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Motivating Students in Electrical Circuit Course

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Abstract

Electrical Circuit course is the elementary core course for the students of undergraduate program of electrical and electronic engineering. The course is taught in the very first semester of the freshmen. In undergraduate level, most of the engineering disciplines also require this course that is taught in the first to third semester or so. Since this course has many real life applications in many engineering tasks, it is therefore, required to teach efficiently so that students can apply the knowledge earned from this course in solving their practical problems. But it has been observed that many students drop out the program due to lack of motivation after studying this course. Motivation is the key to engaging students in meaningful and productive work. Identifying individual students' interests, providing choice (to promote a personal connection) and supporting competence (through the teaching of immediately useful strategies) result in motivation that deepens learning. Of course, motivating the students is one of the greatest challenges that teachers face all over the world while teaching in engineering courses. In this paper, the teaching method of 'Electrical Circuit' course for undergraduate electrical and electronic engineering students through motivation has been described.

Keywords: Electrical Circuit Course, Teaching, Student Motivation, Student Behavior.

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1. Introduction

In most of the engineering disciplines electrical circuit course is an elementary course. This course has many direct practical applications (Bhuyan, 2014). Without the knowledge of this course, it is not possible for an engineer to design and develop any electrical circuits or systems or networks or any electronic devices and controllers. A recent trend in undergraduate engineering education is the incorporation of introductory engineering courses in the freshman year (Carlson et al., 1997). Therefore, 'Electrical Circuit' course is a very important and useful course in the curriculum of the undergraduate electrical and electronic engineering (EEE) program and is incorporated in the first term of the freshmen year and occupies the core position in EEE curriculum. It is designed to teach the students basic laws of electricity and magnetism, various network theorems for solving various electrical networks and for computing its parameters (Bhuyan, 2014; Boylestad & Nashelskey, 2011; Alexander & Sadiku, 2010).

Learning is an activity that leads to change and control of what is taught, while teaching is a practical activity or action, be intentional and conscious to assist learning. Teachers should act an essential role as a facilitator in the process of teaching and learning. So, the electrical circuit course shall be designed and taught in such a way so that the students are prepared to master various laws, formulas and theorems related to electrical circuits for designing the real-time electrical networks and systems by learning properly (Choi & Saeedifard, 2012). But it should be remembered that they don't loose their motivation while learning and keep learning the subject matter.

Any engineering program should be mandated by an accreditation agency (such as, in USA it is EAC/ABET and in Bangladesh it is BAETE) and the accreditation of an engineering program will be judged with respect to the defined program outcomes. Each program must have an assessment process for continuous improvement with documented results. Any well thought course required for an engineering degree should be able to contribute towards fulfilling the program educational objectives, which are mandated by the ABET criteria 2000 (EAC/ABET, 2004) or BAETE requirements (BAETE 2018).

Currently, the engineering education system is undergoing rapid changes in various parts of the world. Various new methods are introduced and used. Further, it makes teaching more effective and learning is highly significant (Bhuyan, Khan & Rahman, 2014). Now the role of a student has changed from passive to active learner under the new learning paradigm (Lo, 2010). Instructors should play such a role that the student is tempted to become an active learner of the course. An important goal of the undergraduate curriculum in engineering discipline is to develop the integration, design, synthesis and evaluation capabilities of the student. Students usually come to the classes with various ranges of motivations and sometimes with a remarkable lack of motivation. Motivating students is one of the most challenging things that faculty members have to do in the class, and some of them want to throw up their hands in frustration or proclaim that there is a little they can do to motivate the students to learn. It is true that the students carry with them many past experiences that contribute to their motivation in the classes (CET, 2014). However, teachers can make a difference, for better or for worse, in motivating students to learn. If the student is not motivated enough for the course then all the efforts taken by the teachers are in vain. While it is true that teachers have little control over any external factors that influence the students' behavior and engagement, still teachers can play a vital role in shaping the students' behavior what occurs in the class room. In fact, instructional choices and the other relevant strategies for 'Electrical Circuit' course adopted by the faculty member can make a positive impact on the students' motivation in the class.

In this paper, teaching method of the 'Electrical Circuit' course for the undergraduate students of the electrical and electronic engineering program through motivation has been described with examples. After that few recommendations regarding student motivation have also been provided.

2. Framework of Student's Behavior and Motivation

Before exploring some practical applications for motivating students, we should examine the issue from a theoretical perspective. One thing to consider is the expectancy-value theory which can be stated as, "Why am I doing this?" plus "Will I be successful at it?" comprise the level of student motivation". That is, according to this theory, the degree to which a student is motivated to engage in an academic task is jointly determined by his/ her expectancy for success and by the value he/ she has attached to a specific task. This theory suggests that students can be successful if they apply reasonable effort and appreciate the value of the learning activities (CET, 2014). Hence teaching and learning process of the 'Electrical Circuit' course should be conducted in such a way so that the student motivation is enhanced taking this theory as the underlying theme.

3. Strategies for Increasing Student Motivation

Having framed the strategies for student motivation, faculty members shall take several steps to maximize student engagement and success in the class. Faculty members shall create an optimal class room environment that is conducive to learning. Research suggests that this is most effectively achieved through instructional behavior and course design (Rashid, 2008). In the next sub-section, course design strategies of the 'Electrical Circuit' course are discussed to elevate students' interests and hence course engagement.

3.1. Designing Electrical Circuit Course

One of the desired attributes of an engineer (Rashid, 2004; White, 2001) in the global marketplace in the new knowledge economy is that an engineer should have good understanding of engineering fundamentals and design/manufacturing processes. Students respond positively to a well-designed course. Therefore, any undergraduate course should be designed in such a way so that the students are motivated enough to be able to learn how to design electrical circuits and systems. Keeping this in mind, 'Electrical Circuit' course is designed as described in the following sub-sub-sections.

3.1.1 Designing Electrical Circuit Course

This gives the complete description of the course. Students should know what they are going to learn before the start of the class (Bhuyan, Khan & Rahman, 2014; Bhuyan & Khan, 2018). The course contents should be designed in such a way so that the students get a deep knowledge and develop their skills to apply the knowledge in their fields and course objectives are achieved. Incorporation of too many topics in the course may impede the students' learning objectives. So, the optimal contents for 'Electrical Circuit' course are set as follows (Bhuyan, 2014):

Circuit variables and elements: voltage, current, power, energy, independent and dependent sources, resistance. Basic laws: Ohm's law, Kirchhoff's current and voltage laws. Simple resistive circuits: series and parallel circuits, voltage and current division, wye-delta transformation. Techniques of circuit analysis: node and mesh analysis including super node and super mesh. Network theorems: source transformation, Thevenin's, Norton's and Superposition Theorems with applications in circuits having independent and dependent sources, maximum power transfer theorem and reciprocity theorem. Energy storage elements: inductors, capacitors and their series parallel combination. Responses of RL and RC circuits: natural and step responses.

Magnetic quantities and variables: flux, permeability and reluctance, magnetic field strength, magnetic potential, flux density, magnetization curve. Laws in magnetic circuits: Ohm's law and Ampere's circuital law. Magnetic circuits: series, parallel and series-parallel circuits.

Course Objectives

Learning objectives or instructional objectives are statements of what students should be able to do if they have acquired the knowledge and skills the course is supposed to teach them (Bhuyan & Khan, 2018). This should be communicated to the students by the course teacher before the start of the class. The objectives of 'Electrical Circuit' course based on the course contents have been set as follows (Bhuyan, 2014):

1. To list the basic elements of the electrical circuits
2. To list the various types of electrical signals
3. To state various laws of electrical circuits
4. To apply various theorems to solve the problems of electrical circuits and to interpret the results
5. To find the various parameters from electrical circuits
6. To determine the transient response in electrical circuits
7. To analyze the magnetic circuits
8. To sketch various types of electrical and magnetic circuits.

3.1.2 Course Outcomes

Course outcomes or learning outcomes reflect the degree to which the program has met its objectives; outcome indicators, the assessment instruments and procedures that will be used to determine whether the graduates have achieved the outcomes (Bhuyan & Khan, 2018). The course teacher should explain how his/ her students enrolled in the class can be successful. He/ she also should explain what the students will be able to do after successful completion of the course with a minimum grade (Bhuyan, 2014). If a student can successfully complete 'Electrical Circuit' course, it is expected that the student will be able to

1. Identify and use of various electrical circuit elements
2. Draw the various types of electrical circuits using symbols
3. Simplify and design various electrical circuits
4. Find out the parameter values in electrical circuits
5. Apply various laws and theorems of electrical circuits to solve the problems
6. Predict the transient responses and hence its parameters
7. Design magnetic circuits
8. Apply laws of magnetic circuits
9. Perform various numerical computations of circuits.

3.2. Adopting Variable Teaching Methods

In addition to the traditional lecture, students are engaged in various activities during lecture, such as taking immediate feedback, incorporating problem-based learning, course project, collaborative learning, laboratory experiments, taking assignments, use of technology, minute paper, taking class presentations, taking short explanation, demonstrating practical applications of electrical circuits etc. Few examples are cited in the following for 'Electrical Circuit' Course.

1. If the teacher is teaching how series equivalent resistance is found then he/she may ask the students to calculate it from a given circuit where two or more resistors of known values are connected in series.
2. Once a network theorem is taught then the student may be asked to tell what he/she has understood.
3. If few students understand any topic after the lecture and the other students don't understand then few groups may be formed to teach the topic to the others who don't.

4. Students may be given first assignment on series, parallel and complex circuits, such as, wye-delta circuits, from the exercises of the text book after explaining the associated formulas for it and solving the problems given in the examples. The second assignment may be given on network theorems after explaining the associated theorems and solving the problems given in the examples.
5. In case of RL and RC transient responses, students may be asked to draw the wave shapes in the class note and the course teacher may check it in the class.
6. While solving magnetic circuit problem, students may be given the B-H curve and asked to determine the required value of H from a given value of B graphically.
7. Students may be given the options in the class on what topic the students should give the presentations. They will decide their topics. In this case, the students will feel a sense of autonomy and this will help them to develop skills for self-directed learning. During presentations, students will ask the questions to the presenter and if the presenter can answer he/she may be given the bonus marks and if he/she fails then the student who asked the question will get that bonus marks. In this way, student will feel their ownership in the class.
8. Few sudden tests on relatively challenging topics may be given in the class to extract the intellectual skills of the students. If the student can answer then the degree of difficulty should be increased as the semester progress the is to strike a balance so the every student feels that he/she, with reasonable effort, has the capability to succeed while still being challenged to stretch hi/her limits.
9. In the class, the teachers may demonstrate few practical applications of series circuit, parallel circuit, and electric bill calculation based DC/ AC home appliances, or how an electric connection can be established for a room, or how a common home appliance works based on the already taught laws and theorems on electricity. This will certainly create enthusiasm among the students for the electrical circuit course.

3.3. Referring Standard Text and Reference Books

Teacher shall refer standard and text and reference books for the students. For 'Electrical Circuit' course the following books are suggested as the text and reference books:

Text Book:

1. Introductory Circuit Analysis
   Robert L. Boylestad
   Prentice Hall, USA.

Reference Book:

1. Fundamentals of Electric Circuits
   C. K. Alexander and M. N. O. Sadiku
   McGraw Hill, USA.

Since these two books cover all the course contents of this particular course, students will be motivated to use these books. This is also another form of motivation to the students that they should study to achieve their learning outcomes from their text books.

3.4. Adopting Standard Evaluation Policy

In the very first lecture, teacher should clarify the students about the evaluation policy of the university as well as for the particular course. Course teachers who seek to obtain accurate learning outcomes may need to use a variety of assessment methods, in difference to the students' differential learning styles and thinking paths (Oblinger, 2003; Williams, Berger & McClendon, 2005). The following assessment scheme is adopted for the 'Electrical Circuit' course:

Each student will be assessed individually by different ways, such as, by monitoring class attendance, by assigning home works, by giving capstone project or case study, by taking the class tests, by conducting midterm and final examinations. The examination syllabus is notified before the examination starts.

Test Policy:

If any student is absent from a test that will not be retaken if prior permission is not availed by the student. If any student wants to sit for the make-up examination with permission he/she may have to pay the necessary fee as decided by the university authority. This fee may not be waived.

Mid-term examination is of 1.5 Hours duration and the final examination is of 2 Hours of duration. Zero tolerance to any kind of cheating or adopting unfair means in the examination hall during any kind of examination and the punishment level varies from the cancellation of the particular examination/ answer scripts to the expulsion from the university.

Grading Policy:

This university follows UGC's uniform grading policy as shown in Table 1.

Table 1. Uniform Grading Policy of UGC, Bangladesh

Marks out of 100	Letter Grade	Grade Point
80 - 100	A+	4.00
75 - 79	A	3.75
70 - 74	A-	3.50
65 - 69	B+	3.25
60 - 64	B	3.00
55 - 59	B-	2.75
50 - 54	C+	2.50
45 - 49	C	2.25
40 – 44	D	2.00
00 – 39	F	0.00

Besides, 'W' and 'I' grade could be awarded as per the university rules and regulations.

Marks distribution:

The final course grade will be awarded based on the marks obtained out of 100 marks (Table 1). Percentages of marks for the different heads are given below:

Attendance:	10 %
Class Test:	10 %
Assignment:	10 %
Mid-term Exam:	30 %
Final Exam:	40 %
Total:	100 %

If any student's attendance falls below 75% of the total classes conducted in the course then that student will not be allowed to sit for the final examination of the course.

4. Teachers' Behavior

The role of the teacher is to facilitate learning. It is often a formidable and time consuming task to find ways to motivate students that will achieve the objectives of the 'Electrical Circuit' course. Teachers' behavior has an immediate and visible impact on students' motivation. If the teacher frames all the strategies for increasing students' motivation in the class and also adopts all the teaching methods for attracting students to the subject matters of the course but his/ her behavior is not proper in the class then he/ she may not be able to properly control the class. Students should be happy with the teacher's directions and support (Lo, 2010). In order to increase students' learning and motivation to learn, a teacher should consider the following things as his/ her behavioral pattern in the class room.

4.1. Showing enthusiasm

Teacher is the major source of stimulation for the course contents designed in the 'Electrical Circuit' class. Therefore, it is important that the teacher should model his behavior as he/she wants to see his/her students to demonstrate in this course. If he/she becomes bored or uninterested then it is most likely that that the students will respond negatively. To show enthusiasm, teachers should discuss the various aspects and importance of this course in their curriculum. Since this is the beginners' course, the teacher should explain various new terminologies of the course, such as, electrical current, voltage, resistance, signal sources, electrical power and energy, electrical networks, various units of signals and circuit parameters etc.

4.2. Avoiding division in the class

Teacher should inspire healthy competition among the students in the class, but he/she should not divulge them to be divided rather than to be united. The student in the course should feel that the teacher is treating all the students fairly, i.e. teacher is unbiased irrespective of gender, color, social class, religion, sect, nation etc.

4.3. Showing importance of the course

Teacher should explain why the course is important and useful for the students, especially how the knowledge of this course will be beneficial for the higher level courses, such as, for analog and digital

electronics, electromagnetic, communication engineering, electrical machines, control systems, power system, power transmission and distribution, semiconductor devices, VLSI circuit design etc. courses.

4.4. Taking tutorial classes

Teachers should take tutorials (extra classes apart from normal schedule classes of the week) in each week to solve any kind of mathematical problems or to explain any tough topics that may have been difficult in the class for understanding. This class should be informal and more student centric.

4.5. Communicating for the success

Teacher should engage the students and interact with them to know their expectations and try to raise them his/her level of expectation. Positive influence upon the student might work for this purpose. The teacher should communicate grading decisions and its process to the students. He should also explain how student can achieve their expected grades.

4.6. Providing feedback

Teacher should provide feedback to the students as quickly as possible. Because, students want to be recognized for their work and most of them view grades as a primary incentive for their scholastic efforts. By evaluating assignments with positive and negative comments and returning quickly, teachers actually letting the students know their learning progress and full-filing the course objectives.

4.7. Creating conducive class room condition

Teacher should create such an environment of 'Electrical Circuit' course that is very conducive to all the students. He/ she must encourage students to ask questions in their mind; try to make them understand the subjects several times, if necessary. If student fail to understand the subject he/ she should show patience. He/ she should use multimedia technology to make them understand the subject more clearly. He/ she should always be well prepared for the class and should not allow any student to create disturbances in the class. The teacher must be able to promote student queries regarding courses and other related issues.

5. Course Outcome Measurement Through Motivation

To measure the achievement of the course outcomes through motivation, it is first necessary to analyze the educational objectives and corresponding learning abilities of the students at different sessions. Course outcome achievement is measured through various types of assessment schemes adopted in the course. It is mainly measured through the continuous assessment of all the students in the 'Electrical Circuit" course. This is a 3-credit course, i.e., classes are held 3 hours per week. Two (2) classes of 1.5 hours duration are conducted per week in a semester of 13 weeks excluding the mid-term and final examination weeks.

As a case study, two cohorts of students (Batch IDs 143 and 151) of the 'Electrical Circuit' course, having almost equal class size, are considered in two different consecutive semesters (Fall 2014 and Spring 2015) of Electrical and Electronic Engineering Department of Green University of Bangladesh. In student cohort 143, there are 40 students and traditional teaching approach is followed in Fall 2014 semester. In student cohort 151, there are 42 students and teaching is given through motivation in Spring 2015 semester, by the same teacher. At the end of the final examinations, statistical analyses of the grade points are calculated as shown in Tables 2-5.

From the tables, it is observed that the results are very satisfactory as statistics have improved in student cohort 151 (Table 3), where motivation is provided for teaching the students, than that in

student cohort 143 (Table 2). Comparing tables 2 and 3, it is observed that the percentage of students getting the lowest grade (i.e., "F") has decreased from 40% to 26.2% whereas the percentage of students getting the highest grade (i.e. "A+") has increased in student cohort 151 (23.8%) than that in 143 (10%). Besides, percentage of students getting "A" and "A-" grades has also increased from 2.5% to 7.1% and from 2.5% to 4.8% respectively.

Table 2. Grade Distribution of Cohort 143

Grades	No of Students	Percentage of Students
A+	4	10.0%
A	1	2.5%
A-	1	2.5%
B+	3	7.5%
B	2	5.0%
B-	3	7.5%
C+	1	2.5%
C	7	17.5%
D	2	5.0%
F	16	40.0%
Total	**40**	**100.0%**

Table 3. Grade Distribution of Cohort 151

Grades	No of Students	Percentage of Students
A+	10	23.8%
A	3	7.1%
A-	2	4.8%
B+	5	11.9%
B	4	9.5%
B-	1	2.4%
C+	3	7.1%
C	2	4.8%
D	1	2.4%
F	11	26.2%
Total	**42**	**100.0%**

From the Tables 4-5, it is observed that the results are very satisfactory as statistics have improved in student cohort 151 than that in student cohort 143. Comparing tables 4 and 5, it is observed that the mode, median, mean, quartiles, class CGPA etc. have increased in cohort 151 than that in 143. Therefore, it can be inferred the motivational technique is better to retain students due to improved results. This is also helpful to retain students as pass rate is increased.

Table 4. Statistics of Grade Points of Cohort 143

Statistical Parameter	Value
Mode	2.25
Median	2.75
Mean	1.74

Standard Deviation	0.70
Quartile1	2.25
Quartile3	3.31
Average Deviation	0.60
Class CGPA	1.74

Table 5. Statistics of Grade Points of Cohort 151

Statistical Parameter	Value
Mode	4.00
Median	3.25
Mean	2.41
Standard Deviation	1.39
Quartile1	2.50
Quartile3	4.00
Average Deviation	1.06
Class CGPA	2.46

6. Conclusions

The engineering graduates must be well prepared in the current changing global competitive knowledge-based engineering job market. Like graduates from all other disciplines in the world, the engineering graduates must also have the ability to manage engineering knowledge as well as their skills. Therefore, universities are facing challenges as well as opportunities for creating and transferring knowledge to the students of engineering discipline in efficient and smart way for their survival in job market and also to attract and retain the students in the university.

This paper describes the teaching and learning method of 'Electrical Circuit' course for electrical and electronic engineering and the other engineering discipline students through motivation and inspiration. Of course, it is not the single factor that will improve students learning of a particular course. Even then it is necessary to acknowledge the importance of 'student motivation' in their learning process. But each individual student will be motivated differently than the others. Therefore, it is the individual course teacher who will dynamically decide how he/ she will motivate each individual student in his/ her cohort. Since 'Electrical Circuit' is an elementary core course in the undergraduate curriculum of electrical and electronic engineering degree and for most other engineering programs, therefore, this course must be designed and taught in such a way so that the students feel encouraged and motivated to learn and hence be able to develop their knowledge and skills on designing and analysis of various types of electrical circuits or networks in their real life engineering applications. Besides, better results inspire the students to remain in the program. So, to increase the student interests towards the subject and to increase the retention rate of the program students should be taught the courses through motivation.

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