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Role of Teamwork in Improving the Affective Abilities of Engineering Mathematics Students

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Abstract - This paper investigates the role of Teamwork among the Engineering Mathematic students of first year with an aim to improve their affective abilities through action research. Mathematics learning is not just an aspect of cognitive domain, but also an affective ability. Every class will have students, who face difficulties in understanding and solving the mathematics problems.It is not the grades but their attitude towards the subject ,their fear and their difficulties which determine the learning and improvement among students. Teamwork encourages the learners to overcome their fear towards Mathematics by developing various aspects of affective domain, which include their attitude towards the subject, emotional reasoning, attention while learning, organizing skills along with cognitive development. This being an action research approach will help not only the students, but also creates the scope for improvement in teaching methods of the teacher. Teamwork was the action research approach, that was adopted to implement effective teaching-learning process.To prove the effectiveness of Teamwork , a Teaching-Learning process was adopted to improve our students' learning. This process was designed to implement a different learning strategy to support mathematical knowledge, problem solving and team working skills. This paper will present an account of our study and highlight various issues in the use of action research.

Keywords:Affective Ability, Engineering Mathematics, Action Research

I. INTRODUCTION

Teaching Engineering undergraduates of different disciplines have provided me with significant knowledge about the multiple learning difficulties of the students. Even after taking all necessary steps for a successful Teaching-Learning process, one can find failures or poor performers in each class.

Being a teacher of Engineering Mathematics, it was observed that the expected outcomes are attained, if students develop interest in solving problems of Engineering Mathematics on their own.

The Learning process is successful only when the results of the learning are not only in terms of numbers, but also in terms of behavior and attitude of the students towards the subject. Improvement in various aspects of affective domain can also be a parameter to study the growth of students in the relevant discipline.

A good teacher always thinks of innovative ways of Teaching-Learning methods which motivates the students to enhance their learning abilities.

In this paper, a Teaching-Learning process was adopted, that focuses towards identifying poor performers in a class understanding the student's beliefs, attitudes, emotions and values and working towards improving their self-confidence, changing their attitude towards learning the subject, increasing their mental ability and Problem-solving skills.

II. LITERATURE REVIEW

Most of the people assume that learning is an intellectual process including studying, understanding and reciprocating. But there is also another side, which is the mental process of behaviour, attitude, mind mapping and sometimes physical skills.

In the learning process, no two students are the same, some have the capabilities of faster receiving, analyzing and responding and some are very slow. What is much more difficult is to address the student who are not motivated to learn, who are defensive when given asked to learn, extremely shy/quiet to express and always try to avoid learning. These affective skills are harder to practically define & identify.

Much research work has been done in Teaching-Learning process of Engineering Mathematics. Roselainy Abdul Rahmana , Yudariah Mohammad Yusofb, SabariahBaharunc[1]have studied about methods of improving teaching of Engineering Mathematics by using Action Research.

They suggested that a teacher has to understand the learning behavior among students. Multiple approaches have been applied like critical reflection, observation of colleague's teaching.Interviews, conversations,

questionnaire were also included to evaluate the learning process. A specific development strategy with teaching materials was suggested. Their results described the factors that shaped and affected the teaching practice.

Anastasia and Konstantinos [2] investigated the effectiveness of Group Work in mathematics.Their research focused on use of group learning among students for deeper understanding of the concept. They suggested that Group Work improves analytical and communication skills, critical thinking approach ,respect for other opinionsand Problem-solving skills among students. Their study included both group learning and active learning.

Kholidah Sitanggang, Herman Mawengkang and Tulus[3] have discussed about creating critical thinking from affective domain in successful learning of mathematics, they suggested different modes to enhancing learning and develop a positive attitude towards learning outcomes. A teacher should select the method according to the affective factors of the student.

Anthony [4] studied about the factors which influence the success in mathematics.Ignasia, NG, Nieto, LJB, Barona, E.G. [10] concluded that Affective domain has an important part to play in study of mathematics. McLeod D.B.[11] investigated on beliefs, Attitudes and Emotions in the study of mathematics education.

Nuria Gil Ignacio, Lorenzo J. Blanco Nieto and Eloísa Guerrero Barona, [5]in their paper titled the affective domain in mathematics learning explained that the existence of positive attributes, beliefs, and attitudes about themselves as learners was a source of motivation and expectations of success in dealing with the subject. It was found that neither the students' gender nor their year of studies influenced their beliefs about their self-concept of mathematics.

Chapman, [24] in his research work concluded that students with mathematics learning difficulties due to their repeated experience of failure are those who present the most maladapted attributional patterns. Doubting their own abilities, students exaggerate the magnitude of their deficiencies, and tend to attribute their failures to their lack of ability. According to him they also show low expectations of success, and give up easily in the face of difficulties. When such students are successful, they attribute their success to the easiness of the problem, to help from the teacher or their classmates, or to luck. Continued failures are seen as confirmation of their low level of ability. The negative beliefs about themselves as learners prevent those students from improving their mathematics performance, since they believe that it is beyond their possibilities to do well.

McLeod [23] has done a great contribution in the study of Affective Domain in mathematics according to whom it as a broad range of feelings and moods which are generally considered to be different from pure cognition, including, as specific components, attitudes, beliefs, and emotions.

McLeod [25] differentiates four axes relating to beliefs: mathematics (the object), oneself, mathematics teaching, and the context in which mathematics education takes place (social context).

Motivated by the research carried out in Engineering Mathematics teaching by these eminent authors has inspired me to do research in this domain. My paper investigates further into the role of teamwork in improving the Affective abilities of Engineering Mathematics students by action research.

III. RESEARCH METHODOLOGY

Research, analysis and self-study have put forth that the students usually improve their Affective capabilities, when they are in a group. This allows to better learn and understand themselves and also others in the group.

When in a group, there is a lot of peer interactions, which put up various learning opportunities for lesser skilled students from more skilled. This improves their learning capacity and also a much better satisfaction that they are learning and also sharing their knowledge to gain more.

Group learning also provide tangible benefit for students, who are highly skilled as there are better opportunities to get clarity when they explain to other members. This will improve their knowledge significantlyand this will be benefitedto all the members in the group.

Finally, a group of less and highly skilled students involved in informal group activities will provide situations for immediate improvement as the involvement of the students in the class will be high. This will significantly improve the performance of the individuals in the group and the group itself. This is the beauty of group learning.

Let us know more about group learning by performing an experiment considering a sample class of 120 students of first-year Engineering Mathematics. Here to effectively implement the group learning experiment, a Teaching-Learning process was implemented to study and better understand the student’s affective capabilities and work towards improving them.

The sample 120 students were planned to be put through a 16-weeks of study and learning process, where regular classes will be conducted in the classroom environment and the students were introduced to different concepts of Engineering Mathematics.

The concepts were also selected keeping in mind that the students were a mix of both less skilled and high-skilled. The concepts were also planned to be taught through classroom teaching, assignments, discussions, and tests.

The concepts of Engineering Mathematics selected for the experiment were also less of complex and easily understandable like Matrices, Sequences&Series and other topics. This allowed to properly gauge the student.
The experiment, which is of 16-weeks was split into two stages, Stage 1 – where the preliminary investigation was done before the teamwork was implemented and Stage 2 – after the teamwork is implemented.

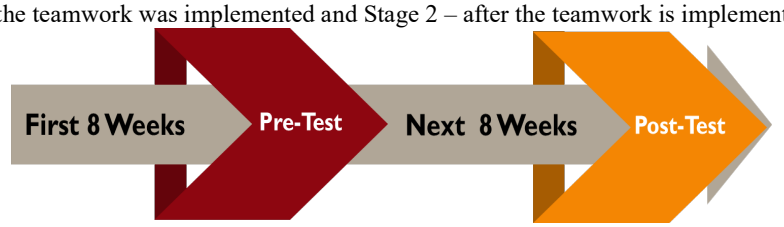

Figure 1: Stages of Teaching-Learning Process

Stage I: First 8 Weeks

The Stage I is aninitial investigation stage, where the students are allowed to be themselves and the teaching is done through classroom environment. The stage is of 8-weeks, where the students are taught different topics from MATHEMATICS -IlikeMatrices including Eigen values and Eigen vectors of a matrix, Cayley Hamilton Theorem, Quadratic formetc. and Sequences&Series which included different test to check the convergence of a given infinite series ,Alternating series convergence etc.,
These 8 weeks, all the students were made to attend all lectures delivered by the teacher and understand the mathematical concepts on their own. No personal attention was given (towards the student's interest understanding). They were left free to experiment through their though process, learning habits, analyzing & understanding and responding.
Over the period of 8-weeks, the students were put through various learning activities and their affective capabilities aspects, where noted down. The students were silently observed on their affective capabilities like their understanding, interactions, involvement, conversations, emotions, participation in discussions, communication skills, thinking, mental abilities and other areas.
After the completion of the stage I, at the end of the 8th week, a Pre-Test was conducted. The objective was to identify the poor performers in the subject by recording their scores. Simultaneously the affective domain aspects were recorded.
The Pre-Testwas conducted for a total of 20 marks and had Engineering Mathematics questions on the topics covered in the 8 weeks like "Finding the Consistency of System of Linear Equations", "Nature and Index of Quadratic Form by reducing to Canonical Form", "Convergence of Infinite Series" and others. The test results helped to analyse the student's performance, their understanding and problem-solving skills.
It was conducted in a classroom environment and the students were given the treatment of any other engineering subject examination. The students were given questions and they have to provide answers. (The students were) given significant time of 1 hour to complete the examination.
The Pre-Test was evaluated based on two aspects –

1. The performance of the student in the examination
2. The student's affective capabilities during the teaching-learning sessions

It has put forth various interesting characteristics of each students, their marks showed their understanding, their learning abilities, their knowledge and from the affective capabilities their behavior and attitude.
The Pre-Testevaluation results showed that, out of 120 students, there were around 29 students, who scored less than or equal to 50% of the total marks i.e. ≤ 10 marks. As shown in Table 1 and Fig 2.

Table 1: Pre-Test Marks Scored

Marks	Nos of Students
0 – 05	11
06 – 10	18
11-15	54
16-20	37

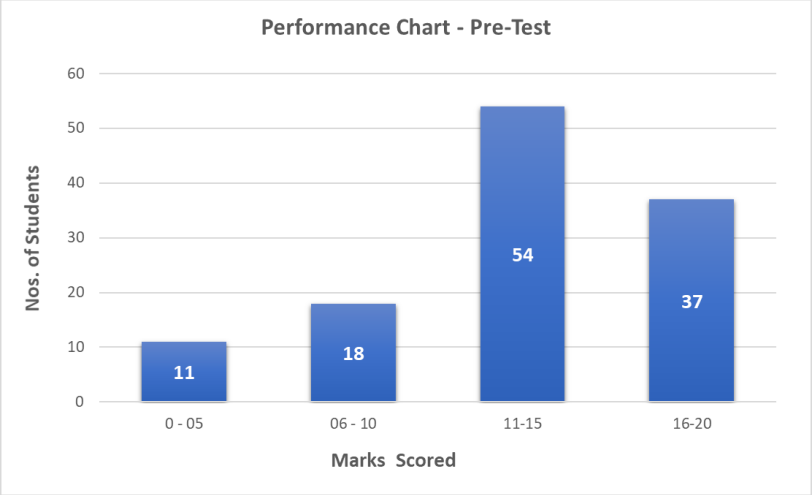

Figure 2: Performance Chart - Pre-Test

With the completion of Stage I, and the *Pre-Test* the Stage II was implemented.

Stage II: Next 8 Weeks

The Pre-test gave a wide-range of understanding on the student's physical and mental abilities. The Table 1 and Figure 2, shows in-details performances of the students. This allowed to identify that 29 students have performed poorly in the class of 120.

A detail analysis was conducted on these 29 students, where their basic learning skills were assessed. The assessment was done based on their marks scored, their classroom behavior, learning attitude, emotions, communication skills, involvement and other parameters.

Apart from the assessment, the students were individually assessed through an interview process and a face-to-face interaction. This allowed to study the interaction, involvement and emotions of the students.

Based on the assessment report and the personal interactions, among the 29 students, 25 students were identified, who needed improvement on their affective capabilities and learning abilities. The rest of the 4 students, were leftover as their affective capabilities showed more than average performance. (they had some personal reason like no preparation, not well and others).

The 25 identified students were then separated from the group and were personally counselled on their lack of affective capabilities and that they will have to improve these areas to better perform in their academic examinations

Based on the consent of these students, they were taken forward into the Stage II, for implementation of the Learning-Teaching process.

The Learning-Teaching process allowed to perform the affective domain study by implement the teamworkexperiment. This allowed to study the student's feelings, emotions, values, appreciation, enthusiasm, attitude and other attributes of the affective domain.

The teamworkwas an experiment planned to improve the mental motors of the student and make them more efficient and effective towards the different affective factors. This experiment was planned to be implemented as part of a comprehensive Teaching-Learning process and to be implemented in a phased manner. As shown in the Figure 1, the phases.

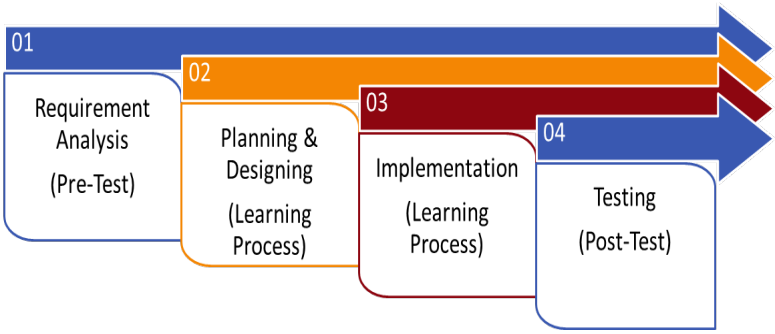

Figure 3: Teaching-Learning Process

Phase I - Requirements Analysis

Here based on the preliminary investigation, student assessment, their Pre-Test performance and their behavior and attitude through the classroom teaching sessions different affective domain factors were recorded for each of the students.
It was found that through the assessment, there were some common factor that the students were facing problems like lack of concentration, attitude to learning, distractions, emotions towards peers, enthusiasm, and others.
All these factors were noted down, and a requirement matrix was created to define all the requirements needed to meet and fulfill these to make the Teaching-Learning process efficient and highly-effective.

Figure 4: Affective Domain Factors

Phase II - Planning & Designing

The Teaching-Learning process was planned and designed to include different scenarios for teachers to perform various learning activities and observe the student's feelings, motivations, attitude, appreciation and enthusiasm. This allowed to identify and study the affective domain parameters/attributes in students and then work towards the success of the *teamwork* experiment.

Based on the performances of the students in the Pre-Test and analysing the requirements gathered, the *teamwork*was planned and designed. This team consists of two students, a poor performer and the other an above average or a good performing student.

As part of this experiment, the Teaching-Learning process were included with the following planned activities:

- Providing study material
- Presenting lectures through classroom environment
- Enforcing students to seek help
- Providing worked examples during teaching
- Encouraging to take notes during lectures
- Improve the ability to think mathematically
- Importance of Time Management
- Provide regular assignments
- Conducting Tests and Internal Assessments
- Provide adequate examples and realistic expectations

- Enforcing attention and active participation during lectures
- Presentations, practice papers
- Providing relevant content for study

and many other activities.

Phase III - Implementation

For these 25 poor-performing students, another 25 above or good performing students were identified. These students were selected from the group, who have achieved marks >= 15 marks in the Pre-Test.
The selected students above or good performing students, where then counselled regarding the teamwork experiment. The students were briefed about their involvement for the development of the affective capabilities study.
Out of the 50 students, 25 teams were built. The teaming had to be done with a poor performer and a good performer. The teaming of the students was done based on their consent and their compatibility with each other.
All these teams were briefed on the teamwork experiment and the 8-weeks plan. The teams were also informed on the study that will be performed on these paring and their performance will be noted down.
Throughout these activities, all the teams were monitored. The teams were encouraged to take part in all the activities.Their involvement, understanding, interactions, discussions, enthusiasm and emotions during the activities were noted down.
These teams were asked to undertake daily learning activities like solving the given set of problems, discussions and doubt clearing sessions, knowledge sharing, creative approach to solve the same problem in different waysetc.,
All the teams were kept under constant observation to keep a check on their progress and to see that they are not deviated from the practice. The topics covered during these 8 weeks were calculus(both vector integration and vectordifferentiation).The teacher took the initiative to find the difficulties faced by each individual within the team while learning these concepts. The teacher evaluated and recorded the progress of the students. This experiment was performed on a daily basis for the next 8 weeks.
During the process of teamwork, teacher counselled the poor performers to find out their difficulties in learning and the students were monitored throughout learning process not only during the class hours, but also during practical and tutorial hours by assigning them some tasks.

Phase IV - Testing

After the completion of the 8 weeks, a Post-Test was conducted. This Post-Testwas for a total of 20 marks and had Engineering Mathematical questions on the topics covered in the 8 weeks. Subject taught includes Mean value theorems ,curvature , radius of curvature evaluates and involutes, Fourier series, multivariable calculus and vector calculus ,Special functions (Beta and Gamma functions).Questions like “express the given function as the Taylors series expansion, Determine the Maxima and Minima of the function f(x,y), Derive the relationship between Beta and Gamma functions, Define solenoidal and irrotational vectors etc.,
When the Post-Testwas evaluated, it was found that out of 120 students there were around 15 students, who scored less than or equal to 50% of the total marks i.e. ≤ 10 marks. As shown in Table 2 and Fig 5.
The marks scored by the students were noted down and the change in their attitude towards subject was also recorded. It was observed that there is appreciable enhance in the affective abilities of the students after the Post-Test, there were about eleven (11) students with scores between 0-5. After Post-Test the number reduced to six (6) there was a substantial increase in the number of students who scored above ten after Post-Test. As shown in Table 2 and Fig 5.

Table 2: Post-Test Marks Scored

Marks	Nos. of Students
0 - 05	6
06 - 10	9
11-15	51
16-20	54

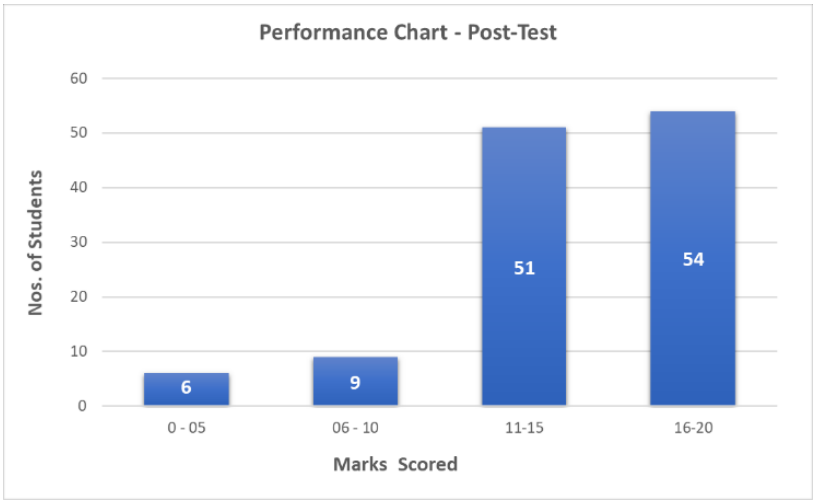

Figure 5: Performance Chart - Post-Test

There was also significant change in the attitude and behavior of the 25 poor performing students after the teamwork experiment. The students showed good signs of progress in their understanding, problem solving, emotions, attitude and did good in their Post-Test

Comparing the results of Pre-Test and Post-Test, it was observed that there is significant improvement in the performance of the student in learning of engineering mathematics. As shown in Table 3 and Fig 6.

Table 3: Comparison of Marks Scored

Marks	Pre-Test	Post-Test
0 - 05	11	6
06 - 10	18	9
11-15	54	51
16-20	37	54

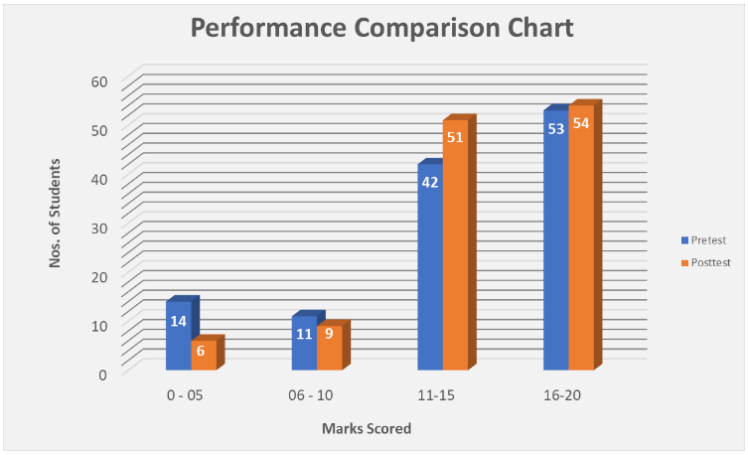

Figure 6: Performance Comparison Chart

Doing the task and assignments in different approaches lead to improvement in their creative thinking among teams.

- Problem solving skills were developed during *team work* activities
- The students learnt the concept of critical reasoning and started respecting other's opinion
- There was improvement in independent thinking of the students, which developed their interest towards the subject.
- Doubts clearing session taken up personally by teacher had more impact on learning outcomes.
- Not only poor performers but the people who helped them by forming teams got their scores improved.

IV. CONCLUSION & OUTCOMES

On the basis of above findings and analysis, it can be concluded that team work plays a vital role not only in improving the performance of the student in the subject test, but also enhances their affective abilities like

- Change in attitude towards learning the subject
- Receiving & Responding
- Organizing
- Creative Thinking
- Independent thinking
- Analyzing & Problem-solving skills
- Appreciation and respect for other's work

Thus, using action research, it is verified that the team work has a significant role to play in the improvement of affective domain of Engineering Mathematics students thus encouraging them to excel in their respective domains.

V. FUTURE SCOPE

As it is evident from the data and graphical representations, that there are still some students, who need to be dealt in a specific way with respect to their affective and cognitive domains.There can be good scope for any researcher to suggestdifferent teaching-learning methods to improve the performance of such Engineering Mathematic students.

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