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VBL Collaborative: An Approach for Teaching Complex Transmission Line Problem Statements

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***Abstract*— The educator's choice of techniques is intended to foster a strong love of learning. The different methods of learning can improve learners' abilities. The need of pupils to learn cannot be met by only conventional teaching. When pupils graphically answer the provided question, this is clearly seen. This paper studied students' performance for the graph based topic 'Smith Chart' for the course 'Radar and Microwave Engineering' for the third year of engineering students. Total 64 students of the same class considered for the experiment. Video based learning (VBL) is methodology is used in this paper. Total 64 students learn the said chart (Smith Chart) through videos. VBL along with collaborative approach is carried out for experimental group. The two group posttest is carried out. The two group post test results presented in the paper. The assessment is carried out w.r.to Learning Outcomes (LO) and Bloom's Level (BL). The objectives of the study are to introduce and make students understand Smith chart (BL: Understand, LO1); to determine transmission line parameters and impedance along the line (BL: Apply, LO2); to examine the effect of load variations on transmission line parameters. (BL: Analyze, LO3). The results w.r.to LOs and BL are presented in this paper for both control and experimental group. To assess the level of effectiveness of the intervention feedback is taken from experimental group. Almost 96% students liked the activity.**

Keywords— ***smith chart; transmission line; LO; BL; VBL***

I. INTRODUCTION

Charts make it simpler to interpret data by assisting pupils in organizing and analyzing information in well-structured formats. Graphs particularly appeal to visual learners, who frequently comprehend information without much text in a better way. However, pupils have trouble using graphs. It is also difficult to extract data from the graphs. This topic matters because, despite the fact that many studies (Alfredo Bautista et. al., 2015) have investigated at how pupils struggle with charts, there has been little study on how teachers implement them in the classroom. It will be beneficial to use visuals to help learners learn graphs.

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As per psychological research (Pylyshyn, Zenon W., 1973) in mental representation words and images are used. Instead of only visual information if it is paired with verbal information, learning can be enhanced (Clark, Ruth C.; Mayer, Richard E. 2011). This is also called multimedia effect (Elsayed Abdelwahed Elkilanyet. Al., 2021). Videos that explain explicitly how to use the graphs and how to extract the data using the charts are useful. For this paper, we are looking at the case of students in third year electronics & telecommunication engineering for the course Radar and microwave engineering. Transmission lines are the specific topic of this course. Transmission line parameter, Impedance measurement and impedance matching are an important and integral part of this course. We are looking at the determination of transmission line parameters and impedance measurement graphically using Smith chart

II. RELATED WORK

The survey of research work on Graph Based Learning is carried out. Also the use of Moodle platform is also found. This paper focused on graph based learning using videos that are made available on Moodle. Additionally students collaborate to achieve the given task. Using a diagnostic tool created specifically to elicit graphical misunderstandings as well as one that can be used as a questionnaire to gauge teachers' pedagogical content knowledge (PCK), (Hadjidemetriou and Julian Williams) paper expands on our earlier research on graphical conceptions. This study looked into 12 teachers' assessments of the items difficulty, suggested learning sequences and awareness of mistakes and misunderstandings. The study propose a hierarchy of perceived difficulty for teachers and compare it to a hierarchy of perceived difficulty for learners. In this research (Te-Yi Chan et. al., 2008) the teacher made the decision about how the conceptual graph would be structured before the course started. The way the conceptual graph was set up was according to the course's plan. The learning materials were created from the group members' "diagnosed conceptual graphs" of cooperative learning groups at each stage of the learning. Each group got the best learning materials, so they were able to learn more quickly. The study ran from October 2007 until January 2008 and showed that the proposed learning materials production strategy could help group learners learn better. Thoughts about the connection between fact learning and higher order learning are frequently expressed, but factual (Agarwal, Pooja K. 2019) confirms the

hypothesis that practicing with higher order retrieval improves students' higher order learning. Study shows that exams with challenging content that require students to recall their prior knowledge have the greatest impact on students' higher order learning. In this study (Ming-Shang Huang, Wei-Hung Hsiao et.al., 2012), showed cooperative learning system is learning effective based on the theory of social presence. Author conducted an experiment to see how effective the cooperative learning system is for two groups of students (self-form group, and random group). The results of the experiment showed that students had consistent learning effectiveness for both of the heterogeneous groups. This study verified the usefulness of the developed cooperatives learning system and showed that interactivity has significant difference. In (Sunita M Dol, 2022) WRITE-instructional strategy is used to teach the course Database Engineering. WRITE consist of five phases which stand for W- Watch, R- Read, I – Implement, T – Test and E – Evaluate. The course is designed for students on Moodle platform. (Bonwell, Charles C.; Eison, James A., 1991) defines active learning create excitement in the classroom. The methods include visual learning, writing, problem-solving, computer-based instruction, cooperative learning, debates, drama, role playing, simulations, games, and peer teaching. The paper also discusses obstacles to implementing active learning techniques. The impact of active learning strategies investigated The review (Susanna Hartikainen et. al, 2019) looks at the idea of active learning, how it relates to learning objectives, and how engineering higher education research measures it. The examination of 66 empirical studies showed that there are several definitions for active learning and that the majority of the indicators used to assess its influence on students' learning outcomes are derived from course-specific knowledge growth and self-report data. The implementation of active learning and empirical treatments should be made more transparent by providing more thorough explanations and theoretical support. The study (Marcela Hernández-de-Menéndez et.al, 2019) examined the use of Active Learning in engineering curriculum and discovers that it enhances performance and retention rates, encourages the growth of in-demand skills like teamwork, analysis, and problem-solving, is adaptable, and can be progressively incorporated by businesses. Innovative active learning tactics have replaced traditional approaches in the education system (Sathyendra Bhat et. al, 2020), especially in the field of engineering education. One prominent approach that appeals to millennial learners is collaborative learning, which has gained acceptance.

III. METHODOLOGY

Video based learning (VBL) for third year engineering students in Radar and microwave engineering course is presented in this paper. The topic of this course considered for research is transmission line parameters and impedance measurement. This can be determined in two ways. One using equations, analytical approach and other graphically using the Smith Chart. Transmission line parameter, impedance measurement and impedance matching are an important and integral part of this course. We are looking at the determination of transmission line parameters and impedance measurement graphically using Smith chart. Determining transmission line parameters and impedance using equations takes a lot of time and effort. Determining parameters graphically and analyzing impedance is interesting and faster. The calculation using equations needs scientific calculator. When we do the same using graph the job is done without calculator. Only the difficulty for answering the given transmission line question using graph/chart is that Smith Chart is complex and difficult to understand and use. Smith Chart is one of the complex charts in chart category.

The expected LOs of the study are

LO1: Learner should be able to use the chart from basics of Smith chart (BL: Understand)

LO2: Learner should be able to determine transmission line parameters and impedance along the line (BL: Apply)-LO2

LO3: Learner should be able to examine the effect of load variations on transmission line parameters. (BL: Analyze)

Smith Chart - It is the most difficult chart to use and understand as shown in Fig.1. Because of the complicated structure of the chart, students are afraid of the chart and find it difficult to use it. Students find it hard to understand what a Smith chart is and how it can be used.

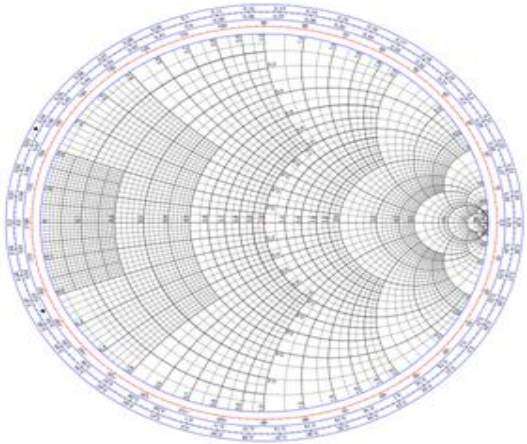

Fig.1. Smith Chart

Instructional Strategy:

This is the starting point for the instructor to come up with a strategy especially to use on charts. Here, the instructor mainly focused on the topics where the students need to draw and analyze by themselves using charts. This strategy is very useful for the topics like drawing and analyzing with graphs and charts. The experimental set-up of the instructional strategy used is given in the block diagram shown in fig. 2. The introduction and explanation of the chart, in this case the Smith chart, is done with the help of the videos provided in Table 1. The format of two videos created by the instructor is as follows:

- Introduction
- Begin with learning objectives.

- It has a reflection spot where the student reflects on the question posed in the video.
- A comprehensive explanation of the topic is provided along with the relevant graph and a problem solution using the graph.
- References

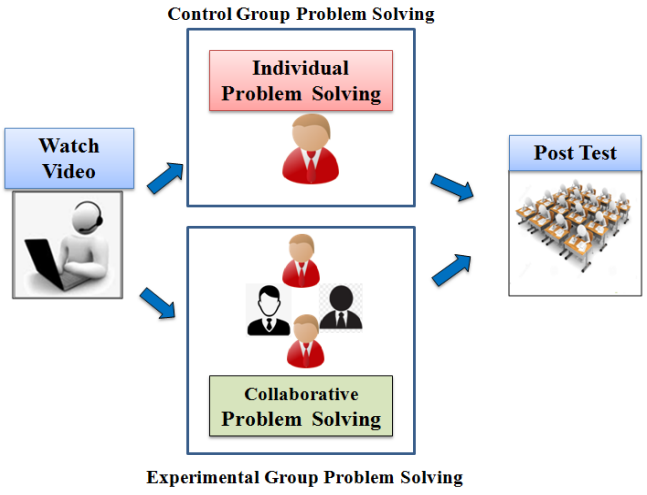

Fig. 2. Instructional Strategy

a)Watch Videos created by instructor:

Instead of making students to solve transmission line problem directly using Smith chart it is necessary to give a detailed explanation of chart and its different portions. Students are informed to go through the video1 'Smith Chart: Part I -Smith Chart Basics' individually at their own pace. The details of the video are given in Table 1. Here the student is introduced to the various parts of chart and their importance. Students understand how to use the chart by recalling the knowledge gained in video 'Smith Chart: Part I-Smith Chart Basics '. The sample video is shown in fig.3.

Fig.3. Sample Video

Then student is advised to go through video2 'Smith Chart: Part II-Using Smith Chart' details of video is given in Table 1. Here the student is get detailed knowledge on how to plot on the chart to determine the parameters and impedance of transmission lines. Students apply the knowledge of video entitled 'Smith Chart: Part II-Using Smith Chart' to solve the given problem statement on transmission lines. The students can watch videos at their own pace. Students advised to go through both the videos. Videos are made available on the institute you tube channel.

TABLE I
VIDEO1 DETAILS

Video	Additional Information	Link
Smith Chart: Part I -Smith Chart Basics	• Smith chart Information. • Details on the Smith Chart.	https://shorturl.at/KNT17
Smith Chart: Part II-Using Smith Chart	• Determining parameters using Smith Chart. • Analyzing impedance along transmission line using smith Chart.	https://shorturl.at/ilrwJ

b) Problem Solving

Total 64 students of third year engineering class underwent the proposed intervention. Based on previous semester results two groups are formed of equal ordinances each of 32 students in a group. One group control the experiment 'control group' and other receive treatment is 'experimental group' as shown in fig.4.

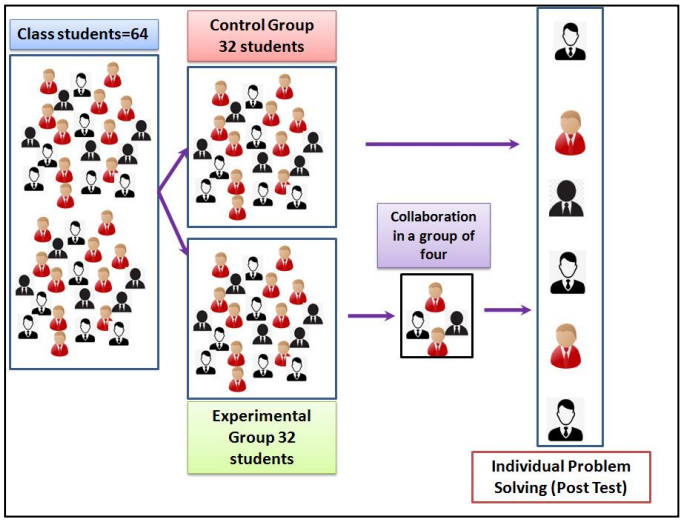

Fig.4. Students distribution

i) Control Group Problem Solving

Control group is the one which control statistical experiments. This group instructed to watch videos. Learn basics and usage of Smith Chart using videos VBL. Then, this group attempted post test. Post-Test questions are mentioned in Table 2.

ii) Experimental Group Problem Solving

The 32 student group receives the treatment 'experimental group'. Based on the outcomes of the previous semester, groups are created that contain student from all ordinances. Groups of four pupils each are formed from the student body. The students asked to watch videos VBL individually. Collaborative approach $VBL_{Collaborative}$ is applied for this group. The students were asked to work in groups (group of four) to collaboratively solve the given question mentioned in Table 2.

TABLE 2
POST-TEST QUESTIONS

Questions	Marks	LO	BL
Q. A lossless transmission line with characteristic impedance 100 ohm is terminated in a load 150 + j 75 ohms. Using Smith Chart find the following			
1. Magnitude and angle of reflection coefficient	10	LO1	Understand
2. Voltage Standing Wave Ratio	10	LO2	Apply
3. Impedance at a distance λ/4 from the load	10	LO3	Analyze

The teacher will serve as a mentor during the collaboration. Rather than instructing the class, the teacher may assist them during collaboration, if necessary. The problem is about determination of transmission line parameters and analyzing impedance using Smith Chart. Table 2 shows post test questions.

c) Post Test

Then a post-test is administered, during which each student must graphically solve the provided question using a Smith chart. For both the control group and the experimental group, the post-test scores are compared to a maximum of 30 marks. Fig. 5 to 8 presents the students' post-test findings for learning outcomes (LO) from LO1 to LO3.The questions asked in post-test covers questions of different cognitive levels from understand to analyze level as per Revised Bloom's Taxonomy(https://en.wikipedia.org/wiki/Bloom%27s_taxonomy). Bloom's Taxonomy BL is a hierarchical model used to classify the Los in education into various levels of complexity and specificity. Post Test marks of control group and experimental group are as per LOs shown graphically in fig. 5 to 8. Students have to solve the given transmission line question according to the values of characteristic, load impedances. The test is assessed maximum score of 30 marks. Below are the post test results of the two groups.

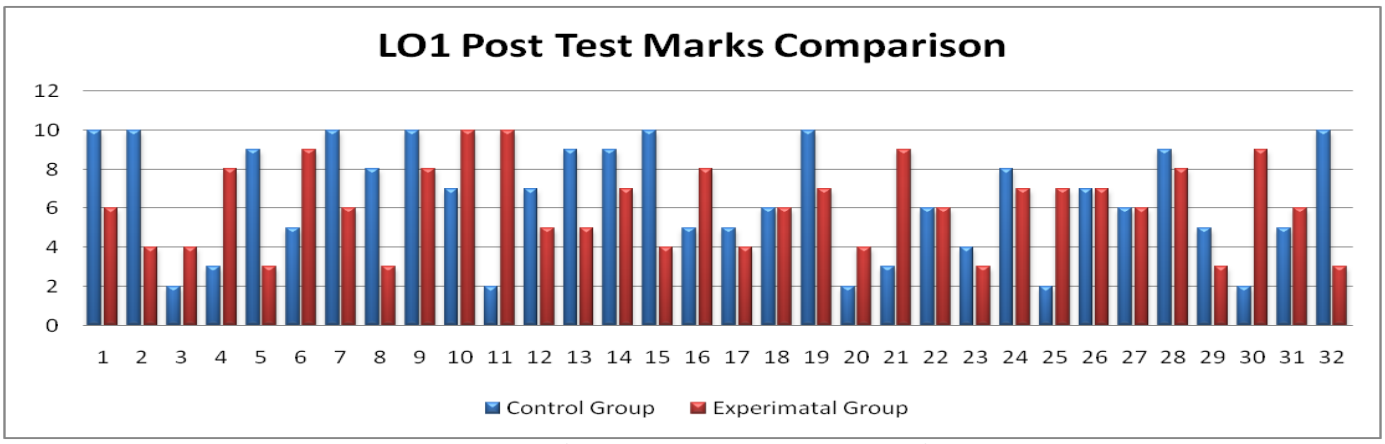

Fig.5. Post Test Marks Comparison of Control Group and Experimental Group for LO1 (BL: Understand)

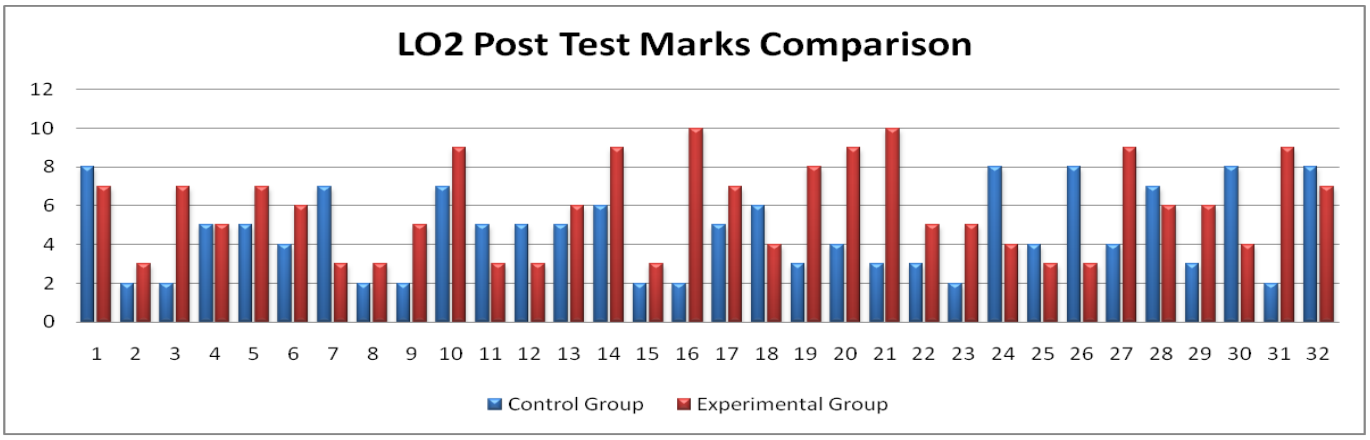

Fig.6. Post Test Marks Comparison of Control Group and Experimental Group for LO2 (BL: Apply)

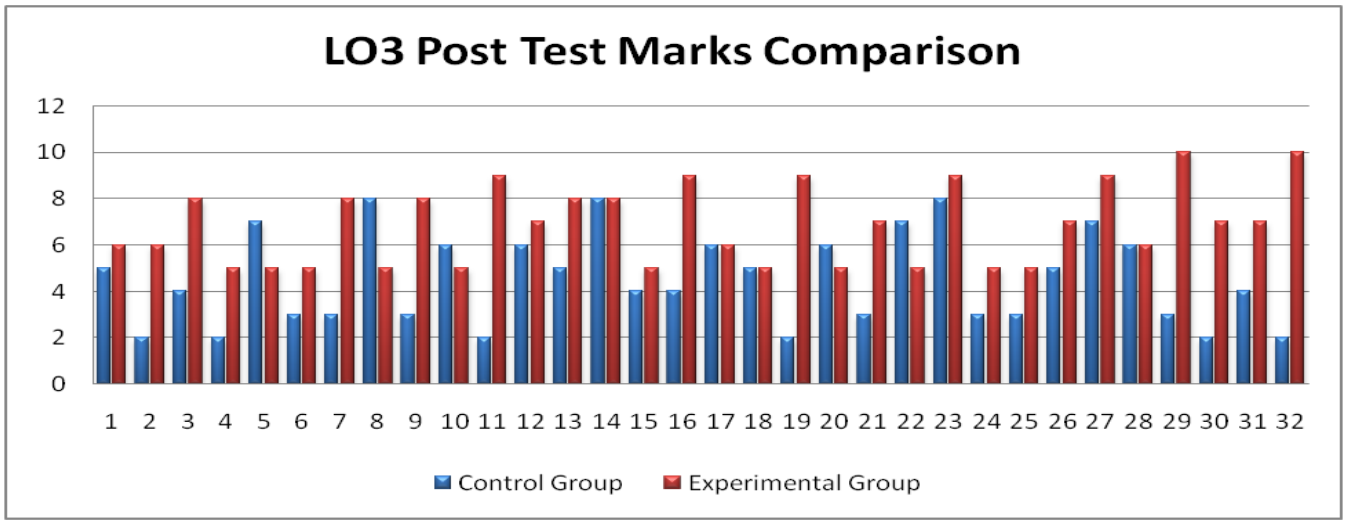

Fig.7. Post Test Marks Comparison of Control Group and Experimental Group for LO3 (BL: Analyze)

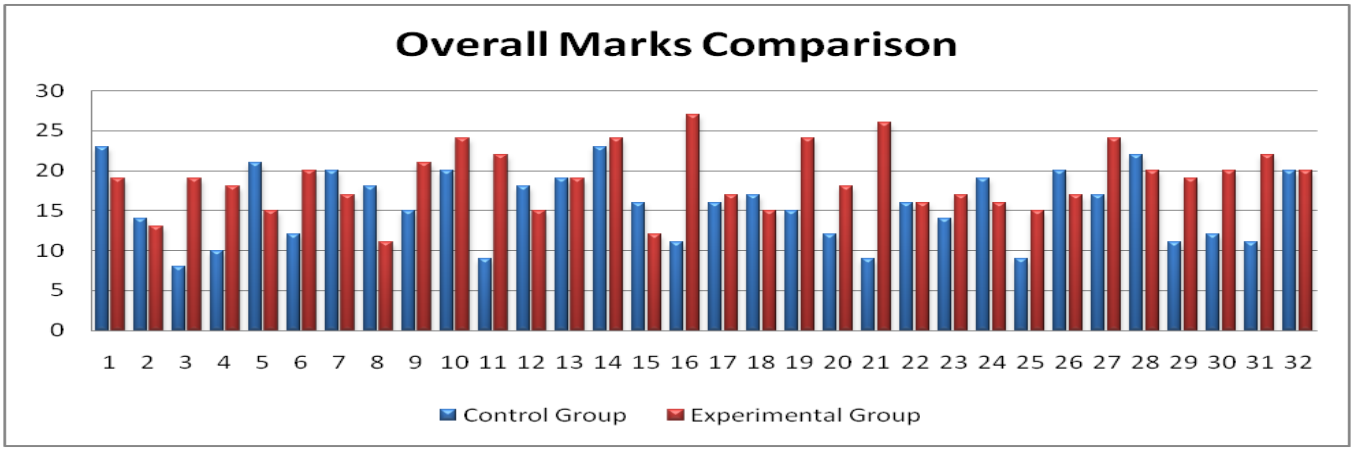

Fig.8. Overall Post Test Marks Comparison of Control Group and Experimental Group

IV. RESULTS

The t-test is carried out to determine t value and p value from the post-test of control and experimental group. t-test helps us to determine the significant variation in the set of samples used. The p-value measures consistency between the results actually obtained from the set of input samples. The p-value assesses the consistency of the conclusions drawn from the set of input samples. P-value serves as proof that the outcomes of comparing two sets of inputs were significant. (https://www.statskingdom.com/paired-t-test-calculator.html). This test is employed to assess whether two sets of data exhibit significant differences. The p-value gauges the agreement between the observed outcomes in the experiment and the explanation based solely on random chance. The p-value offers support for the noteworthy outcomes derived from comparing two groups (Ronald A. Thisted, 2010 & Luc Demortier, 2007). This test is employed to assess whether two sets of data exhibit significant differences. $p < 0.05$ indicates significant difference in post test marks of two groups considered. Table 3 shows that LO1 (BL: Understand) the post test marks of two groups are not much different as $p > 0.05$. From Table 3, we can observe for LO2 (BL: Apply) $p < 0.05$ but closer to the threshold. It indicates experimental group performed better than control group but results are not much significant. For LO3 (BL: Analyze) the p value as can be seen from table 3 is very much less than 0.05. This indicates experimental group performed exceptionally well for LO3 (BL: Analyze) as compared to control group. This indicates there is significant improvement in the post test results of experimental group compared to control group. If we check p value for overall result this also indicate that p is much less than 0.05. So in overall post test performance experimental group performed very well as compared to control group.

TABLE 3
STATISTICAL ANALYSIS : T-TEST RESULTS SAMPLE SIZE=32

LO	LO1	LO2	LO3	Overall
t -value	-0.485	2.1314	4.6389	2.8724
p - value	0.05307	0.04109	0.00006029	0.007287

*The result is significant at $p < 0.05$

V. FEEDBACK

To gain a better understanding of the student's view of the intervention feedback from all the intervention students is collected. The feedback is collected at the end post test for the experimental group. For the experimental group, the asked questions are rated in feedback. The feedback analysis and the questions on the feedback form are shown in Table 4. The questions are about clarity of the videos. To what extent cooperation was advantageous (Sathyendra Bhat et. al, 2020). It also asks how well the subject being discussed is understood. Additionally, measures how much the students enjoyed the task as discussed in literature (Bonwell, Charles et.al, 1991).

TABLE 4
FEEDBACK ANALYSIS OF THE PROPOSED INTERVENTION

Sr. No.	Question	1 (High)	2	3 (Neutral)	4	5 (Poor)
1	Rate the extent the strategy helped you to solve the given question	57%	43%	-	-	-
2	Rate the extent videos helped to clarify concepts	61%	34%	5%	-	
3	Rate the extent collaboration helped you to solve the given question	73%	25%	2%	-	-
4	Rate the extent you were able to apply the concepts to determine transmission line parameters using Smith Chart.	69%	31%	-	-	-
5	Rate the extent you were able to analyze impedance along transmission line using Smith Chart.	72%	28%	-	-	-
6	Rate the extent you enjoyed learning.	96%	4%	-	-	-

VI. CONCLUSION

This paper showed students' performance analysis using the Smith Chart for the course Radar and Microwave engineering for the third year engineering students. The statistical analysis 'p' value is calculated (https://www.statskingdom.com/paired-t-test-calculator.html) from post test marks obtained by the students in control group and experimental group. It is found that LO1 (BL: Understand) the post test marks of two groups are not much different as $p > 0.05$. For LO2 (BL: Apply) $p < 0.05$ but closer to the threshold. For LO3 (BL: Analyze) p is very much less than 0.05. This indicates experiment group performed exceptionally well for LO3 (BL: Analyze) as compared to control group. The p value for overall result is much less than 0.05. So in overall post test performance experimental group performed very well as compared to control group. It is found that after the intervention, students reached higher cognitive level from understand to apply and analyze. Experimental group students achieved learning outcomes LO1 to LO3. Whereas it can be concluded that control group students failed to achieve LO2 and LO3. The test is assessed for maximum 30 marks. Total 64 students of the same class underwent the proposed intervention. The control group students were able to solve questions of cognitive level understand. Still results are not acceptable for the questions of higher cognitive level apply and analyze. In contrast, the experimental group performed very well as compared to the control group; for BL understand, apply and analyze. Videos and collaboration $VBL_{Collaborative}$ is found much effective for complex graph based questions. Feedback conducted for experimental group. Based on the feedback, it is found that students were engaged and almost 96% students enjoyed learning.

VII. FUTURE SCOPE

The intervention $VBL_{Collaborative}$ applied here for solving question using chart or graph. The same intervention can be applied for other topics also. The proposed intervention can be analyzed for higher cognitive level and for project based learning pedagogy.

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