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Influence of Pedagogy on the Epistemological Estimation of Electrical Engineering Subject

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Abstract : COVID-19 pandemic has brought sudden changes in teaching and learning process compared to conventional face to face mode of education all around the globe. During social distancing in pandemic environment, the most common change that has been introduced was to opt online and hybrid mode of learning using e-resources by students and faculty at several organizations. In our organization, the BlackboardTM platform has been used to teach the course either in e-learning or blended mode. The present work is an epistemic case study of an electrical engineering subject taught in blended mode to undergraduate students. The performances of the students have been analysed in continuous assessment as well as in final assignment. The analysis criteria was based on expected "course learning outcomes" taken from ABET guidelines which was planned before the commencement of academic semester. In this case study, a specific part of the final assignment in which a questionnaire was framed to assess the "Understanding", "Apply", "Analyzed", "Evaluate" and "Create" levels of Bloom's Taxonomy by determining the correlation factor among various parameters. It was observed that students had felt the difficulty in achieving the satisfactory response in "Evaluate" and "Create" while performed well in first three levels of Bloom's Taxonomy. Based on analysis and results, it is concluded that to achieve satisfactory response of the students, continuous hands-on-experience of laboratory experiments and instruments are essential. In the coming months when it is difficult to start the face to face mode of teaching and learning, an alternate method for laboratory could be catered by introducing virtual laboratory and simulations. In addition a remedial plan has to be prepared to enhance the critical thinking of the students to improve the "Evaluate" and "Create" levels of students.

Keywords ABET; Blended learning; Bloom's Taxonomy; Correlation Coefficients; Epistemology.

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1. Introduction

BLENDED learning mode (BL) is a combination of face to face (F2F) learning and electronic/online mode of learning (EL) and different methodologies. Basically, there are three types of blended leanings (i) combination of face-to-face and online teaching, (ii) combination of technologies and (iii) combination of methodologies [1]. The outbreak scenario of COVID-19 has compelled to an option of blended learning i.e. mixture of F2F and technological intervention [1-5]. The spread of COVID-19 has created an environment to enforce the educational organizations to alter their teaching-learning strategy abiding the advice of WHO [6] to ensure the social distancing with safety precaution.

Various strategies [7-9] have been adopted during this challenging situation to ensure the best delivery of course contents using available tools and resources.

The majority of curriculum of engineering programmes consists of classrooms lectures, tutorials and laboratory sessions. The inherent characteristics of Electrical Engineering subjects are closely integrated with the scheduled hands-on-experience in sophisticated laboratory locations. While adopting the new strategy, it has to be ensured that course learning outcomes (CLO) recommended by Accreditation Board for Engineering and Technology (ABET) [10] should be met optimally. In general the execution of course plan is scheduled on weekly basis. But in COVID-19 environment first part of the course was covered in F2F mode and the rest of the part was exclusively covered through EL mode [11].

The BL mode is unique in present scenario to meet the challenge of CLO because the academic activities were uniformly distributed across the semester, but in new strategy some of the activities may not be conducted such as practical sessions, laboratory based research projects, industrial visits, etc. To compensate the laboratory practice, virtual labs [12-14] are one of the options available, but it is having its own limitations. Similarly, the laboratory based research projects were apprehended and were concluded on the basis of their presentation. In addition the industrial visits were compensated through available video clips on internet. However these replacements could serve the purpose up to a certain extent only.

In present case study, the remaining course contents (at the time of outbreak) were covered through various available resources such as Learning Management System (LMS), webinars, voice over presentation, videos, virtual laboratory, etc. Here the BlackboardTM (BB) [15] could play a vital role to academically engage the students with instructors through various tools incorporated in the BB. To validate the strategy adopted, an epistemic survey was conducted for undergraduate students. This was based on a part of their final assignment in Electrical Machines subject. The epistemic survey was framed to test the performance using different levels of Bloom's Taxonomy (BT) [16-17]. The aim was to validate the strategy through performance analysis using correlation method [18]. This study could contribute through analysis among F2F, EL and BL mode during COVID-19 environment. The study addresses the following research questions:

- By changing the mode of learning is it possible to attain the same course learning outcomes.
- Impact on continuous assessment on changing the mode of teaching learning.
- Epistemological assessment of students for academic achievements in Blended mode.

The entire paper has organized in five sections. Section-1 is about the introduction while section-2 describes the methodology used to carry out the work. Section-3 presents the results and its analysis while work is concluded along with recommendation in section-4. The brief information to conduct a case study has explained in appendix-1 of the section-5. Also the various parameters of students learning outcomes prescribed by ABET are shown in appendix-2.

2. Methodology

In this case study the undergraduate students of electrical engineering are taken into consideration to assess their leanings and performances in three modes like F2F, EL and BL. In F2F learning mode students were attending the regular classes in synchronized way to interact with instructor for theory and laboratory sessions. The theoretical concepts of electrical machines and problem solving tutorials were conducted in classroom while the associated experiments on electrical machines to get hands-on-experience were performed at scheduled laboratory under supervision of laboratory engineers and instructor. The students were assessed to gauge their learning level and performance by various components of continuous course works such as quiz, assignments, and laboratory reports.

In mid of the semester, the COVID-19 pandemic environment had forced F2F mode to confine online leaning to coop-up rest of course contents maintaining same course outcomes proposed before the commencement of semester [1-6]. The instructors had uploaded the course literature in the form of audio-video and power points using LMS tools such as BlackboardTM [15] and Google Drive. Some components of continuous course works were framed to assess the students learning level and performance based on EL mode while few course components were prepared to assess the performance of the students in BL mode of learning. For instance a questionnaire as shown in appendix-1 was set as a part of the final assignment covering full syllabus including laboratory and students were asked to answer these questions which were discussed during regular classes

Table 1 : Levels of Bloom Taxonomy

Bloom Taxonomy parameter	Understanding	Apply	Analyse	Evaluate	Create
Symbol used	BT_L2	BT_L3	BT_L4	BT_L5	BT_L6

and in online course material. The response of questionnaire by students was used to judge the Bloom's Taxonomy levels (BT_L2 to L6) as mentioned in the table 1. In this case study nine parameters as shown in next section are belonging to three modes of learning.

These are taken into consideration for a cohort of 37 undergraduate electrical engineering students. The statistical correlation coefficients (CRC) among various parameters as shown in table-2 and 3 were obtained using Karl Pearson's equation [18] as shown below: Correlation between sets of data is a measure of how well they are related.

$$CRC = \frac{n(\sum xy)-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2]\left[n\sum y^2-(\sum y)^2\right]}} \quad (1)$$

Where, 'x' and 'y' are variables.

The absolute value of the correlation coefficient indicates the strength between two variables. Higher the 'CRC' stronger will be the relationship.

3. Results And Discussion

The ABET performance indicators are reflected by the students' outcomes while the questions framed for assessment are representing the various levels of bloom's taxonomy [16-17]. The correlation matrix table is shown in table-2. There are 9 parameters which are directly or indirectly correlated to each other. The correlation coefficient [18] varies between -1.00 to 1.00. In the table-2, NA means "Not Applicable" i.e. the correlation coefficient (CRC) is very small or negligible.

Let us begin the discussion with correlation between attendances during F2F mode with the attainment in continuous assessment. The CRC is 0.417 which reflects that students have attended the classes in F2F mode in regular manner & actively participated in classroom activities to attain rather a good score. Our main focus is on epistemology of the students. A positive CRC can also be seen between the F2F attendance and Understand level (BT_L2) as well as apply level (BT_L3) of BT which is in line with the expected outcome of the course. Whereas the CRC between F2F attendance and create level of BT is –ve which indicates that the course outcome has not been

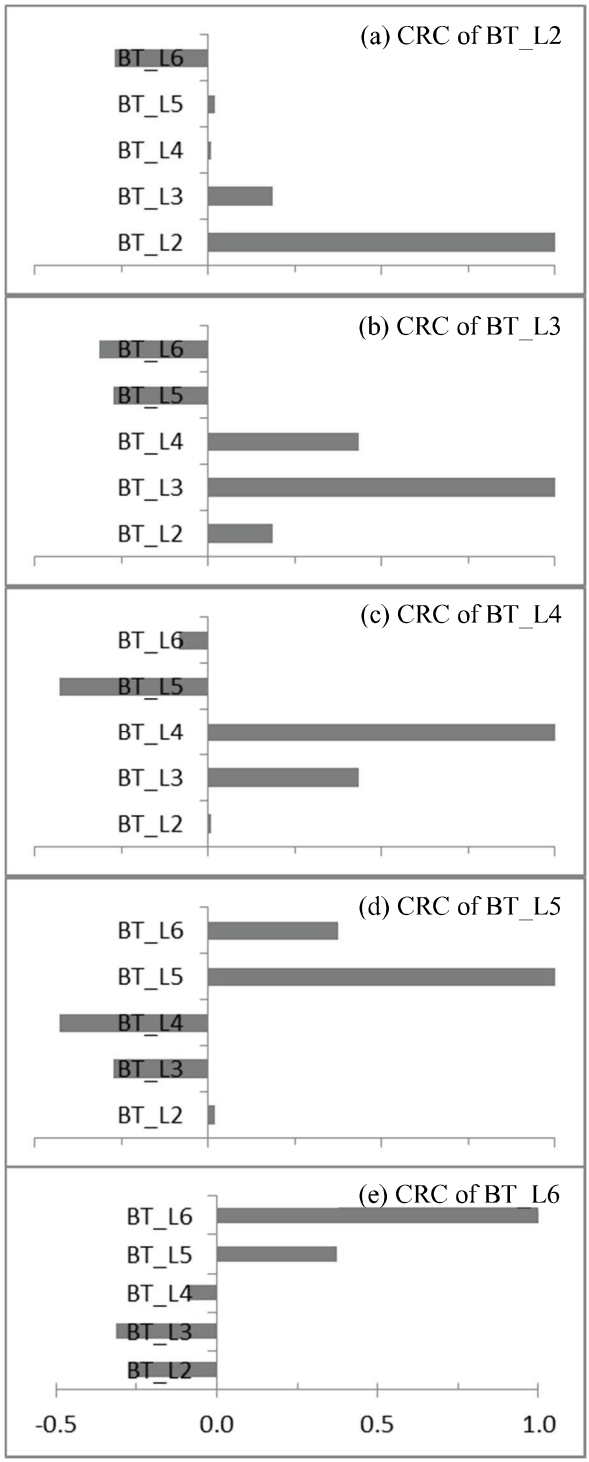

Fig.1 : Representation of correlation coefficients of (a) BT_L2 with other levels of BT (b) BT_L3 with other levels of BT (c) BT_L4 with other levels of BT (d) BT_L5 with other levels of BT (e) BT_L6 with other levels of BT. CRC is 1 with itself

achieved because for design of a machine the rigorous hand-on-experience and thorough analysis is essential.

In addition the CRC between the Performance in F2F (PER_F2F) and performance in BL mode is +ve because BL is directly proportional to the F2F mode of learning. The students who perform well in F2F had also done worthy in BL mode. Also the CRC between PER_F2F and BT_L2 and BT_L3 are +ve because the students have positive trend to understand the concepts of electrical machines in class during interaction with instructor and also the students who understood the basic concepts of electrical machines were able to solve the numerical problems more efficiently. However the CRC of PER_F2F and BT_L6 is negative. This indicates that student could not achieve the learning level to modify the machine to meet its required operation.

After the intervention of Covid-19 advisory it was mandatory to deliver all course contents through e-learning (EL) mode. In which the most challenging task was to organize lab sessions in EL mode through virtual labs or simulation models. In all, the course has been transformed into a blended mode from F2F.

Table 2 :
Crc Among Bloom's Taxonomy For Specific Study

Parameters → / ↓	*BT_L2*	*BT_L3*	*BT_L4*	*BT_L5*	*BT_L6*
BT_L2	1.000	0.186	0.007	0.017	-0.270
BT_L3	0.186	1.000	0.435	-0.275	-0.313
BT_L4	0.007	0.435	1.000	-0.430	-0.086
BT_L5	0.017	-0.275	-0.430	1.000	0.373
BT_L6	-0.270	-0.313	-0.086	0.373	1.000

During the EL mode of learning the student has participated in various activities such as downloading the audio visual version of course contents, submission of assignments and laboratory experiments presentation. All these activities are represented as part of blended activities (ACT_BL) and score obtained in these activities are represented Performance in Blended Learning Mode (PER_BL). A CRC between ACT_BL and PER_BL is significantly +ve and internal performance in BL is better than ATT_F2F because all the students had accessed the online course material made available on a regular manner on the Blackboard. As a result most of the courses outcomes are faithfully attained by students except the design/create part of the machines. And while gauging the performance indicator like "Ability to communicate effectively through oral presentation" as student learning outcome according to ABET, it was observed that further improvement is required.

Moving further the CRC between ACT_BL and BT_L4 is +ve which represents the problem solving approach had learned by the students in F2F mode of learning whose analysis is reflecting in BT_L4. Therefore students had reproduced CRC up to a good extent by F2F and EL. Whereas the CRC between ACT_BL and BT_L5 as well as BT_L6 is –ve since the blended mode of learning is combination of F2F & EL and the online activities started at midway e.g. after a gap of 9 to 10 weeks from the commencement of semester. Therefore a considerable discontinuation in lab activities may be responsible for negative correlations.

During the whole semester a correlation between the learning and performance through F2F and EL has a contribution to assess the attainment of Bloom's taxonomy levels. To epitomize the CRC between PER_BL and BT_L2, BT_L3 & BT_L4 is +ve which designates that under COVID-19 environment BL mode could serve the purpose of attainment of students learning outcomes satisfactorily. However it can be depicted that CRC is -ve between PER_BL and BT_L5 &L6 which required the laboratory practice to achieve the adequate outcomes.

As mentioned in the methodology that a specific task was designed from the prescribed syllabus in BL mode to assess the BT levels. The details of the task/questionnaire can be seen in appendix 1. Hence it is worth to have the correlation among the performance in the different levels of BT in the designed questionnaire as shown in Table-2 and represented graphically through fig. 1 (a) – (e), where x-axis shows the CRC and y-axis shows the BT levels BT_L2 to BT_L6. The value of CRC = 1 shows the correlation with itself.

The right side of the x-axis is +ve CRC and on the left side, the CRC is –ve. The understanding level i.e. BT_L1 has not been included in questionnaire because it need to be tested as the student is mature enough.

The CRC between BT_L2 and BT_L3 is +ve which specifies that student has identified the correct parameters which are ultimately helping for him/her to determine the correct solution of the problem.

Table 3 :
Crc Among Attendance, Activities, Performance And Bloom's Taxonomy Parameters For F2f Mode, Bl Mode And Epistemic Study

Parameters	*ATT_F2F*	*PER_F2F*	*ACT_BL*	*PER_BL*	*BT_L2*	*BT_L3*	*BT_L4*	*BT_L5*	*BT_L6*
ATT_F2F	1.000	0.417	NA	NA	0.125	0.335	NA	NA	-0.422
PER_F2F	0.417	1.000	NA	0.719	0.169	0.407	NA	NA	-0.124
ACT_BL	NA	NA	1.000	0.537	NA	NA	0.249	-0.209	-0.422
PER_BL	NA	0.719	0.537	1.000	0.239	0.536	0.464	-0.100	-0.225
BT_L2	0.125	0.169	NA	0.239	1.000	0.186	0.007	0.017	-0.270
BT_L3	0.335	0.407	NA	0.536	0.186	1.000	0.435	-0.275	-0.313
BT_L4	NA	NA	0.249	0.464	0.007	0.435	1.000	-0.430	-0.086
BT_L5	NA	NA	-0.209	-0.100	0.017	-0.275	-0.430	1.000	0.373
BT_L6	-0.422	-0.124	-0.422	-0.225	-0.270	-0.313	-0.086	0.373	1.000

Moving further the parameters BT_L3 and BT_L4 are closely related (explained in the next paragraph) and their CRC is substantial but the impact of BT_L2 is not directly related to BT_L4 as well BT_L5; hence it is not exhibiting direct influence over it. Therefor the CRC between BT_L2 and BT_L4 as well as BT_L2 and BT_L5 is almost at the level of zero. Though the CRC between BT_L2 and BT_L6 is –ve which represents that critical thinking of the student has not developed as expected because of e-learning was introduced in halfway of the semester without any preplan due to COVID-19 environment. All these results are depicted in fig. 1 (a).

After having correlation of understanding level with all other levels of BT, now let us see the correlation of apply level of BT with analyze, evaluate and create/design levels. According to the table-3 the CRC between BT_L3 and BT_L4 is +ve revealing that if the student can solve the problem correctly the chances of the analysis to be correct, become higher. But the –ve CRC to BT_L5 and BT_L6 point outs that the L4 and L5 learning are highly influenced by the hands-on-experience at laboratory and creative thoughts have not been generated as per the expected course outcome as can also be depicted from the CRC between BT_L4 with BT_L5 and BT_L6. All these results can be seen in graphical mode in fig. 1 (b).

Remarkably, the CRC of BT_L5 with BT_L6 is +ve. This is due to the fact that if a student has identified the correct priorities and recommendations of the problems then he/she was able to hit the target by suggesting the appropriate solution of problem at design level. The interrelated CRC among BT parameters for epistemic study can be seen in fig.1 (a) – (e).

4. Conclusion, Recommendations And Future Scope

To summarize the present work in a unique scenario of COVID-19, a systematic epistemic study was conducted as a part of final assignment for Electrical Machines course. The course was taught in a BL mode i.e. F2F followed by EL mode. In both the cases Blackboard as LMS platform was used. To assess the course, CRC among the nine parameters had been taken into account. After the detailed analysis, it is observed that performance in F2F and EL mode was beyond satisfactory up to analyze level of BT but the CRCs for evaluate and create/design levels were –ve in most of the cases. This leads to identify a scope of further improvement to the instructors.

Now to enhance the performance in evaluate and create/design levels, following strategic endorsements are being proposed by ensuring the efforts to deliver proper emphasis on remember, Understanding, Apply and Analyze level of BT .

(i) Trouble shooting part: Trouble shooting part can be introduced in the virtual labs so that students can be acquainted with working environment of the experiment up to a good extent.

(ii) Lab visit may be planned: The schedule can be made in such a way so that students can attend the lab sessions by having one or two visits to campus on weekly basis subjected to abide the COVID-19 advisory of local administration.

(iii) As an alternate of F2F labs, virtual labs can be conducted. Various platforms such as Amrita

labs [12] are available with interactive tools to perform the experiments of various subjects. Indigenous recording on the local lab setup can be prepared by the instructor and can be shared with students well before the conduction of the session.

(iv) Online quiz may be conducted: To maintain the spontaneous response skills of the students, the online quiz may be considered as a useful component of assessment.

APPENDICES

A. Appenix-1

Note: Final assignment is consists of full syllabus including the practical experience of laboratory in the course.

Questionnaire (in final assignment):

A self-excited DC generator has been operating at 'N' rpm to cater a steel mill which required adjusting two values of no load voltages. The second value of armature voltage must be 'Y'% lower than its first value. The magnetization curve supplied by the manufacturer of the generator is shown in fig-2. Answer the following:

(i) Summarize the parameters responsible to build-up the armature voltages.

(ii) If the total resistance of field circuit of generator is 'Z' Ω and the corresponding field current is 'X' Amp, relates these parameters to determine the no load armature voltage build up by the generator.

(iii) It is observed that generator is unable to build-up the second value of armature voltage; analyze what could be the possible causes for not attaining the required voltage?

(iv) Prioritize the recommendation to rectify the problem of part (iii).

(v) Suggest how to modify the magnetization curve of the given machine which could change the associated parameters to build-up the armature voltage.

Here 'X','Y', 'Z', and 'N' are arbitrary numbers

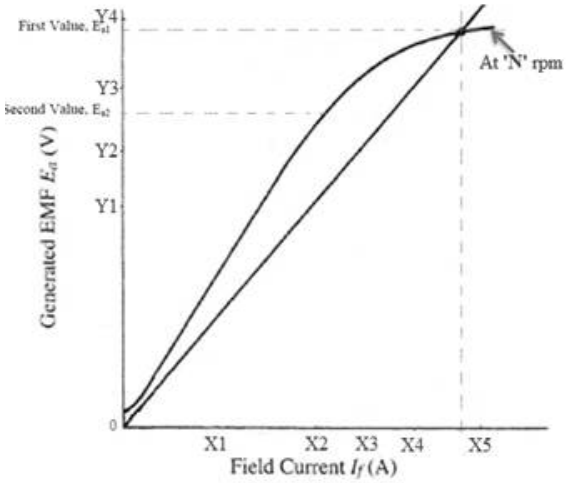

Fig. 2 : For questionnaire shown in appendix-1

B. Appendix-II

The students learning outcome prescribed by ABET are as follows:

(a) an ability to apply knowledge of mathematics, science, and engineering;

(b) an ability to design and conduct experiments, as well as to analyze and interpret data;

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

(d) an ability to function on multi-disciplinary teams;

(e) an ability to identify, formulate, and solve engineering problems;

(f) an understanding of professional and ethical responsibility;

(g) an ability to communicate effectively;

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

(i) a recognition of the need for ability to engage in life-long learning;

(j) a knowledge of contemporary issues, and

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Abbriviations

ABET: Accreditation board for engineering & technology

ACT_BL: Activities in blended learning mode

ATT_F2F: Attendance in face to face learning mode

BB: Blackboard

BL: Blended learning mode

BT_Lx: Bloom's Taxonomy level number

CLO: Course learning outcome

COVID-19: Corona virus disease of 2019

CRC: Co-relation coefficient

EL: Electronic/online learning mode

LMS: Learning management system

NA: Not applicable

PER_BL: Performance in blended learning mode

PER_F2F: Performance in face to face learning mode

TM: Trade Mark

WHO: World health organization

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