [1]. According to [1] students taken through the PEER programme are much better prepared for future educational paths.

[3] presents the construction of an engineering programme entitled Optical Networking in traditional classroom format after which the style would be enhanced by making available the course material in audio, video and PDF format all available to students on call. The revised course consisted of three main components which are content, virtual labs and a project [3]. [3] indicates there is a need to develop a strategy of connecting teachers to the learner in a way that will improve the learning experience. Course content is delivered in the form of lectures which are recorded and made available to students in audio, video and PDF form [3]. Laboratory exercises were made available in virtual form via simulation-based interactive laboratory exercises which had been developed by the ATel LLC [3]. The design project being the cornerstone of the programme allowed students to apply all material learned to undergo the development of an optical network [3]. At the end of the programme a student evaluation was done and students generally were satisfied of the approach used [3].

[5] summarized the experiences of project-type courses at the first two semesters of the undergraduate programme of Electronics and Information Technology at the Copenhagen University College of Engineering. According to [5] it is difficult to motivate students coming from high school to learn theory on physics, calculus, etc. [5] also concludes that teamwork assists students in overcoming difficulty of adjusting to university life where they will be distant from family. The examination results indicated that students performed better under this new approach presented by [5]. Pass rates increased under the new approach. Also student evaluations

conducted indicate that's students approve of this new approach. The failure rates for the initial two semesters of the programmes decreased from 40%-45% to under 25% under the new approach.

[6] presents a strategy for teaching combinational logic circuits theory using the VHDL. According to [6] the main purpose for teaching VHDL in this course was to enhances student understanding and skills of logic circuit design. This was also done to promote student independent exploration of computer aided design software via assignments [6]. At the end of the programme an assessment of results indicated that no student failed the course and that students were very enthusiastic about the material taught [6].

[7] utilized the Conceive-Design-Implement-Operate (CDIO) [2] initiative framework for engineering education programmes to design and implement a project-based learning programme entitled Exploring Electrical Engineering. This programme was proposed as a means of increasing the appeal of electrical engineering to students. The strategy was implemented and tested by 200 grade 5 students and teachers across eight classes at a variety of local schools [7]. 150 more students and teachers signed up for the testing in these subsequent months. Student feedback was obtained and based on this feedback 76% of students endorse the participation in group projects increased their interest in electrical engineering, while 96% have indicated that they believe that this strategy made them more creative [7].

This paper explores application of a better methodology to teaching electrical and electronic technology (EET) subject to students of Presentation College, Trinidad and Tobago. The paper compares the student performance when this approach is utilized in comparison to previous approaches. In conclusion, this paper proposes an effective methodology to teaching electrical and electronic technology (EET) subject to students of Presentation College, Trinidad and Tobago.

UNIT 1 EET COURSE DESCRIPTION

The Electrical and Electrical Technology (EET) programme is based on Electrical Theory and Communications. The aims of this subject are as follows:

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1. Develop an interest in, and an awareness of, career choices and options for further study in the field of Electrical and Electric Engineering.
2. Develop analytical, practical and experimental skills in the use of electrical and electronic technology in industry.
3. Develop an awareness of practical applications of electricity and electronics within industry.
4. Provide opportunities for the acquisition of advanced knowledge of the concepts and fundamentals of electricity and electronics.
5. Encourage the adoption of specific safety practices.
6. Inculcate an appreciation of the pivotal role of electricity in the socio-economic development of their country and the region."[12].

The EET syllabus consisted of the following topics:

1. DC Circuit Theory
   - DC Theory
   - Electrostatics
   - Inductance
2. Analogue Electronics and Communications
   - Semiconductor Diodes
   - Bipolar Junction Transistor
   - Operational Amplifiers
   - Electromagnetic (EM) Waves
   - Modulation
3. Introduction to Power Systems
   - Electromagnetism
   - DC Rotating Equipment
   - Introduction to Power Supply Protection
   - Introduction to Supervisory Control and Data Acquisition (SCADA) Systems

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International Journal of Engineering Technology Research & Management

PREVIOUS METHOD FOR TEACHING UNIT 1 EET

The previous method of teaching Electrical and Electronic Technology at Presentation College, San Fernando was utilized during the years 2012-2014 and involved formal teaching of the subject matters by two Physics teachers. Materials were presented using tech-books and blackboards as is customary in secondary schools in Trinidad and Tobago. Tutorial sessions were incorporated in the curriculum by using some class sessions as tutorial sessions. Tutorial sessions simply consisted of the subject teacher presenting some past paper questions to students and allowing them to attempt the question, after which the subject teacher presented the solutions on the blackboard. During the years 2012-2014 only one the EET Internal Assessment (IA) consisted of only one project. As such students were required to design and implement a simple battery charger system and submit a technical report on its construction and testing. EET was pretty much taught in the same approach used to teach all subjects at secondary school level: detailed delivery of subject matter. The traditional approach can be summarized as follows:

- In-class subject matter delivery using textbooks and blackboards
- Past-paper based tutorial sessions
- Structured lab-based Internal Assessment sessions

NEW METHODOLOGY FOR TEACHING UNIT 1 EET

This new teaching strategy was presented in years 2015-2016 and utilized an Electrical and Computer Engineering graduate for teaching and coordinating the programme. The new strategy of teaching EET at Presentation College, San Fernando consisted of three main components:

- Lecture-based topic presentation using Multimedia Projectors and Whiteboards
- Past paper-based tutorial sessions included in lecture-based topic presentation
- Lab-based mentorship program for progression in Internal Assessment

The lecture-based presentation was done in a 40-seater classroom using laptop equipped with Microsoft Windows 7 operating system, Dell Multimedia Projector. Lectures were prepared for each topic and presented to students. The lecturer paused occasionally during or at the end of lecture slides to entertain any questions students may have about the material being presented. At the end of each topic presentation a tutorial question was presented to students and they were given 15 – 20 minutes to attempt it individually. The lecturer was mobile in the classroom attending to any individual questions students had while attempting the tutorial question. This tutorial component t allowed the lecturer the opportunity to determine areas of concerns faced by students in the topic matter. After the 15 - 20 minutes period the solution to the tutorial question was presented to the class on the whiteboard using whiteboard markers.

The lab-based mentorship program for progression in Internal Assessment was actually conducted at the University of the West Indies campus, St. Augustine. During the years 2015-2016 students were required to submit one Internal Assessment per Module compared to one Internal Assessment per Unit as required in previous years. As such for both years students were required to pursue the following three projects:

Module 1 – Design and construct a RC car battery charger capable of fully recharging a fully discharged 12 V battery in 2 minutes. The battery charger must be capable of switching to a 15V DC source for full recharging when battery charger is 80% discharged.

Module 2 – Design and construct a 9 V ± 0.3 V, 0.5 A, Zener Diode Regulator. The regulator must exhibit a voltage regulation of 5% or better and must be fed by a DC input voltage from a laboratory power supply.

Module 3 – Design and construct a 9 V ± 0.3 V, 1 A, Zener Diode Regulator. The regulator must exhibit a voltage regulation of 5% or better and must be fed by a DC input voltage from a laboratory power supply. In addition, the regulator must incorporate over voltage protection circuitry which would disconnect the load from the regulator when the voltage from the regulator exceeds 10 V.

Students were first introduced to breadboard wiring in week one of this programme. Some videos on wiring were also presented to strengthen students' understanding of the topic at hand. Students were then given sample circuits and give materials such as breadboards, jumper wires, resistors, capacitors, diodes, etc, and allowed to

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International Journal of Engineering Technology Research & Management

attempt the wiring process with these components. The course instructor was mobile in the lab unit the entire time, offering assistance to students. After the one-week training phase students were allowed to begin their Internal Assessment projects under limited supervision of the course instructor. Students were also allowed to submit draft versions of their project reports to the instructor for review. Reviewed projects were returned a week after so that students can make corrections to their reports.

COMPARISON OF STUDENT PERFORMANCE UNDER PREVIOUS AND NEW TEACHING METHODOLOGIES

The performance of students over a five-year period 2012 – 2016 was analysed and compared. Its importation to note that the previous teaching method was executed in years 2012 – 2014 while the new teaching method was executed in years 2015 – 2016. It is important to note that the subject syllabus remained the same for all five years. The number of students enrolled in the programmed for the five-year period is shown in Table I.

TABLE I: SUMMARY OF NUMBER OF STUDENTS ENROLLED IN EET PROGRAM FROM YEARS 2012 - 2016

Academic Year	No. of Students Enrolled
2012	27
2013	32
2014	29
2015	31
2016	33

Table II shows the performance of students over the five (5) year period. The new teaching method resulted in a substantial increase in the number of students obtaining Grade A's and B's. The new strategy also resulted in a substantial decrease in the number of students receiving Grade F's and E's.

TABLE II: COMPARISON OF STUDENT PERFORMANCE IN THE LAB EXERCISE CONDUCTED UNDER THE THREE TEACHING STRATEGIES

Grade Category	% Student Performance				
	PREVIOUS METHOD			NEW METHOD	
	2012	2013	2014	2015	2016
A (I)	0.0	0.0	0.0	13.7	49.6
B (II)	0.0	3.1	0.0	51.8	37.4
C (III)	22.2	28.1	13.8	31.3	13.1
D (IV)	25.9	37.5	27.6	3.2	0.0
E (V)	33.3	21.9	34.5	0.0	0.0
F (VI)	18.5	9.4	24.1	0.0	0.0

As can be seen in Figure I (a) the new strategy resulted in a substantial increase in the number of students scoring grade A's in EET unit 1. The number of students scoring grades A – C also increased over the years (see Figure I (b)) while the number of students scoring D – F decreased substantially over the years (see Figure I (c)).

Another very important highlight of the new methodology for teaching EET was that students of 2014 cohort ranked in the top 10 in the Caribbean in EET UNIT 1. Students also obtained the only Grade A's obtained in the subject in the entire Trinidad and Tobago in 2016.

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International Journal of Engineering Technology Research & Management

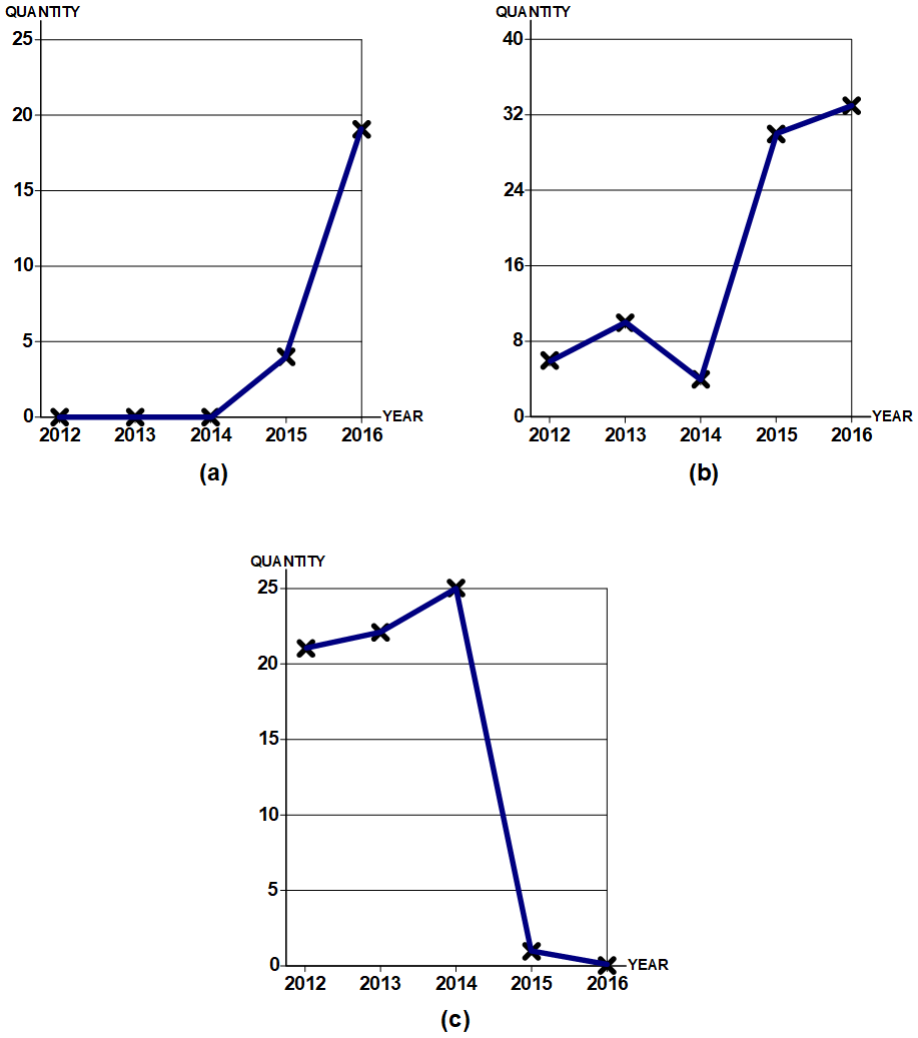

FIGURE I: (A) NUMBER OF STUDENTS SCORING GRADE A. (B) NUMBER OF STUDENTS SCORING GRADE A – C. (C) NUMBER OF STUDENTS SCORING GRADE D – F

COMPARISON OF STUDENT FEEDBACK UNDER PREVIOUS AND NEW TEACHING METHODOLOGIES

Feedback through the course student feedback questionnaire was an important part of the evaluation of the effectiveness of the two teaching methods. Students taught using the previous method of 2012 - 2014 didn't benefit from much practical experience with the practical aspect of the topics. Students also complained that the use of textbooks was not adequate for the study of the subject matters as most of the material required clear linkages to the practicalities of engineering where the topics were concerned.

Students taught using the new methodology were generally very pleased with the presentation of material using multimedia via Microsoft PowerPoint for presentation of material as it effectively ensured visual presentation of material in a consistent manner. Students were also very pleased with the interaction with the lecturer during the presentation which improved there learning experienced. The presentation of the tutorial-based activity after each topic was presented allowed students to attempt actual questions at varying difficulties and then received correction afterwards, and students were extremely happy and appreciative of this. The lab-based activities towards the internal assessment component of the subject allowed a conference between students and instructors using equipment at tertiary level for undertaking engineering projects within the scope of the course. Students were also appreciative of the use of whiteboard and whiteboard markers in presenting further explanations and solutions in the classroom.

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International Journal of Engineering Technology Research & Management

CONCLUSION

This paper explored the teaching of CXC CAPE Electrical and Electronic Technology UNIT 1 to sixth form secondary school students of Presentation College, San Fernando, Trinidad and Tobago. The paper compared the performance of students when both previous and new methods are used. Future developments for this research will obviously be to undertake the investigation using a larger sample size if possible. More students will be encouraged to pursue the course and similar test will be conducted. A major future development is testing the new strategy along with old strategies using the same cohort of students. In this paper this was not done and hence the possibility exists that students in years 2015 and 2016 were just more academically inclined than students of previous years. Another future development includes performing all test multiple times for the same cohort. Feedback for each test can be repeated and findings summarized. A good future development is to now determine the impact of this strategy of teaching EET to secondary students to their attempts at the university electrical and computer engineering program. This should hence determine if the preparation of students with this strategy benefits them when undertaking future programmes, hence providing evidence towards having this EET programme as a prerequisite to the university programme.

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