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Effect of the Jigsaw-Based Cooperative Learning Method on Engineering Students

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Abstract: In the rapidly evolving world "knowing the knowledge" is not sufficient but the knowledge should be used to apply in real time situation. In order to fulfill this requirement students must possess qualities which will help them to solve the problems proactively , make decisions and think critically and creatively, communicate ideas effectively and confidently , work efficiently within teams and groups etc. It is observed that engineering students are lacking in such qualities and unable to sustain in the outside world. One of the major reason behind such situation is because of passive traditional teaching methodologies which is generally a teacher centric rather than student centric. Whereas active learning methods aiming to achieve life-long learning and potential knowledge are student centric methods where involvement of student is ensured compared to the traditional teaching method. In this paper we have discuss the implementation of cooperative type of jigsaw active learning method and its feedback and assessment analysis.

"Instruction begins when you, the teacher, learn from the learner. Put yourself in his place so that you may understand what he learns and the way he understands it." (Kierkegaard)

Keywords: Blooms taxonomy, Traditional teaching method, Active learning method, Jigsaw Activity, Soft skills.

1. Introduction

Over past several years active learning methods come into practice to improve the skills of engineering students those require to adapt the rapidly evolving world in which we live. The basic difference between the active learning method and traditional teaching style is that: active learning methods are student centric whereas traditional teaching method is teacher centric. We had practice this traditional methods over so many years that whenever teacher comes in the class student assume that the teacher have knowledge and he/she is going to impart his/her knowledge to us. But we never think that the same person can be a facilitator or guide who will help us to gain the knowledge and in addition to that he/she will help to develop skill for presenting, applying, rediscover the knowledge. Measuring criteria of good teaching is suppose to be in an amount student learn rather than how good that teacher is able to teach. Of course teaching and learning are very closely related to each other but even if teacher is very good at teaching, learning of all the students cannot be ensured. The reason behind this fact is that only good students take the responsibility of their learning [6], and the student of private engineering are mostly available in wide variety range from less attentive to more attentive. Student attention or involvement can be achieved by adapting the active learning methods to serve the purpose of learning. Gain of knowledge through learning is one of the purpose of educational system, other than that student are also facilitated to the opportunities to develop personal capabilities and effective thinking skills as part of their well-rounded education. This critical and complex part of well-rounded education cannot be achieved by giving same treatment to every student as they have different levels of motivation, different attitudes about learning, and different responses to specific classroom environments and instructional practices. Here the role of facilitator /guide comes into picture who can provide suitable atmosphere for student belong in different category. These different attributes of students are handled by adapting different active learning methods and for that purpose we need to explore different categories of student. Sensation, intuition, feeling, and thinking are four principal psychological functions which indicate how people perceive the world and make decisions. These psychological function which are known as **Myers–Briggs Type Indicator** (**MBTI**) introduced by Katharine Cook Briggs and her daughter Isabel Briggs Myers based on the typological theory proposed by Carl Jung[7]

2. Bloom's Revised Taxonomy

In 1990's a student of Bloom Lorin Anderson revised Bloom's Taxonomy. She re-categorized learning styles as *remembering, understanding, applying and analyzing, evaluating and creating*[4]. The original Bloom's taxonomy had Apply and Analyze as separate levels which were merged together in Lorin's paper *A Taxonomy for learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.* Both the taxonomies have the basic underlying principals of Lower Order Thinking Skills (LOTS) and Higher Order Thinking Skills (HOTS).

LOTS : The first two levels of the Bloom's Taxonomy i.e *Remembering* and *Understanding* require low-level thinking skills. Remembering traditionally involves going through the textbooks and other hand written material. Modern day remembering may involve going through the presentations and videos readily available on the web. Understanding however pushes the learning process slightly towards the students. Traditionally this involves experts and teachers trying to answer the questions raised by students. For deeper understanding, aid of web based teaching material and analytical tools have showed outcomes than the traditional methods in modern times.

HOTS: Applying and Analyzing levels require higher order thinking skills on the part of students. These levels can be reached once the student has successfully completed the lower two levels. These levels require organizing, deconstructing, experimenting and critiquing on the data or concept. These levels can be completed by the students by conducting in-class discussions related to the topics taught.

Evaluation and creation are almost completely reliant on the students. Evaluation involves checking, judging, reflecting on the concept being learned. Creation is the last level requiring application of the learned concepts and knowledge and involves planning, design and production. This can be done by assigning students or groups of students with concept oriented projects.

As described earlier the Jigsaw method requires active participation by students and hence maps effectively to the Analyze and Evaluate levels of the Bloom's taxonomy. The distribution of topics and related material between different home groups gives the students ample opportunity to analyze the topic thoroughly. The use of various resources, traditional as well as modern, allows thorough analysis to be done by students. Further, splitting the home group and forming expert groups leads to cross questioning between various experts in the group related to their respective topics. This cross questioning results in further analysis and evaluation.
As the topics given to different home groups were interrelated to each other, after successful completion of this method students will be in a position to design a system or subsystem. Thus the Jigsaw technique with proper selection of topics and effective use of resources will result in an active learning method that maps very strongly to the Analyze, Evaluate and Create levels of the Bloom's taxonomy.

3. Jigsaw active learning method

R. Dunn and Reinert had demonstrated four basic perceptual learning modalities, which describes the variations among learners in using one or more senses to understand, organize, and retain experience [20].

- Visual learning: reading, studying the concept
- Auditory learning: listening to lectures, audiotapes of the concept
- Kinesthetic learning: experiential learning, that is, total physical involvement with a learning situation
- Tactile learning: "hands-on" learning, such as building models or doing laboratory experiments

Higher level of blooms taxonomy i.e. creates, evaluate and analyse is achieved through kinesthetic and tactile learning modalities. These learning modalities are performed in jigsaw activity by involving student for discussion aiming to achieve particular goal. In this activity student's aim is to retain the technical concept by mean of discussion, teaching and revising. From fig 1 it is evident that student can retain 90% when they use the learning immediately or practice it and also when they need to teach it or explain it to other. All the teaching community is evident for this fact that they understood and retain the concept thoroughly when they had teach it to students rather than when they learn as student in engineering graduation. This Jigsaw activity basically depends upon the phenomenon explain in last stage learning pyramid.

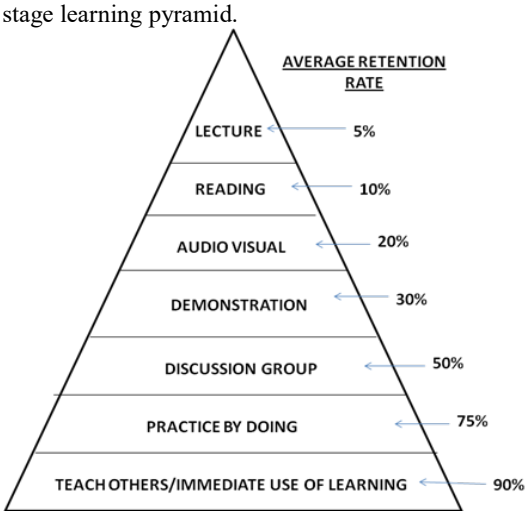

Fig 1: Learning Pyramid on Basis of Average Retention Rating in Percentage of Students

This a group a activity in which student learns through material provided and discussion of particular topic or concept while keeping in mind the fact that they have teach or explain it to others. Hence the Jigsaw activity also fulfill the 5th and 6th stage of learning pyramid in which average retention percentage is 50% to 75% respectively (refer fig

1). This activity is also take special care of their comfort zone, student are very conscious and afraid to explain or present the concept in front of teacher or person who is more knowledgeable in that field than them. But when the students have to explain or present the same concept to other student in group, they feel very comfortable and also other students are not afraid to ask the question to student who is explaining. This activity performed in three steps (refer fig 1) as follows

- Home group
- Expert group
- Home group

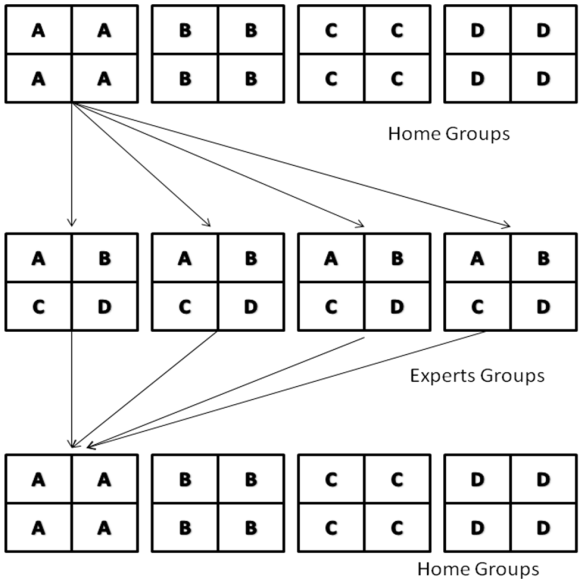

Fig 2: Working Protocol of Jigsaw Activity

The Jigsaw activity for third year students of Electronics & Telecommunication Engineering department at Rajarambapu Institute of Technology, Islampur has been conducted. This activity was performed as In Sem Evaluation which comes under the category of assessment by teachers. Students were assessed on the basis of six parameter i.e. participation, leadership, team-work, use of resources/creativity, relevance to the topic, problem solving skill. The reason behind the selection of this criteria is that in our tradition assessment policy only knowledge is checked but as already discussed in introduction knowledge is not sufficient, along with knowledge the approach toward application, presentation, creativity, problem solving ability is required to survive in vastly growing world. Third year class was of 72 students and hence assessment of student was not possible simultaneously. Two batches of 36 students were created in two different shifts and 36 students of each group were further divided into six groups which are called home groups.

Home group: Six groups are allotted with the different topics from same course which are interlinked to each other for discussion. All material required for discussion have already been uploaded on Moodle server provided by the institute which is accessible to all students. Before conduction of this activity, the students are instructed to carry required books (same as done in open book test), in addition to this handouts of all the topics and sub-topics those have to be covered are provided to confirm the proper direction to discussion. This activity is conducted in well equipped lab so that student can have computer for creativity and internet access for more information.

Each group is provided with 30 minutes for discussion, they have instructed with fact that each of the group member have to explain the same topic to other groups while covering all sub-topics. Co-operative type learning strategy has been adapted to improve the ability to face the common problems. One more important advantage of this learning method through discussion is that students come to know other perspectives of same topic from different angles. Through the interaction with other students, they have explored to whole new methodology, logic developing ability, different techniques adapted to solve the problem, different tools, and different way to presentation. This group discussion type of active learning also helped students to develop the skill set required with knowledge as discuses earlier.

Expert group: Then all the groups were reshuffled in such way that the new groups were formed having students with different topics in their home group. Name itself explain that groups are formed like everyone is expert in their own topic. Each expert have to explain their topic to other students who can ask question to expert to solve their doubt. Very important last stage of learning pyramid is achieved in this step that is immediate use of learning which helps the student to retain 90% of content. Whatever they have learnt or discussed in previous thirty minutes immediately they have used it to explain and teach their own topic to others. Also the presentation skill is tested or otherwise developed during these steps and as comfort zone (explaining or teaching to their classmates only) has been maintained, it was easy to develop the presentation skill of student in this case.

The problem solving ability of students have been enhanced, as they faced questions and doubts asked by other students. One precaution had been taken to channelized sequence of their discussion since topics were interdependent to each other. The expert groups were instructed to maintain the sequence or flows of the topic since all the topics were part of one unit. Time given to this second step was greater than time given to home group, as they have discussed the entire topic altogether (in our case we had provided 45 minutes). As a result of expert group, now all students in each group were aware with the entire topic and were expected to understand thoroughly.

Home group: Last step is very important to assure the complete learning of the topics. In this step all the groups were reshuffled in such way that each student will go to

their original home group. One may ask the why we need this stage as the entire student are already aware with all the topic? Very strong reason behind is that it may happen that during this method any expert have not provided complete information of topic or incorrect information have passed on. In this case there must be some rectification required to improve this undesirable possibility and returning to their home group will able provide platform to solve this problem. After returning to home group, very group is instructed to discuss the understanding of all topics in detail. So even if one of expert had failed to elaborate his topic correctly, now his other expert group member can understand that topic from student of original home group who had understand that topic from expert group. After the discussion in last stage of the entire topic by the students, it is assured the complete learning of all topics by each student.

Report writing: During this method all the topics have been revised twice, hence learning efficiency already had been improved. Learning is occurred by participative discussion, immediate use of that learning, different perspective for the same topic, solving the doubt after returning to home group and also rectification wrong or incomplete knowledge of the topic. Further learning can be improved by writing report on the entire topic either in expert group or home group. We allow the student choose the group in which they are willing to write a report and for that purpose instant poll was taken, as result of that first batch selected expert group to write report whereas second batch chose home group to write the report. Emotion bonding and unity is observed in home group and hence it is possible that everyone will contribute in report writing equally with same interest and zeal. Whereas in case of expert group, advantage is that everyone is expert in their own topic which will very helpful to cover every details of entire topic. Both the choices are advantageous in one or other, so it better give freedom to selection method according to their convenience.

For successful execution of this activity, we have to take care of some factors as follows

- In order to ensure active participation of students in discussion the pre-requisite of the all the topics must have already fulfilled. If the pre-requisite of this topics is not fulfilled in that case instructor need to take some introductory classes on topics, so that students will be in position to discuss the topics
- Some groups may fail to take proper direction toward achieving the goal of learning of that particular topic, in that case interrupt them and help them to take proper direction towards achieving the learning goal. This is very important because if that particular group completely misunderstood their own topic in home group, same wrong information will get pass on to other students in respective expert group. By doing this teacher or instructor becomes the facilitator who guides to give the proper direction for achieving the learning goal .
- If this activity is taken for the purpose of assessment then each student need to be given unique identification, so each student can be assessed without any disturbance.

4. Feedback anlysis

To see the impact of this active learning activity on students, feedback had been taken in the form of questions and ratings. It is observed that students were happy and excited to adapt this active learning method for further topics(fig 3). This activity was conducted as In Semester Evaluation and students were assessed on the basis of six parameters i.e. participation, leadership, team-work, use of resources/creativity, relevance to the topic and problem solving skill(refer appendix B).

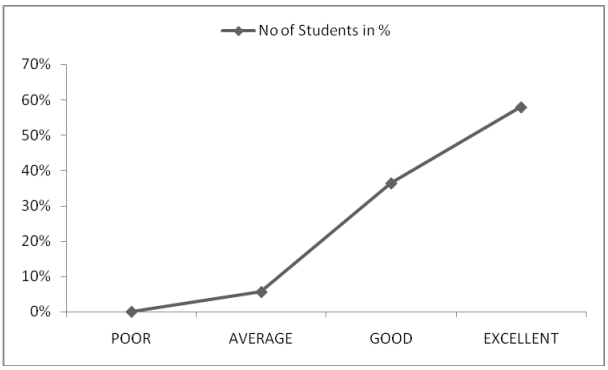

Fig 3: Cumulative Feedback of Students in the form of Rating Given to the Questions Asked

Response of students to the question asked about how this activity helped you to realize the importance of six parameters plus two more parameters i.e. Time management and Proper planning / strategy is excellent(rfer appendix A and fig7) . This proves that active learning activity increases awareness among students about other soft skills which are requirements of vastly growing world. As published in The Hindu on 7th November 2007 according to Nasscom report 75 percent engineering students in India are unemployable. It is also suggested by education experts that the Indian higher education system must give skill building and practical training along with academics to give them an edge. This soft Skill requirement expected from engineering students can be accomplished by creating awareness of it among them and providing platform to achieve it. This can be attained by adapting active learning though various techniques or activities and Jigsaw is one of them.

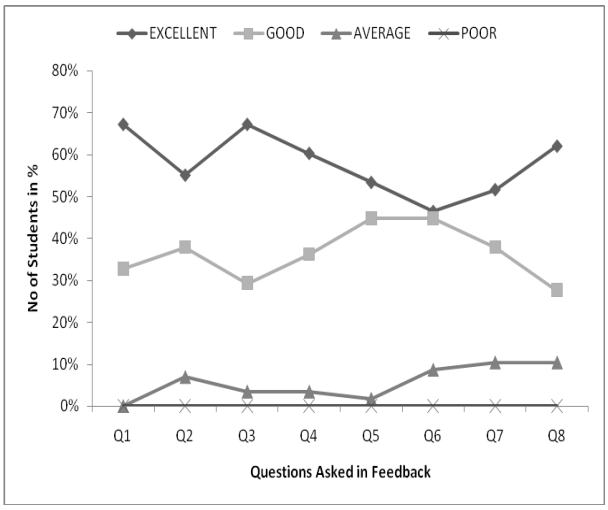

Fig 4: Feedback of Students in the forms of Rating Given to the Each Question Asked

From the statistics given in the feedback report, it is also proved that students agreed to the fact that not only the Jigsaw activity helps to fulfill the learning objective but also it motivates to study the same topics in depth (refer question no. 4 and 6 from fig 4). Student were asked to rate Jigsaw activity in order to conduct this activity on regular basis and 62% students rated this activity as excellent as shown in fig 3. Only 10 % student rated activity as average and no students gave the rating as poor whereas as 28 % student rated this activity good enough to conduct on regular basis. This statistics not only shows that the Jigsaw method is affective but also the student are willing to adapt the active learning method on continues basis.

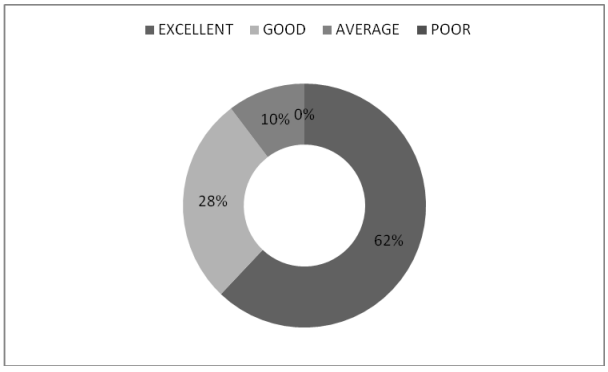

Fig 5: Rating Given By Students to Question No. 8 (Refer Appendix A)

5. Assessment analysis

Performance of the students in Jigsaw activity was evaluated by giving grades as low, average, high to all six parameters: participation, leadership, team-work, use of resources/creativity, relevance to the topic, problem solving skill. This alternative assessment was intentionally adapted over traditional assessment where only writing skill and memorizing data is tested which comes under lower-level thinking skills according to blooms Taxonomy. Maximum engineering Students always tend to focus only on lower-level thinking skills than high-level thinking skills, because we assess the students on the basis of that skill only. Student will focus on higher- thinking level if we will start assessing them on that skill and this is the reason behind selection of six parameters which will encourage the students to improve their higher-thinking level skill.

Assessment sample of 20 students has been selected to plot graph as shown in fig 4 in which assessment of students in percentage is calculated in terms of six parameter as mentioned. This graph shows that our students are lacking creativity and problem solving ability, Also they need to work on their leadership quality. It is also observed that number of students actively took part in Jigsaw activity is more than 50 %. The number student were contributing relevant to the topic is also more than 50% hence it can conclude that the discussion was going in right direction aiming to achieve the learning goal.

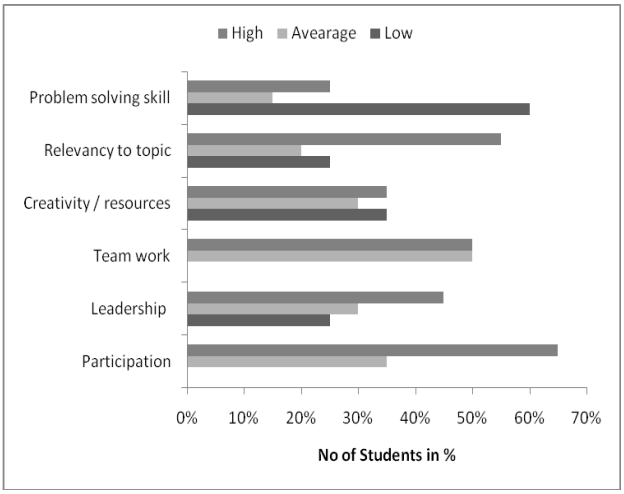

Fig 6: Assessment of Students on Basis of Six Parameters

6. Comparative analysis

As earlier discuss, if we want to shift the focus of students from lower-level thinking skills to high-level thinking skill then we also have to adapt to assessment tool which will test the required high-level thinking skill. As per the requirements, we had conducted activity to test the requied soft skills and result is shown in fig 7. In the feedback, students were asked to rate Jigsaw activity as how this activity helps them to realize the importance of six selected soft skill parameters. Rating given by students shown in fig

7 proves that awareness about the importance of these soft skill had been increased. Once awareness about the importance of soft skill have been developed, we only require to provide the platform as facilitator and students themselves will take a responsibility to develop these soft skills.

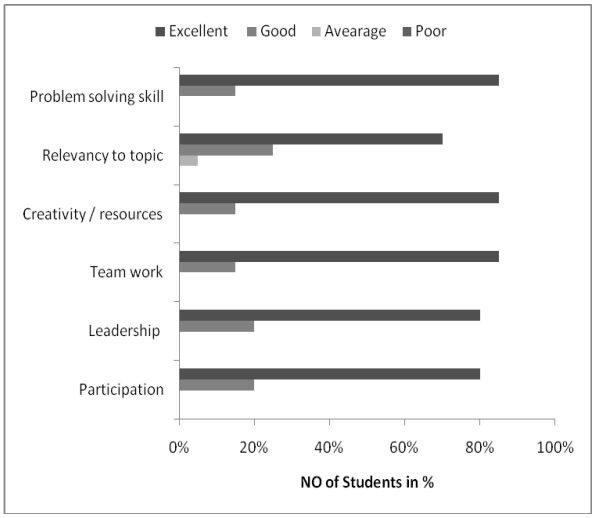

Fig 7: Feedback of Student on the Basis of Six Parameters

7. Conclusion:

Learning and understanding of the technical concept in order to apply it in real-time application or situation is main goal of engineering education system. The Jigsaw active learning is successfully manage to achieve this most important goal simultaneously with developing the soft skill in students. By comparing assessment graph with feedback graph (refer fig 6 and 7), it is observed that even though number of students who posses these soft skill are less but after performing this activity the awareness about importance of these soft skill increased. Outcome of the Jigsaw active learning method which is proposed in this paper has been measured in terms of awareness developed among engineering students about the importance of soft skills simultaneously with the technical knowledge. Once the awareness is created among the students, they will only require platform to polish their skill or to develop the new soft skills. The proposed Jigsaw active learning technique is capable of providing both the facility i.e. awareness of these skill as well as platform to build these skills. Thus the Jigsaw technique with proper selection of topics and effective use of resources will result in an active learning method that maps very strongly to the Analyze, Evaluate and Create levels of the Bloom's taxonomy

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Appendix A

Feedback form of Jigsaw activity

Sr no	Feedback Questions		Rating given by students for Jigsaw learning activity in percentage of students Poor(1) ←----------→Excellent(4)			
			Poor (1)	Average (2)	Good (3)	Excellent(4)
1	Rate the Jigsaw active learning activity					
2	Rate this learning style over traditional teaching style					
3	Do you think each step in this activity is important? Rate it accordingly. (home group→expert group→home group)					
4	Does this activity motivate to study the entire topic in detail? Rate it accordingly.					
5	Have you developed some skills or enhanced skills you already possessed due to this activity? Rate it accordingly					
6	Rate this activity in terms of fulfilment of learning objectives					
7	Rate this activity according to the understanding of topics were developed.					
8	Rate this activity in a way it helped you to realized the importance of these skills	Participation				
		Leadership				
		Team work				
		Creativity / resources				
		Relevancy to topic				
		Problem solving skill				
		Time management				
		Proper planning /strategy				
9	Rate this activity good enough to perform on regular basis.					

Any other additional comment :

Appendix B

Assessment Sheet
Group no :
Topic Allotted :

Roll no	***Attributes***					
	Participation	***Leadership***	***Team Work***	***Use Resources/ Creativity***	***Relevance to Topic***	***Problem Solving Skill***