Effective Implementation of Peer Review as an Active Learning Technique to Attain Course Outcome: A Case Study

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***Abstract*— To engage the students actively in large classes is a challenging task. It became tougher especially in the online mode of conduction of lectures, due to the pandemic situation. In the absence of physical classroom interaction, students tend to lose focus and disconnect with the course content. It is observed that implementation of active learning techniques, helps in enhancing students' engagement. It also appears to be beneficial in improving attainment levels of the course outcomes which is a very important aspect of the outcome based education. This paper discusses Peer Review as an active learning strategy, implemented for the course of Basic Electrical and Electronics Engineering for the first year engineering students. The students were divided into small groups, were asked to solve problems (were given a task based on a course outcome) and were asked to Peer Review the work with the help of assessment rubric provided. Course outcome where Peer Review Technique was implemented is compared with the other course outcomes where this technique was not implemented.**

Keywords— Active Learning, Peer Review, Course Attainment, Program Outcome, Outcome Based Education

1. Introduction

In the online mode of teaching, it is very challenging for a course instructor to keep students engaged with the course content as compared to the face to face interaction in the classroom environment. On the students' part, it is very difficult to stay focused and concentrate on lecture content when they have to attend lecture sessions online. As a result students' attention span tends to decline. It necessitates the employment of active learning Techniques such as peer assessment, think pair share, role play, one minute paper, muddiest point technique etc. In the Outcome Based Education, attainment of Program Outcomes is of prime importance. Program Outcomes are indicators of various abilities such as analytical skills, teamwork, communication skills, professional ethics developed in the graduating students**.** Desai (2022) studied that activity based learning helps students connect with the course content which affects attainment of Course Outcomes and in turn attainment of Programme Outcomes. Due to the COVID-19 pandemic situation the first semester of the first year of the Engineering was conducted in the complete online mode. To engage students actively in the learning process, Peer Review Technique was applied to the course of Basic Electrical and Electronics Engineering taught in the 1st semester of the undergraduate engineering curriculum of Computer Engineering programme and Information Technology programme. Topping (2017) has done elaborate analysis of the literature available related to the peer assessment conducted from elementary schools to universities. Peer Review has become a favorite with the course instructors since the last fifteen years. The simple form of Peer Review is the one where students grade the assignments, in the form of oral presentations or writing of their fellow classmates. The activity can be taken one step ahead with detailed feedback of the work and discussion with the peers which contributes to the learning.

The aim of this study was to encourage students' active participation in the online learning and thus enhance their engagement with the course content which will work towards attainment of the course outcome. The Peer Review strategy was implemented for the DC circuit module of the course Basic Electrical and Electronics Engineering as students find it difficult to apply the circuit theory to the given circuits and find the required parameters. Also there are several ways to solve the same circuit which students can share with each other through peer review. This will be beneficial to attain the course outcome which is defined as, 'after completion of course, students will be able to analyze and calculate parameters of DC circuits'.

2. Literature Survey

Berg et.al. (2006) studied and analyzed seven different designs of peer evaluation for writing assignments and were implemented for seven different courses spread across the programme for history students. These designs were made by combination of ten different variables, chosen from Topping's typology such as privacy, place, reward etc. The effect of these designs on various learning outcomes such as students' grades, students' and teachers' perception of improvement in writing skills, revisions made by students taking into account reviewer's and teachers' comments was studied to determine the best possible design. Students received feedback in terms of content, structure and style. Students revised their work taking into account this feedback. It was summarized that three design parameters are more beneficial for effective peer assessment. The first one is the relation of peer and staff assessment which is the time period available between receiving Peer Review comments and final submission. More the time available, better revision can be done based on peer review. Second parameter is directionality i.e. every student reviewing the work of fellow classmates is bound to get his work reviewed as well and last point is optimum group size for peer evaluation which is 3 to 4

students. If the group is formed of two students, it may not be useful if both the students are academically weaker.

Odom et.al. (2009) employed group Peer Review as an active learning strategy for an undergraduate nursing research course, wherein students were supposed to write a critique of a research article. The aim of implementing this Technique was to develop higher order thinking skills and collaboration amongst the students. In the first step of the activity, student groups were formed on the basis of clinical topics. Each student was to study a research paper related to the topic and write a critique. In the subsequent step, class was divided into the groups where each member had studied a different clinical topic. Each group exchanged and studied the critiques of another group and did evaluation as per the rubric provided. Each student received feedback from faculty members and peers, and made corrections in the research article before final submission. Authors have summarized that students understood evaluation rubric well. Peer assessment may be inaccurate due to lack of rigor and involvement on the students' part. Students' perception about this activity is that it encourages conceptual discussions but at the same time , time investment required cannot be justified for just 5% weightage in the grade.

Hu and Eu Lam (2009) reports study to understand (a) Is Peer Review technique an effective pedagogical technique with adult Chinese students in the teaching of second language (L2) academic writing and (b) how different factors influence peer reviewers'. The Students were 20 English as L2 learners from China who were registered for academic writing class for postgraduate students at a Singaporean university. Response Data included first drafts of writing assignment, written peer comments, revised drafts of the assignment, responses to a questionnaire, and interviews. Analysis of the peer comments and revisions to the drafts show that remarkable improvement in the revised drafts was linked to peer feedback. The analysis indicates that the students' variables of interest did not affect the effectiveness of the peer review activity.

Smith et. al (2012), explains how Peer Review can be helpful to teach software testing, an important skill that is typically not given much attention in teaching such courses. Similarly, Bewoor and Kulkarni(2018) and Bewoor(2020) have reported T-P-S as Peer Review based active learning strategy. These studies have reported their experience. in implementing peer testing into a course having a major programming component and a short time available to teach. It is concluded that irrespective of the extra work, the majority of students enjoyed peer testing and found it worthwhile, and many students expressed an interest in doing additional peer testing.

Søndergaarda and Mulderb (2012) summarized the importance for a general peer review tool, and classified tools based on four dominant 1) Automation- Obscurity of student, the distribution of work between reviewers and reviewee and informing administrators and students about facets of the peer review process. 2) Simplicity- Tool should be lucid and easy to use for both teacher and students. 3) Customizability- Students and teachers have enormously diverse needs, peer review tools should be pliable to allow them to be customized for different needs. 4) Accessibility- Student peer review tools should be free, web-based, it should be available anytime and globally available. They concluded by investigating some gaps in current understanding of developing peer review, and explained how online tools for student peer review can help.

Mulder et.al. (2014) studied students' perceptions of the Peer Review Technique, before and after its implementation and put forth the main four observations. The strategy was applied to four different university courses offered to different disciplines, different academic years, and having different class strengths. It was observed that students had very high expectations from the process of Peer Review prior to its implementation but later they found it little less useful. This downward shift was mainly associated with the concern of the review quality. While analyzing students' perceptions, it was noted that some students thought that they had put in great efforts for critical analysis of their peers' work but they did not receive the good quality review. It was also noted that writing reviews enhances conceptual understanding. It was observed that students exhibited confidence in their fellow classmates' ability to review the work. Overall it was summarized that students should be provided with proper training and guidance and clear and detailed criteria should be made available to them for successful implementation of the Peer Review Technique.

Stigmar (2016) reviewed 30 research papers representing around 66 percent of the studies from the United States of America, including studies from natural- and physical science. They identified that there are a number of research gaps that need to be investigated in connection to peer teaching. In this review paper 4 questions were addressed, where in (1) countries and subjects are the studies considered for peer review technique. (2)Different pedagogical beliefs and theories influence the teaching -learning techniques (3) which study designs are used frequently (4) What are the research outcomes and the evidence in previous research conclude Identified studies where students are involved as partners in teaching in higher education and to explore how teachers and students benefit from peer teaching.,.

Brill (2016), identified peer review as an teaching-learning pedagogy for teaching the design knowledge, skills, and disposal of Instructional Design and Technology (IDT) professionals for newcomers. Study is focused on the research on introducing instructional design courses. It is concluded that there is a need for more research regarding how new teaching-learning methodology can be used flexibly to the intricacy of ID problems in practice. Panange et al. (2019) has considered peer review as one of the evaluation methods to evaluate students' performance using Project Based Active Learning Pedagogy.

Implementation of Peer Review Technique for attaining course outcomes of Basic Electrical and Electronics Engineering is not explored in available literature. This paper focuses on qualitative and quantitative analysis of effectiveness of Peer

Review technique for development of DC Circuit Analysis ability.

3. Methodology

Peer Review design is based on variables described in Topping's typology (1998). 14 variables are considered for the design which is suggested in Topping's typology. The design is summarized in table 1.The objective of the Peer Review is to develop the conceptual understanding of the topic: DC circuit analysis and attain corresponding course outcome of the course Basic Electrical and Electronics Engineering offered to the first year engineering students of Computer Engineering programme and Information Technology programme. It is not used as a substitute for the teacher's assessment. The procedural steps used for implementing Peer Review Technique are shown in the table 1

Table 1: Peer Review Design

Sr. No.	Variable	Description
1	Area	DC Networks
2	Objective	To Enhance ability to analyze and calculate parameters of given DC circuit
3	Product	Marks
4	Relation to staff assessment	Supplementary: only peer feedback
5	Official weight	No contribution to the final official grades
6	Directionality	Mutual
7	Privacy	Public (Teacher and all students)
8	Contact	Online
9	Ability	Groups are selected by teacher as per roll number
10	Constellation Assessors	Group of 6 students
11	Constellation Assessed	Same group
12	Place	Outside class (online)
13	Requirement	Voluntary for students
14	Rewards	No rewards for participation

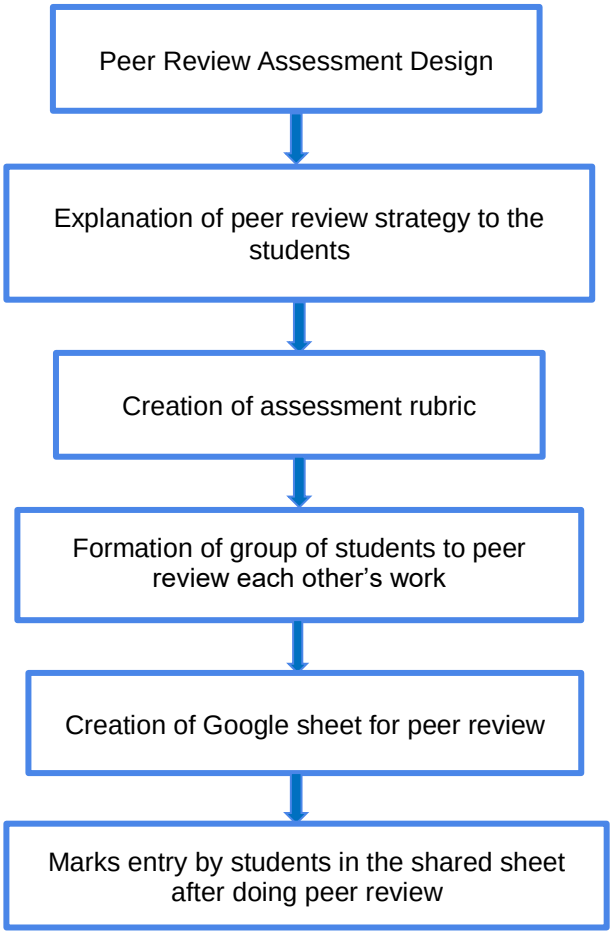


Fig. 1 Procedural Steps for peer review

4. Implementation

Peer Review Technique is implemented for the course Basic Electrical and Electronics Engineering which is offered to first year students of Computer Engineering and Information Technology programme. This course was conducted in online mode due to the COVID 19 pandemic situation. For this course total 5 Course Outcomes (CO) are defined as:
After completion of course, students will be able to,

Table 2: Course Outcomes

CO	Statement
CO 1	Analyze and calculate parameters of DC circuits.

CO 2	Analyze and calculate parameters of AC circuits.
CO 3	Calculate performance parameters of single phase transformers.
CO 4	Analyze I-V characteristics of semiconductor diodes and transistors and design simple analog circuits using these devices.
CO 5	Build simple combinational and sequential logic circuits.

To address the CO1, a module DC networks is included in the course. It is observed that students find it difficult to apply the network solution methods to find required parameters of a given DC circuit. Hence this module is selected for peer review. In this module there are various methods to find the parameters of a given DC network. For implementing Peer Review Technique, 6 methods are considered. Students are divided into groups of 6. For each method, every student in a group is asked to take one circuit and find the required parameter. Students are then supposed to review each other's solution and assess it. To assist the students in peer review, a rubric is provided to all the groups. In this rubric, for each method 7 levels are defined. For each level points are assigned. Students are asked to give the points out of 6 based upon the levels achieved. A google spreadsheet is shared with students in which they are instructed to enter the points of their group mates after peer reviewing activity.

At the end of the semester, CO1 attainment is obtained through the performance of the students in the end semester examination. It is then compared with the attainment of course outcome 3 (CO3) and course outcome 5 (CO5) where Peer Review is not implemented. For all these COs (CO1, CO3 and CO5) descriptive examination is conducted hence comparison is done for these COs. Whereas for CO4 evaluation is done through multiple choice questions (MCQ) hence CO4 is not considered so as to have uniformity in the evaluation process.

Process for Estimation of CO Attainment

Expected course outcome CO1 after completion of the module DC Networks is, 'students will be able to analyze and calculate parameters of DC circuits'. To evaluate this outcome, DC circuits analysis questions were asked in the end semester examination for 13 marks and attainment is calculated in line with the guidelines given in National Board of Accreditation Self-Assessment Report NBA SAR. For CO attainment Benchmark score is decided as 8 (60% of the maximum marks). Target levels are set as

level 1: Less than 40% students' scoring marks more than the Benchmark score (8)

level 2: 40% to 60% students' scoring marks more than the Benchmark score (8)

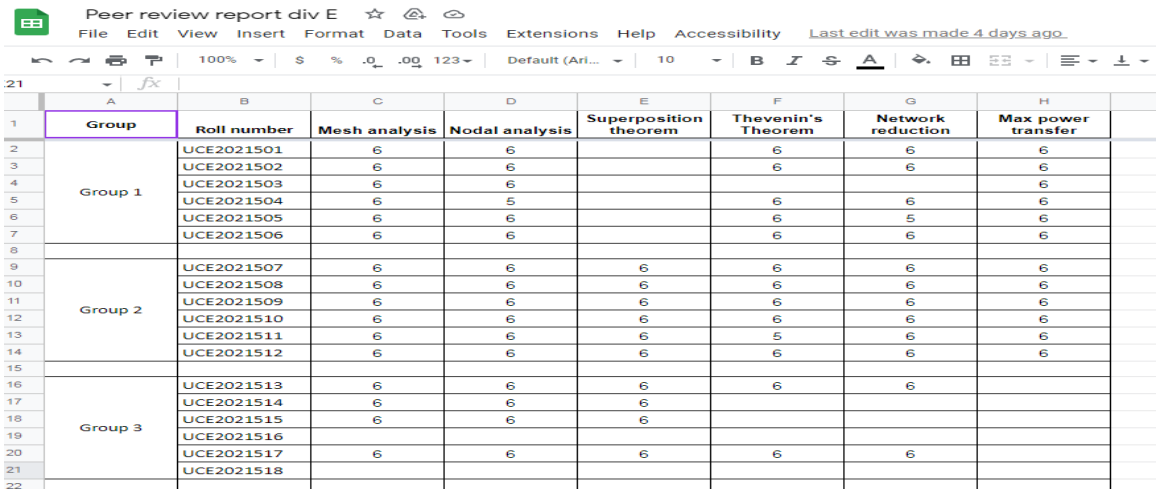
level 3: More than 60% students' scoring marks more than the Benchmark score (8)

CO1 attainment is then compared with the course attainment of course outcome 3 (CO3) and course outcome 5 (CO5) where Peer Review is not implemented. These attainments are obtained through the performance of students in the In-semester examination.

Table 3: Peer Review Rubric

Criteria	**Level 0 (0 marks)**	**Level 1 (1 Mark)**	**Level 2 (1 Mark)**	**Level 3 (1 Mark)**	**Level 4 (1 Mark)**	**Level 5 (1 Mark)**	**Level 6 (1 Mark)**
Mesh Analysis	Cannot identify meshes	Identify Mesh and assign current	Identify Mesh But Cannot Write Correct Equation By Kvl	Identify Mesh and write correct equation by KVL in all loops	Write all loop equations correct but do calculation mistakes	Write all loop equation correct but cannot determine the current in required branch	Write all loop equation correct and determine the current in required branch
Nodal Analysis	Cannot identify all nodes	Identify mesh and assign current in each branch	Identify nodes but cannot write correct equation for branch current	Identify Nodes and write correct equation for branch current but cannot write correct equation by KCL at each node	Identify Nodes and write correct equation by KCL	Write all equations correct at each node but do calculation mistakes	Write all equations correct at each node and determine the current in required branch

Superposition theorem	Did Not replace all remaining sources	Replace sources with incorrect internal resistance	Replace sources with correct internal resistance but can not solve further	Replace sources with correct internal resistance but can not identify required individual current	Identify required current but cannot do if source conversion is required	Can apply all steps but do calculation mistake	Apply all steps without any mistake
Network reduction	Can not identify series, parallel branches	Can convert series , parallel but cannot identify star / delta	Can identify star delta but apply wrong formula	Can do star delta conversion but connect circuit in a wrong manner	Connect the circuit right for few stages but wrong in some stages	Do the conversions correct, connect the circuit correct in each stage but do calculation mistake	Apply all steps without any mistake
Max Power Transfer	Do not know the condition for maximum power transfer	Know the condition but did not replace Rl with Rth	Know the condition but can not apply Thevenin's Theorem	Apply theorem but do calculation mistake	Apply theorem correctly but wrong formula for Pmax	Apply all steps but did calculation mistake	Apply all steps without any mistake



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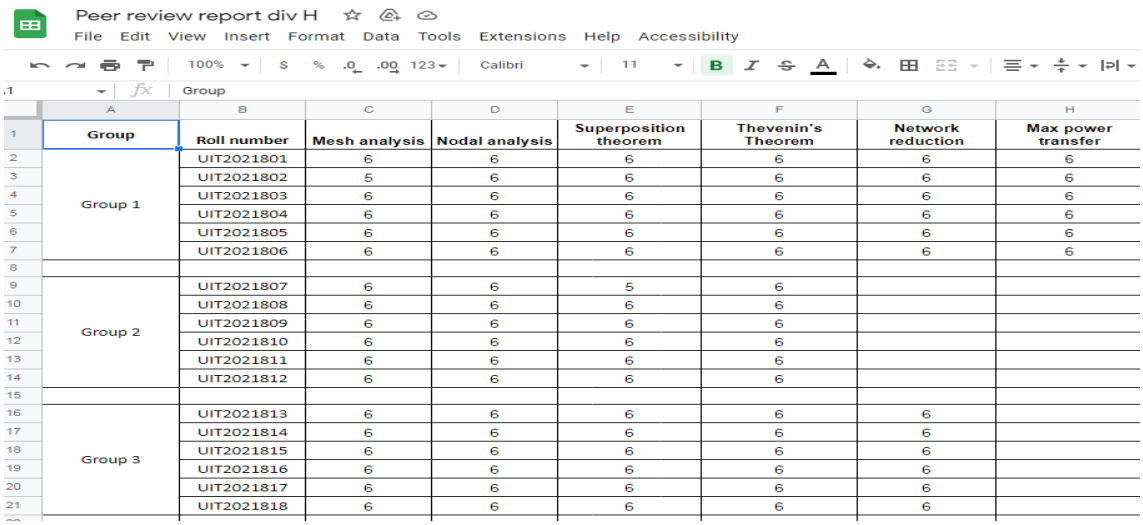
	A	B	C	D	E	F	G	H
1	Group	Roll number	Mesh analysis	Nodal analysis	Superposition theorem	Thevenin's Theorem	Network reduction	Max power transfer
2	Group 1	UCE2021501	6	6		6	6	6
3		UCE2021502	6	6		6	6	6
4		UCE2021503	6	6				6
5		UCE2021504	6	5		6	6	6
6		UCE2021505	6	6		6	5	6
7		UCE2021506	6	6		6	6	6
8								
9	Group 2	UCE2021507	6	6	6	6	6	6
10		UCE2021508	6	6	6	6	6	6
11		UCE2021509	6	6	6	6	6	6
12		UCE2021510	6	6	6	6	6	6
13		UCE2021511	6	6	6	5	6	6
14		UCE2021512	6	6	6	6	6	6
15								
16	Group 3	UCE2021513	6	6	6	6	6	
17		UCE2021514	6	6	6			
18		UCE2021515	6	6	6			
19		UCE2021516						
20		UCE2021517	6	6	6	6	6	
21		UCE2021518						
22								

Fig. 2 Peer Assessment Report of Computer Engineering students



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Group

	A	B	C	D	E	F	G	H
1	Group	Roll number	Mesh analysis	Nodal analysis	Superposition theorem	Thevenin's Theorem	Network reduction	Max power transfer
2		UIT2021801	6	6	6	6	6	6
3		UIT2021802	5	6	6	6	6	6
4	Group 1	UIT2021803	6	6	6	6	6	6
5		UIT2021804	6	6	6	6	6	6
6		UIT2021805	6	6	6	6	6	6
7		UIT2021806	6	6	6	6	6	6
8								
9		UIT2021807	6	6	5	6		
10		UIT2021808	6	6	6	6		
11	Group 2	UIT2021809	6	6	6	6		
12		UIT2021810	6	6	6	6		
13		UIT2021811	6	6	6	6		
14		UIT2021812	6	6	6	6		
15								
16		UIT2021813	6	6	6	6	6	
17		UIT2021814	6	6	6	6	6	
18	Group 3	UIT2021815	6	6	6	6	6	
19		UIT2021816	6	6	6	6	6	
20		UIT2021817	6	6	6	6	6	
21		UIT2021818	6	6	6	6	6	

Fig. 3 Peer Assessment Report of Information Technology students

5. SURVEY QUESTIONNAIRE

To analyze the effectiveness of Peer Review as an active learning strategy, a survey questionnaire is prepared. During the process of preparing the questionnaire, the survey questions related to active learning strategy Reese-Durham (2005) are referred to. [8]. The objective of the survey is to measure 1) the enhancement of students' engagement in the teaching learning process 2) the enhancement of conceptual understanding 3) the enhancement of interest developed in the course. Survey was conducted using Google form. There were seven questions in the questionnaire. Students' responses were recorded on a five point Lickert scale. The survey Questionnaire is as shown in the Table below. (Number of students participated in the survey = 97).

Table 4: Peer Review: Survey Questionnaire

Sr. No.	Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Peer Review activity proved beneficial in revising the topic content.					
2	The feedback received from my fellow classmates was very positive and valuable.					
3	I got to know alternative ways to solve the same problem.					
4	I enjoyed Peer Review as an active learning method.					
5	I would like to have a Peer Review activity for other topics as well.					
6	Clear instructions for Peer Review were given at the beginning of the process.					

7	Rubric for the assessment was given before the Peer Review process.					

6. RESULTS AND DISCUSSION

In this part of the paper both quantitative and qualitative analysis of the Peer Review Technique is carried out. Quantitative analysis is done based on CO attainments of the course Basic Electrical and Electronics Engineering. An attainment value of CO1 where Peer Review is implemented is compared with the attainment values of CO3 and CO5 where this Technique is not implemented, to analyze the effect of Peer Review Technique.

TABLE 5: CO ATTAINMENT OF COMPUTER ENGINEERING STUDENTS

CO	Total No. of Students	No. of Students Scoring above Benchmark	Percentage of Students above Benchmark	Attainment Level
CO 1	72	54	75	3
CO 2	72	44	61.1	3
CO 3	72	40	55.55	2
CO 5	72	54	75	3

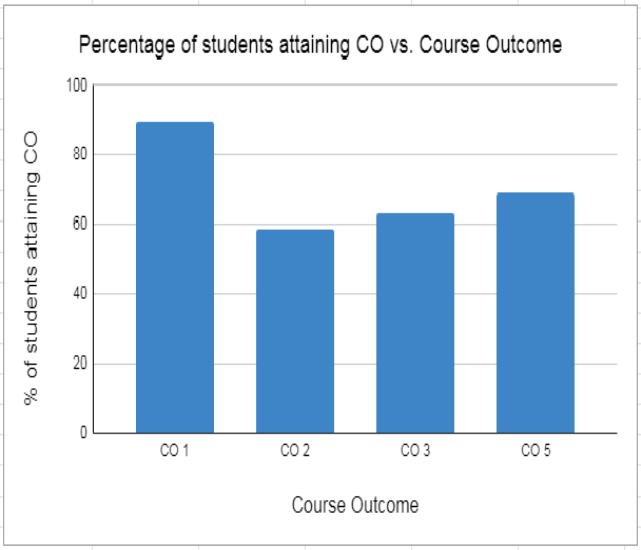


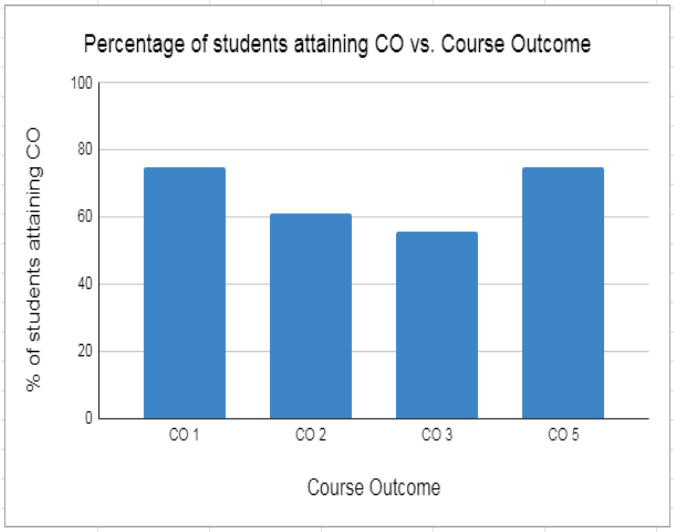
Fig.4 CO attainment of Computer Engineering students

TABLE 6: CO ATTAINMENT OF INFORMATION TECHNOLOGY STUDENTS

CO	Total No. of Students	No. of Students Scoring above Benchmark	Percentage of Students above Benchmark	Attainment Level
CO 1	68	61	89.7	3
CO 2	68	43	63.23	3
CO 3	68	40	58.8	2
CO 5	68	47	69.11	3

Fig. 5 CO attainment of Information Technology students

For qualitative analysis of the Technique students' responses to the survey questionnaire is considered. The responses are analyzed to understand students' perception about the implementation and effectiveness of the Peer Review as an active learning strategy.



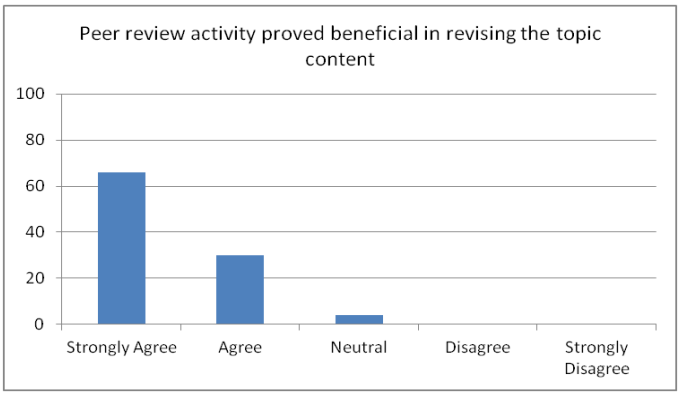


Fig. 6 Benefit of Peer Review for content revision

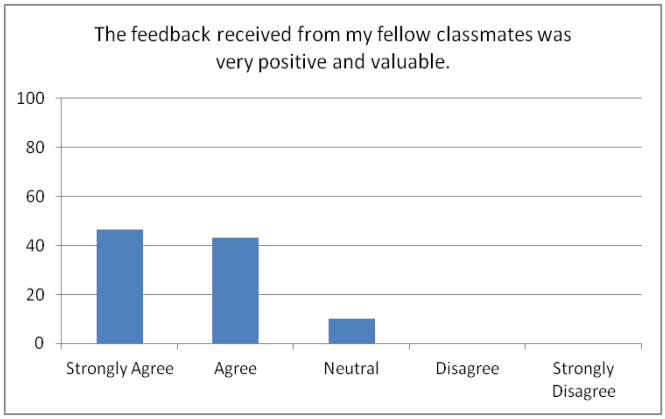


Fig. 7 Usefulness of feedback from classmates

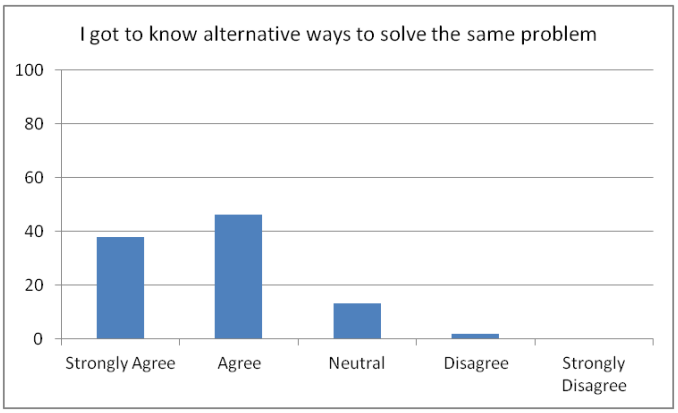


Fig. 8 Knowledge gain of alternative problem solving methods

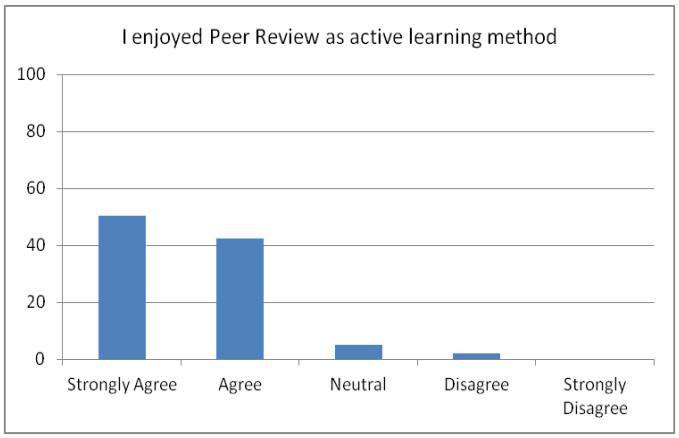


Fig. 9 Enjoyment of Peer Review as an active learning method

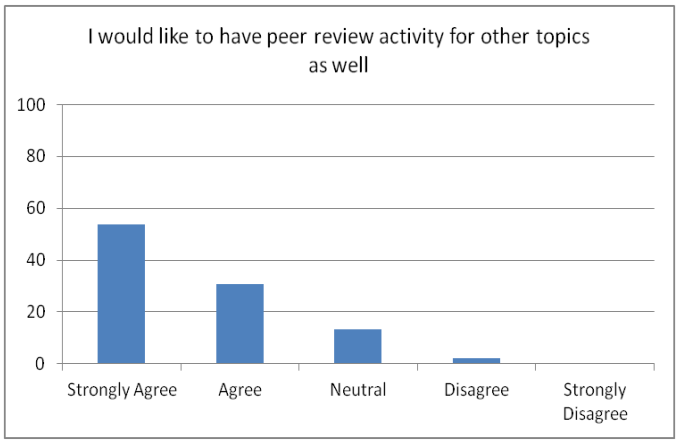


Fig. 10 Implementation of Peer Review for other topics

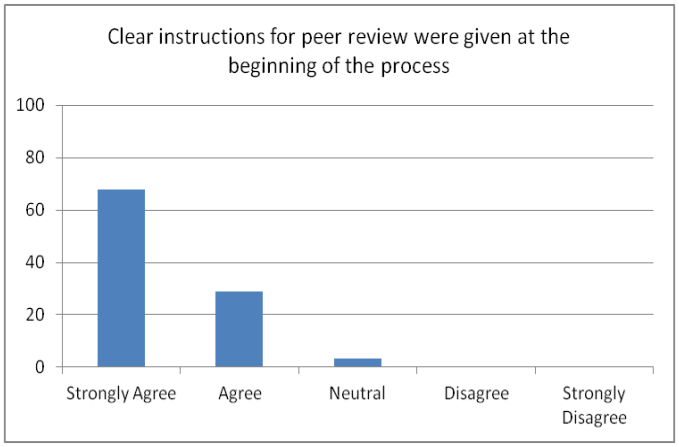


Fig. 11 Clarity of the Peer Review instructions

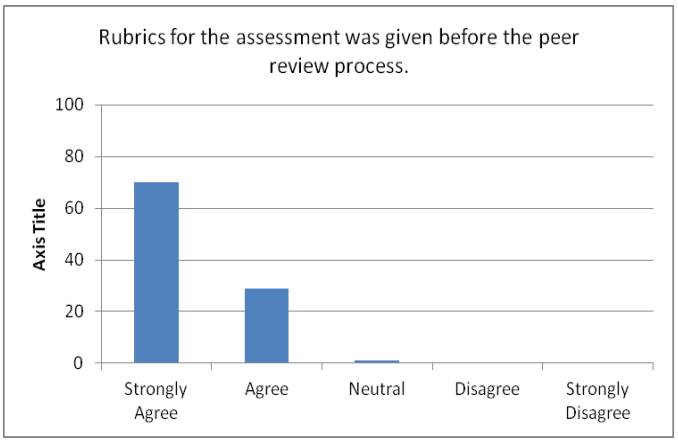


Fig. 12 Availability of rubrics for Peer Review

After analyzing the students' performance following are the observations

- 75 % of the students of Computer Engineering Department Programme have scored more than Benchmark. Hence the CO attainment is 3. For these students attainment of other COs i.e. CO3 and CO5 is 2 (55.55 % students) and 3 (75 % students) respectively. So compared to CO5 attainment, CO1 attainment is on the higher side.

- For Information Technology students, the CO1 attainment is 3 as 89.1 % of the students have scored more than Benchmark. For these students, attainment of other COs i.e. CO3 and CO5 is 2 (58.3 % students) and 3 (69.11 % students) respectively. For this programme percentage of students attaining CO1 for which Peer Review was implemented is remarkably higher compared to % of students attaining CO3 and CO5 where this technique was not implemented.

The Analysis of the students' responses to Peer Review Technique is as follows.

- Around 93% of the students have expressed their view as overall they enjoyed the activity of Peer Review where they got a chance to assess the assignment of their fellow classmates based on rubrics provided by the course instructor.

- Around 96% of the students have expressed their opinion that use of Peer Review Technique has been very useful in revising the content of the topic.

- 90% of the students believe that the feedback received from fellow classmates is very positive and valuable.

- Around 85% of the students have the opinion that as a result of Peer Review activity, they discussed possible alternative problem solving methods.
- Gaining knowledge of additional problem solving methods is very important and highly beneficial to the students.

- As students have found Peer Review activity very useful to them, around 84% of students have opined that this technique should be implemented to other topics as well.

- Rubrics were made available to all the students and 96% of the students have stated that they had a clear understanding of the rubric which was used for peer reviewing the assignment.

7. CONCLUSIONS

Peer Review strategy was applied for the course of Basic Electrical and Electronics Engineering offered to the first year students of the Computer Engineering Programme and Information Technology Programme. After doing both quantitative as well as qualitative analysis some of the important conclusions drawn by the authors are as follows.

- Implementation of the peer assessment as an active learning technique has proven to be beneficial towards the attainment of course outcome CO1, 'students will be able to analyze and calculate parameters of DC circuits'. Percentage of students attaining CO1 is higher as compared to the percentage of the students attaining other course outcomes of the course.
- During Peer Review process, students discussed alternative methods of analyzing the given DC circuit which develops Level 4 learning ability (Analyzing) as per Revised Bloom's Taxonomy described by. Krathwohl (2002), thus contributing in the attainment of Programme Outcome 2 (PO2) 'Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences' as per NBA.
- As students were supposed to do an unbiased evaluation of their fellow classmates' assignment, strictly as per the rubric provided, it helped in instilling the sense and importance of professional ethics in the very first year of the engineering course. They got the opportunity to understand the significance of professional ethics by actual implementation of the peer review. In this way, it has contributed towards the attainment of Programme Outcome 8 (PO 8) titled as, 'Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice' as per National Board of Accreditation (NBA)
- From the analysis of students' perception it is clear that the Peer Review activity has enhanced students' engagement with the course content.

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