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Effective Teaching of Electric Circuit Analysis through Jigsaw Cooperative Learning Method

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Abstract : In recent times, in addition to the conventional teaching methods, new pedagogical initiatives are indispensable to elongate the attention span of the present students from generation Z and generation alpha. Jigsaw is one of the Collaborative teaching practices which involves facilitators working in tandem with the students, instructing and mentoring them to solve problems. This paper presents the implementation of an enhanced Jigsaw learning method for teaching Circuit Analysis course for first-year students. Instead of randomly assigning students to groups, the proposed enhancement in the Jigsaw learning method presents diverse teams based on student personalities (Triguna levels – Sattva, Rajas, and Tamas). Such diverse groups become effective learning units and ensure team coherence. Minute feedback was obtained at the end of the session to analyze the effectiveness of the proposed enhanced jigsaw method. The feedback analysis indicates a paradigm shift in the students' level of understanding, and the assessment scores of Tamas students had a significant improvement of 20%. Also, the post-session data shows a boost in the confidence level of the students in solving different Direct Current (DC) and Alternating Current (AC) based electric circuits. A comparison between the conventional teaching method and the enhanced Jigsaw teaching-learning process is also presented. The results indicate that this method proves to be effective both from the students' learning and the faculty's teaching perspective. In addition to improving the desired learning outcome, the enhanced Jigsaw method also makes the learning process enjoyable.

Keywords : Teaching-learning process, Jigsaw method, Triguna levels, Electric circuits, circuit analysis, active learning.

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I. Introduction

CIRCUIT Analysis is one of the professional core courses offered to the Electronics and Communication Engineering stream and Electrical and Electronics Engineering stream students. Since it is one of the main courses introduced in the core domain, it has received significant attention among the students and the faculty engaging in the course. Also, facilitating effective learning and increasing students' classroom engagement makes them focus better and explore more in the field of Electronics. Thus, designing an optimal instructional method to foster conceptual understanding of the topics among the students and increasing the desire to learn serves as a major challenge to the course handling faculty (Bernhard & Carstensen, 2002; Carstensen &

Bernhard, 2009; Ogunfunmi & Rahman, 2010; Trajković, 2011).

The Circuit Analysis course provides a fundamental understanding of the behavior of different circuit elements and sources (independent and dependent). It introduces different theorems and laws about the analysis of DC and AC circuits. Firstly, it involves the analysis of resistive circuits with independent sources to determine the current passing through the elements and the voltage across the elements in the circuit. Then, the analysis is extended to circuits with dependent sources and other circuital elements. This course also covers the transient analysis of first-order RL, RC circuits, second-order series, and parallel RLC circuits. All these concepts are taught through extensive problem-solving activities.

While teaching circuit analysis course through the traditional approach (teacher-centric), the authors found that students experienced several difficulties grasping the concepts. While analyzing complex circuits, many students could not exactly determine whether the circuit components are connected in parallel or in series. Also, they were uncertain in identifying the nodes and loops in the circuit, thereby writing incorrect nodal and mesh equations. Students were confused while assigning polarities for voltage across an element or determining the direction of current flowing through the elements in the loop. They experienced difficulty correlating the circuit diagrams with the mathematical equations, hindering the application of relevant circuital laws in appropriate circumstances (de Coulon et al, 1993). This daunted the students resulting in loss of interest and became a major challenge. Also, the faculty is expected to shoulder the responsibility of uplifting the teaching-learning process effectively, helping students rectify their misconceptions and thereby increasing the learning interest towards the course (Ortega-Alvarez et al, 2018). Traditional lecturing alone does not seem to facilitate conceptual understanding in applying circuital laws to analyze the circuits. Previous studies suggest that students' conceptual learning is improved when they actively participate in the learning process (Becker et al, 2013)

Students also develop various skills, such as problem-solving, written and oral communication, self-directed independent learning, and teamwork, while they involve themselves in active learning strategies (Gleason et al, 2011). So, there is a dire need to couple the conventional chalk and talk teaching method with active learning strategies and Information and Communication Technology (ICT) tools. The upshot is the deployment of blended learning methods with a mixture of synchronous online/physical classes, Audio-visual resources, engaging activities, and open source tools (Deepa et al, 2021).

Collaborative learning is one such student-centric active learning approach. The students learn together and help each other in the learning process by forming groups, where the teachers act as facilitators. The collaborative learning process aims to improve individual accountability and fosters the communication and interpersonal skills of the students (Mourtos, 1994). However, if the collaborative learning process is not planned well or if there is a lack of positive involvement among the group, it will not provide fruitful results (Dillenbourg, 2009). Hence, sessions must be well-organized and structured with classroom instructions to increase the likelihood of effective learning.

Many structured pedagogical methodologies like Think Pair Share, Co-Op, Pyramid, Brainstorming, and Jigsaw have been adopted from time to time to enhance the teaching-learning process (Hertz-Lazarowitz et al, 2013). Jigsaw is a structured, cooperative active learning method that fosters cognitive collaboration and provides different perspectives to the same problem when students solve it as a group. It serves as an effective method to handle analytical subjects. It also helps both the facilitators and the students to move towards their goals in unison. This paper presents the process and outcome of deploying an enhanced version of Jigsaw to teach the concepts of mesh and nodal analysis of circuits.

About Jigsaw: Jigsaw is a collaborative active learning strategy that categorizes students into the home and expert groups. The students are assigned learning tasks after forming the expert group; on completion of the task, they return to their home group to teach their learnings to the other members in the homegroup. Aronson et al. introduced it in 1979 (Aronson & Bridgeman, 1979). Topics to be taught are broken into chunks and assigned to student expert groups. Later, Robert Slavin (1986) developed 'Jigsaw II Students', in which it is suggested that students will receive an individual grade and a team grade determined by adding the test scores of all members of each Jigsaw team (Slavin, 1991). This method improves students' self-esteem, student-student interpersonal relationship, academic performance and also promotes quality teaching.

Benefits of Jigsaw Method

The Jigsaw method of teaching has the following benefits: (Johnson & Johnson, 1985, 1992)

Tangible benefits

- All students work together to complete the task.
- Improves critical thinking.
- Improvement in assessment scores.

Intangible benefits

- Promotes independent learning and enhances individual accountability.
- Provides a platform for team work.
- Students of any learning style get actively involved with a positive attitude
- Students develop the ability to resolve their doubts by themselves. Sometimes even the teacher might not be able to comprehend the difficulties of the students, while the peers can resolve it in an effective manner.
- Creates interest in learning and this, in turn, reduces the dropout in undergraduate courses.
- Increases students' learning satisfaction.
- Facilitates the development of communication skills.
- Aids face to face interaction.

2. Related Articles

Previous studies point out the effectiveness of practicing the Jigsaw method of cooperative learning technique for students in different academic domains such as medical sciences, nursing, and other science courses (Kritpracha et al, 2018; Kumar et al, 2017; Márquez et al, 2017; Orcos et al, 2016). Aydin & Biyikli (2017) and Yoruk (2016) presents the usefulness of the Jigsaw method for teaching physics and chemistry laboratory courses. In most of these research works, the authors compare the traditional teaching practices with the Jigsaw method. The analysis reveals that the Jigsaw method helps students excel in learning, motivates the students towards academic achievement, promotes a self-directed learning approach, and helps in simultaneous knowledge sharing among the students. Susanti (2019) discusses the effectiveness of Jigsaw teaching methods to enhance the student's critical thinking and problem-solving skills. The authors claim that this method helps develop cognitive skills and promotes team skills among the students. Costouros (2020) analyzed the improvement in students' grades due to the application of jigsaw cooperative learning strategy for the course Insurance Principles and Practices. The analytical study of incorporating jigsaw cooperative learning strategy also reveals that the students acquire a greater sense of autonomy, deeper-level processing and experience a greater social relatedness.

In Dhage et al (2016), the authors studied the merits of the Jigsaw process for teaching courses in the engineering discipline. They concluded that being a student-centric method, Jigsaw facilitates a life-long learning capability, one of the engineers' graduate attributes. The optimum class size required for implementing Jigsaw is explained in Balestrini et al (2013).

Different pedagogical strategies followed for teaching electric circuits courses were found in the literature Kang et al (2019); Johnson et al (2018) and Yoshikawa et al (1992). A student-centered approach for electric circuits is presented in Becker et al (2013) and Yoshikawa et al (1992). The teachers facilitate deeper understanding by introducing specific applications related to the concepts under study. This type of active learning provides a meaningful experience to students while learning this course. Johnson et al (2018) highlights the benefits for both the teacher and the students while having a flexible physical classroom to practice active learning. In Yoshikawa et al (1992), the authors introduced an intelligent tool that assists the students in exercising many problems related to electric circuits. However, the application of Jigsaw as cooperative learning method for the course circuit analysis was not found in the literature. Suganya et al (2020) discusses the implementation of the Jigsaw learning method for the course Microcontrollers for undergraduate electrical engineering students. The authors used the continuous assessment marks scored by the students and feedback responses to analyze the performance of the Jigsaw activity. However, the jigsaw team formation was not explored. The team-Based Learning (TBL) approach for teaching Electric Circuits is explained in O'Connell (2014). The students were provided instructional materials for the upcoming topics to be taught in classrooms. It is a flipped type of pedagogical strategy, and the students prepare before the actual session, and once they enter the classrooms, they work in groups to solve problems or applications related to the study material provided. O'Connell (2014) also analyzed the size of the team for TBL activity. The authors claim that if the team size is large, some students may be disinterested and remain unnoticed without contributing much. As TBL does not guarantee individual upliftment, the team size is reduced to as low as four members. The same problem may also happen while implementing Jigsaw activity for teaching circuit analysis courses and the literature does not suggest any solution.

Hence, this paper addresses the necessity for a modified version of Jigsaw activity to ensure its effective implementation in terms of quality team formation and individual upliftment.

Objective:

The purpose of this paper is to compare and analyze the outcomes of an enhanced Jigsaw method of teaching with the traditional method for the course 'Circuit Analysis' offered during the first year of the Engineering Programme.

3. Methodology

This section explains the methodology followed for deploying conventional teaching methods and the enhanced Jigsaw method for the students. Sixty students pursuing undergraduate 'Electronics and Communication Engineering' program under Anna University, were divided into two batches for this study; A batch of 28 students who participated in the traditional style of teaching were identified as the control batch, and the remaining 32 students who participated in the Jigsaw method of teaching were identified as the experimental batch. The objective was to make the students solve electric circuits using mesh and nodal analysis methods in different teaching-learning environments (traditional vs collaborative). The course outcome for the chosen topic is "Analysing DC and AC circuits using the Mesh and Nodal Analysis". Initially, all the students were collectively given an elaborate explanation of the underlying concepts required for deriving and solving the mesh and nodal equations in the introductory session. The subsequent tutorial sessions were handled separately for the control batch and the experimental batch of students.

Table 1 : Questionnaire For Minute Feedback

Minute Feedback						
Please respond to the statements in a 5 point scale		1	2	3	4	5
1.	The session enabled in -depth understanding of the topic.					
2.	The session helped in enhancing the communication skills.					
3.	The session helped in overcoming inhibition and hesitation in the class.					
4.	It was interesting and enjoyable to solve the problems.					
5.	The level of confidence in taking up a new problem and solving it on your own has increased.					

A. Conventional Method

The conventional method of teaching was adopted for the control batch of 28 students. After an introductory session on the topic, the faculty solved a few sample problems in the class for mesh and nodal analysis. During the subsequent tutorial sessions, the students were provided tutorial sheets, in which the difficulty levels of the problems ranged from simple to complex. The circuits with independent sources are quite easy, whereas circuits with dependent sources need critical thinking. This traditional way of teaching, alongside the practice sessions, required about 4 to 5 lecture hours for the teacher to complete the topic. This type of teaching was more teacher-centric, where the teacher shared their knowledge/expertise with the students. The students were also assigned homework problems in mesh and nodal analysis. Some students approached the teacher and clarified their doubts while solving the homework problems. They experienced some difficulties in applying the concepts to solve new problems with different meshes and nodes.

Through this teaching method helped the students

Table 2 :Average Response For The One-minute Feedback- Traditional Method

Response Statements		Average Response (Max. 5)
1.	In-depth understanding of the topic after the session.	3.2
2.	Enhancement in Communication skills	2.0
3.	Overcoming inhibition and hesitation in the class	1.8
4.	Interesting and enjoyable nature of the session to solve problems and understand	2.1
5.	Level of confidence in taking up a new problem and solving it independently.	2.5

grasp the concepts and expertise from the teachers, it lacked the important aspects of the learning process, namely, individual upliftment and the ability to apply the learned concepts to new scenarios. The learning process is also expected to trigger other professional attributes such as interpersonal skills and teamwork in addition to technical knowledge.

After completing the topic, minute feedback was obtained from the students. Table I shows a questionnaire for the minute feedback. The feedback provided by the students was not satisfactory, as detailed in Table II. From the feedback analysis, it can be seen that students had a less in-depth understanding of the topic. Also, the confidence level of the students to take up a new problem and solve independently on the topic was low.

Furthermore, the traditional method does not create much interest among all the students in learning the topic. It does not significantly enhance communication skills, neither does it help them to overcome hesitation in interaction. Table 2 shows the average response score for the feedback statements obtained from the traditional method (on a scale of 1 to 5).

According, to the graduate attributes defined by National Board of Accreditation (NBA) (NBA SAR-format, n.d.), apart from problem solving skills, it is essential to help students develop other graduate attributes such as social interactions, societal understandings, professionalism, team work, communication, ability to function effectively as an individual, or as a member or leader in a team and ability to comprehend, give and receive clear instructions while working as a team. It is inferred from the feedback analysis that the traditional method does not help in building the above mentioned graduate attributes.

B. Enhanced Jigsaw Method

Need for Enhanced Jigsaw method: The Jigsaw methodology was adopted for teaching the same topic for the experimental batch of 32 students. Even though the Jigsaw method aided the various dimensionalities of learning in the collaborative learning environment, it could not cater to students' individual needs. Certain students tend to stay within their boundaries when injected into team-based learning environments. The construction of the team formed a vital part in reaping the maximum benefits of the collaborative activity. So, the enhanced Jigsaw method proposed in this paper incorporated the grouping of the students based on the Triguna model, a personality prediction model rooted in Indian Vedic literature (Sharma et al, 2016). This methodology also averts the risk of grouping all the proficient students into a single group.

Triguna Model-based Enhanced Jigsaw method: In this proposed method, the students were categorized based on their gunas, such as Sattva, Rajas, and Tamas, with the help of the Personality Assessment test - Triguna model Sharma et al (2016). The grouping of the students for the enhanced Jigsaw method was done so that each group had a mix of all the three predominant guna levels. Students with a predominant Sattva guna are naturally capable of adapting to different situations and can convert any challenging scenario into a growth-promoting opportunity, whereas a student with more inclination to Tamas guna inherently possesses inertia or laziness and procrastination. Even though the students with Rajas guna are known to possess compulsive qualities

Mesh Group	Group 1	1	2	3	4
	Group 2	5	6	7	8
	Group 3	9	10	11	12
	Group 4	13	14	15	16
Nodal Group	Group 5	17	18	19	20
	Group 6	21	22	23	24
	Group 7	25	26	27	28
	Group 8	29	30	31	32

Fig. 1 : Expert grouping of students

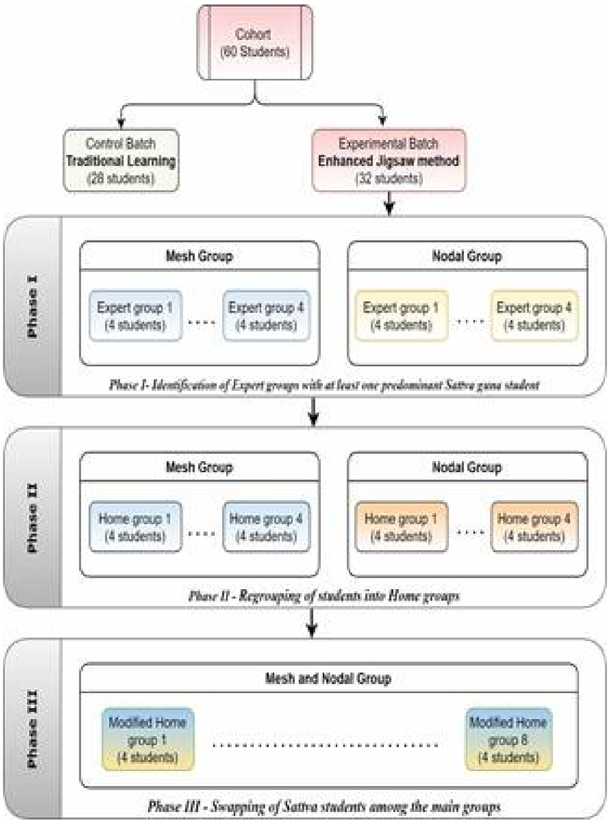

Fig. 2 : Different phases of enhanced Jigsaw method

Mesh Group	Group 1	1	5	9	13
	Group 2	2	6	10	14
	Group 3	3	7	11	15
	Group 4	4	8	12	16
Nodal Group	Group 5	17	21	25	29
	Group 6	18	22	26	30
	Group 7	19	23	27	31
	Group 8	20	24	28	32

Fig. 3 : Regrouping of students into Home groups with the Sattva students indicated by encircled.

Mesh and Nodal Analysis	Group 1	1	5	9	21
	Group 2	2	26	10	14
	Group 3	31	7	11	15
	Group 4	4	8	20	16
	Group 5	17	13	25	29
	Group 6	18	22	6	30
	Group 7	19	23	27	3
	Group 8	11	24	28	32

Fig. 4 : Swapped groups to complete the other half of the problem set

of energy, passion, and action, they also exhibit self-centredness. They are not conducive to promoting positive and harmonious group interactions. So, students with predominant Sattva guna were identified and added to each of the expert groups to facilitate effective collaboration and positive interdependence among the students.

Execution of Enhanced Jigsaw method: The experimental batch of 32 students were divided into two main groups: Mesh analysis Group (1 to 16) and Nodal analysis Group (17 to 32). Each of these groups was then subdivided into four sub-groups with four students each. Thus, Fig. 1 shows all the eight sub-groups, which were identified as the expert groups. Each expert group had at least one predominant Sattva guna student, as illustrated with encircled numbers.

The problems to be solved were divided into three categories based on the level of complexity:

- Category A - easy to solve
- Category B - medium complexity
- Category C - a higher level of complexity

Jigsaw activity implemented to solve mesh and nodal analysis problems were divided into three phases, as depicted in Fig. 2.

1) Phase I- Identification of Expert groups with at least one predominant Sattva guna student

Firstly, each expert group solved a distinct set of three problems, one problem from each category starting from a low level of complexity (Category A) to higher complexity (Category C). The students collaboratively solved the problems; they discussed each other and came up with solutions. This enhanced the ability to work as a team and kindled the critical thinking capability of the students. The faculty acted as a facilitator of the activity while the Sattva guna students played a major role in helping others to solve the problems. Such students became task specialized and were prepared to disseminate the knowledge to other groups in the next phase.

2) Phase II- Regrouping of students into Homegroups

Once each group solved the three problems assigned to them, the students were regrouped, as shown in Fig.3. This group formation was identified as the base group or the homegroup. In this home group, each student is an expert in 3 distinct problems.

Each student in the homegroup shared the knowledge gained in solving the problems with their home group members. This sharing of knowledge enhanced their group interaction and communication skills. This way, the entire Mesh group (16 students) finished solving all 12 (4 sets of 3 each) mesh analysis problems and the nodal group (16 students) solved all the 12 (4 sets of 3 each) nodal analysis problems under different levels of complexity. Every student, who was accustomed to different learning styles was cooperatively involved in the Jigsaw method. The successful completion of the learning activity promoted a more positive attitude towards the course.

3) Phase III- Regrouping Swapping of Sattva students among the main groups

In order to make the whole class solve all 24 problems under the mesh and nodal analysis, a Sattva student from the mesh analysis homegroup was swapped with the one in the nodal analysis home group, as shown in Fig. 4. For example, the Sattva student (number 13 in Fig. 4) helped the other students of home Group 5 to solve the problems based on mesh analysis, in addition to learning the nodal analysis problems from their peers. Similarly, all the migrated Sattva students ensured sharing of knowledge through peer learning in their respective sub-groups. This served as a win-win situation in boosting the confidence level of the Tamas students and instilling a feeling of responsibility for the Rajas students to impart skills to their peers. Thus, all the students were interested in the activity and finally solved the complete set of problems with a thorough understanding.

Even though the enhanced Jigsaw method produces better results compared to the traditional methods, the success of this method lies in the fact that the faculty must plan and prepare the Jigsaw activity well in advance. A good rapport with the students will also help the faculty in the formation of student groups. Moreover, the faculty must prepare the questions with care. In the present case study, the problems were arranged under three categories, from easy to difficult. Therefore, beginning with simple problems and then slowly increasing the complexity level builds students' interest in solving the problems.

Fig. 5 : Peer learning hall ambiance

Table 3 : Average Response For the One-minute Feedback- Jigsaw Method

Response Statements		Average Response (Max. 5)
1.	In-depth understanding of the topic after the session.	**4.05**
2.	Enhancement in Communication skills	**3.81**
3.	Overcoming inhibition and hesitation in the class	**4.20**
4.	Interesting and enjoyable nature of the session to solve problems and understand	**4.28**
5.	Level of confidence in taking up a new problem and solving it independently.	**4.32**

Furthermore, the faculty were present throughout the activity and facilitated the learning process by clarifying whenever a student approached. Thus, the role of the facilitator was indispensable for the smooth conduct of the enhanced Jigsaw activity. The facilitator also made sure that the discussions were in the right direction according to the scripted instructional design for the enhanced Jigsaw learning activity.

The enhanced Jigsaw learning activity was conducted at the peer learning hall allotted for active and collaborative learning activities. It is a well-ventilated space with a size of 30' x 40' sq. ft. (Fig. 5). The hall has a total seating capacity of 75 students, has a good ambiance and infrastructure to accommodate students as groups of 5 in 15 round tables. The classroom setup helped the teacher to move around and hop from one team to another while monitoring their progress. The students also had a comfortable discussion experience while being seated at a round table facing each other. The peer learning hall is also equipped with a green board of size 20' x 4' sq. ft, two hand microphones, one collar microphone, and a Smart TV with a wide 72" screen with internet connectivity.

Table 4 : Comparison of Assessment Marks in Percentage 'part A'

Mode	Min	Median	Mean	Max
Conventional method of Teaching (Control Batch)	43	77	71.87	100
Enhanced Jigsaw Method (Experimental Batch)	64	84	83.07	100

*Part A weightage: 10 marks

Table 5 : Comparison of Assessment Marks in Percentage 'part B'

Mode	Min	Median	Mean	Max
Conventional method of Teaching (Control Batch)	35	65	63.40	95
Enhanced Jigsaw Method (Experimental Batch)	60	79	78.73	99

*Part B weightage: 20 marks

At the end of this enhanced Jigsaw activity, the students were asked to provide minute feedback on the learning activity conducted. The same questionnaire, which was given to the control batch, was provided to the experimental batch to compare the learning outcome attainment and its effectiveness.

Table III shows the average response of the students from the experimental batch. The feedback obtained suggests that the Jigsaw activity made the session more exciting and enjoyable. From the rating for in-depth understanding, it was inferred that around 81% of students felt more comfortable communicating actively with their peers during the activity compared to their communication with the course instructor. The confidenc level of the students also increased to over 86%.

4. Results And Discussion

The effectiveness of implementing the enhanced Jigsaw method can be gauged in terms of the following factors, namely: students' performance, observation by the faculty, and effectiveness of guna classification for grouping the students.

A. Student's Performance

After the completion of the learning process, a one-hour assessment was conducted to gauge the learning effectiveness of both the traditional and Jigsaw students. The assessment questions were divided into two sections, 'Part A' and 'Part B'. In Part A medium complexity questions were framed to test their conceptual understanding. The other section included complex problems, which require higher-order thinking skills in applying appropriate theorems to arrive at a proper solution. Table IV and Table V shown below, compare the scores converted to a percentage for the control and experimental batches.

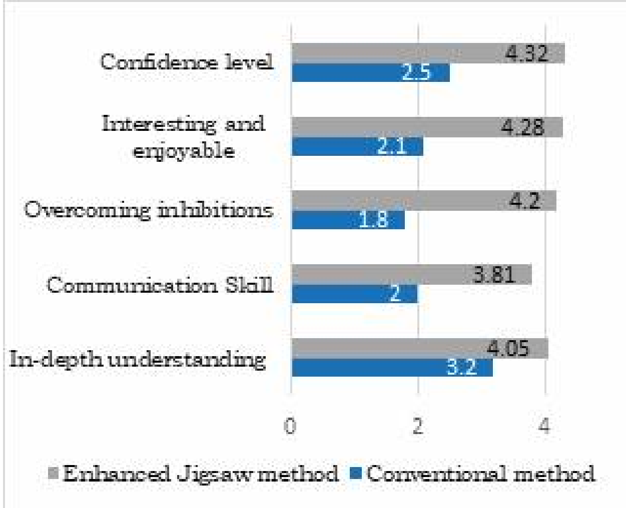

Fig. 5 : Bar graph comparing the average feedback scores in both the teaching methods

Table IV and Table V compare the students' assessment scores of the control and experimental batches. It was observed that the students performed well in both Part A and Part B while adopting the enhanced Jigsaw methodology. Both the groups of students were able to perform well in Part A. But the experimental batch adopting the Jigsaw methodology showed increased performance in Part B compared to the control batch.

The graph in Fig. 8 compares the average feedback scores obtained by the students using the two different methodologies in Table II and Table III. It was observed from the students' feedback (Fig. 6) that the in-depth understanding, communication skills, confidence levels and interest towards learning was higher for the experimental batch who learnt by the enhanced Jigsaw method compared to the control batch - conventional teaching learning experience.

B. Observations by the faculty

While elaborating the concept using conventional teaching, the faculty felt that the lectures were monotonous, and the students experienced difficulty understanding the concepts. The faculty had to spend additional time teaching the students who could not grasp the concept in the classroom sessions. The faculty was also unable to address the needs of the reluctant students in the class. When the students were provided with home assignments, they experienced difficulty getting along with their peers in solving the problems.

The faculty felt that the interaction between the students improved substantially, and the students' engagement was maximized while adopting the Jigsaw methodology. When the students were grouped into small teams, every student got the opportunity to help and learn from their peer group environment. It was also observed that the experimental batch was enthused with positive energy, and the students built a constructive competition among and outside their group. The faculty were also highly motivated to provide additional problems of higher-order thinking to cater to the learning interests of students.

Table VI compares the traditional teaching method and enhanced Jigsaw method of learning in terms of the utilization of time resources and the number of problems solved. The table inferred that the Jigsaw method helped in utilizing the time resources efficiently and the students meticulously solved more problems under different categories.

Table 6 : Comparison Of Traditional Teaching Practice And Jigsaw Method Of Learning

	Traditional Teaching Practice	Enhanced Jigsaw method of learning
No of lecture hours required to introduce the concepts of mesh and nodal analysis and solve basic problems :	1 lecture hour + 3 tutorial hours	1 lecture hour + 3 tutorial hours Phase 1: 1 tutorial hr Phase 2: 1 tutorial hr Phase 3: 1 tutorial hr
No of problems solved	Nine problems as in-class activity and ten problems as homework (easy to medium complexity)	24 Problems (easy, medium, and high complexity problems)

Table 7 : Average Assessment Scores (in Percentage) For Guna Based Classification Of Students

Classification of students based on Predominant Guna	Average assessment score	
	Conventional teaching method	Enhanced Jigsaw method
Sattva	75.21	87.94
Rajas	86.08	90.33
Tamas	47.99	67.06

C. Effectiveness of Guna Classification

When the students were grouped in a team of five or more, predominant Tamas Guna (unprepared or unwilling students) tend to contribute very little in group work, being unnoticed throughout the sessions; in other words, they may "hide" easily. However, a team size of four with guna classification was found to provide sufficient intellectual resources to solve the problems at different levels and prevented students from "hiding" and motivated them to contribute in at least small means.

From Table VI, it was found that the enhanced Jigsaw activity improved the interpersonal skills of the students when they were asked to interact among their groups, facilitated by the faculty. Also, the Sattva students made sure that the discussions were fruitful and in the intended direction establishing a harmonious environment. The faculty encouraged the Sattva students to promote a win-win situation among the group consisting of Rajas and Tamas students. Rajas dominant students were quite hyperactive and did not easily help their peers, but the Jigsaw created an atmosphere for compulsive interaction. The students clarified their doubts by interacting with their peer groups. This activity also enabled the Tamas students to come forward and get involved in the group activities rather than being conservative, thereby scoring better than the same cadre of students in the control batch. Also, it was observed that this activity served as an opportunity to kindle the Sattva guna characteristics among the Rajas and Tamas guna students.

5. Conclusion

The enhanced Jigsaw learning activity was conducted for the first-year students of Electronics and Communication Engineering. The learnings in terms of the impact of the adopted methodology on the teaching-learning process were presented. The students, categorized using the Triguna levels, were divided into an expert and home groups to solve Mesh and Nodal analysis problems. Initially, the students were reluctant to participate in the collaborative activity. Later, it was observed that the student's interest in the activity and completion of tasks improved significantly. The post-session feedback, students' assessment scores, and the comparison between the conventional and enhanced Jigsaw activity served in inferring the effectiveness of the adopted active learning strategy. This activity ensured to improve every student's learning curve, problem-solving, and critical thinking ability and promote collaborative interdependence among the students. This group activity kindled the positive attributes of the students with different Guna levels and helped them in establishing a coherent environment for their learning activity. This methodology also to deliver the course contents at a faster pace within the stipulated duration, without compensating for the students' academic performance and conceptual.

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