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# Numerical Theory to Practical Working Model Learning Approach

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***Abstract*—**This paper is on the experiential teaching learning method applied as a part of active learning and active student engagement for the courses such as Numerical based, Calculative courses. The students solved the numerical, and based on the same numerical they have been asked to prepare a working model or animation with the same dimensions (scaled) and motion parameters. This was applied to second year of polytechnic level course of Mechanical Program. Their demonstration on model in-line with the numerical were evaluated and credited in their course with 10% weightage. There was a great response received from the students for numerical to working models' approach, their learning from calculative numerical course was improved and the comfort in it was increase. The performances and the implementation is found to be indunted. Further this approach could be modified with the same methodology for betterment in learning of students and incorporating in the courses at different levels and to different programs.

***Keywords*—** Active Learning, Innovative best practices, Student Centric Teaching-Learning method.

## I. INTRODUCTION & LITERATURE SURVEY

THIS paper is an at actual experienced teaching learning strategy to enhance the learning in analytical or numerical calculation based courses in an Engineering Educational Institute.

In the last almost two years the COVID 19 has affected and transformed the education from offline to online mode however the demand from students as well as their Guardians and utmost the faculties itself is to have Teaching Learning process more in offline with a blend of technology supports & online platforms. Regardless of this there are few course contents and issues for increasing students' active participation like numerical courses and analytical courses.

There are few courses in engineering sciences which deals with the design and analytical calculations, which became a hurdle to teach in online mode for the students residing in rural and with low economic supports. As there is less hold and attention of student for such calculative content in the course it becomes tough to trace the student learning at lecture delivery.

Of course, there are various active learning techniques evolved which have increase the student attention and learning. Few active learning methods of cooperative and collaborative type have yielded the maximum learning (Marjan Laal, 2012). The learning methods and styles of the students are very important to know, which lets mentor/teacher to act and plan the course delivery. IRSIEC is the active learning method which gives the idea about learning styles and student approach as well as expectations from the course learning, teacher delivery (Mulla A A, 2021). It also tells the assessment approach for individual and group performances. The problem-based learning uses approach of student learning were student or group of students find solution with a small scope for given problem with shorter work and often single subjective using case studies and similar active learning methods (Faghri, 2016). While the Project base learning is multi-subject, usually lengthy creating product or some performances. It may use real world scenarios.

In our case we are using single subject shorter but creating a product or performance like approach for teaching-learning. There becomes harder for teacher and student to imagine the calculative values and their relation with the real world (Shute, 2012). The analytical course, Numerical based course, design calculation like courses, etc. whose imaginary calculative numbers or values does not give the real feel of experience of the relevant course content. However, the calculative courses are more important as an engineering program perspective, the calculative, numerical based courses give the students the actual practicing and measured action as an engineering job. The calculative course learned than the theory learned are more applicative and drives in the attainment of higher blooms level. Few course contents have been simultaneously taught with laboratory performances but could not cover the maximum course and contents in the programs. So, to give a real world and feel of numerical, calculative content there was learning experiments done on the engineering sciences students for the course of Program Mechanical Engineering and course name Theory of Machines.

## II. METHODOLOGY AND IMPLEMENTATION

Student learning for the course content like Numerical, analytical course is linked with the real world by either Simulation software technology support or by preparing mechanism or mechanical model which will give the interpretive information of calculations done or numerical solved.

For the polytechnic level education, to the second-year course of Mechanical Engineering Program, Theory of

Machine course was delivered with tilted teaching learning approach. There are numerical in this course content where student has to design cam profiles, do the calculation to determine the velocities and acceleration for various mechanism those are present in Mechanical Machines. Doing

calculations gives an imaginary learning of content for which the calculation was. There is very less connectivity and learning to the students from the calculative values unless and until they could very well imagine, experience in simulation or at actual physical/real form.

### *A. Methodology*

The students in a group of four were given to solve numerical based on the content from course and they were asked to prepare a simulation or animation or Working model from low-cost material based on same numerical that they have solved. These students were asked to Demonstrate the complete learning of that numerical by delivering or demonstrating as a part of real world, feel experience.

Student were more interested to develop working models of the mechanism of which they were asked to solve numerical. In the implementation for the course Theory of Machines of Polytechnic level in mechanical Engineering Program, the content choose was, Solving Numerical related to Fundamental of Mechanism, Four bar link mechanisms and their motions such as velocity and acceleration, and the Numerical based on the cam and follower design and their motions.

For the mechanisms students were asked, to solve numerical and take the same dimension input values for developing the models. They asked to scale up and scale down the dimensions for the convenience of building the actual models.

For the cam and follower design and motions, students were given numerical base on the different types of cam types, follower types, and types of motions such as Simple Harmonic motions, Cycloidal motions, Uniform displacement motion, Uniform velocity, etc.

Students were given flexibility for using low-cost materials so that economic limitations could be overcome. The material used were metal, wooden material, rubber material, plastic material, etc.

Many students have developed working models for the given numerical to solve (Bazilali, Ansar, n.d.). They have solved numerical, learned the purpose of that numerical in the course, linked with the working model, analyze the working model parameters such as motions, dimensions, its behavior in the applications. Students have developed a small teaser video which shows their learning enthusiasm and the part of learning interest with this style of teaching learning methods.

The detailed methodology and the implementation of the active teaching learning method is shown in Figure 1 and is detailed in latter section.

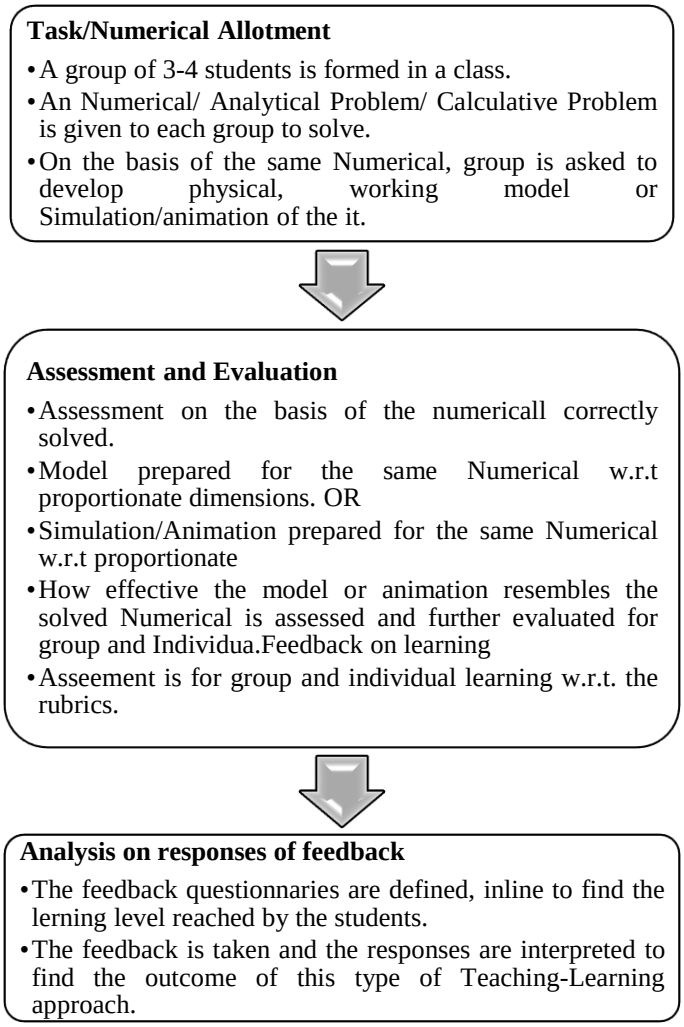


Figure 1: Methodology and Implementation

There were 24 groups of students formed and the numerical and models to prepare were give, out of which sixteen groups choose to solve numerical and prepare working models, while remaining choose to demonstrate it by preparing animations.

Few titles have been listed below on which numerical to solve and preparing working models,

Single Slider Single Crank Four Bar
Locomotive Coupler
Whitworths Quick Return
Scotch Yoke
Elliptical Trammel
Oldham's Coupling
Pantograph
Four Bar Inversions
Pendulum

Disc cam and knife edge, offset type follower with dimension from problem numerical given.

Disc cam and Roller follower, radial type with dimension from problem numerical given.

Disc cam and Roller follower, offset type with dimension from problem numerical given.

Disc cam and knife edge, radial type follower with dimension

from problem numerical given.

These are all the numerical from the course content and delivered in the teaching learning processes.

For example, the sample Analytical numerical or Problem was given to a group, the question is, *"Draw the profile of cam to raise a valve with S.H.M. through 40mm in 1/4$^{th}$ of revolution, keep it fully raised through 1/10$^{th}$ of revolution and to lower it with uniform retardation in 1/6$^{th}$ of revolution. The valve remains closed during the remaining part of revolution. The diameter of roller is 20 mm and minimum radius of cam to be 30mm. The axis of cam passes through the axis of cam shaft".* This question is to draw a profile of cam for the said design calculation. The students group solve the numerical and the solved values, cam design is used for developing the proportionate mode. The report of the same is submitted with video and made available here (Bazilali, Ansar, n.d.), (A.) .

*B. Assessment and Evaluations*

These students completed their task of solving numerical and developing working model as well as they have prepared small video showcasing their learnings.

Assessment and evaluation were done with two parts Individual and group evaluation. This evaluation has also a credit as part of one of the assessment tools in the course academics.

The weightage of assessment was given 10% of the total assessment tools used for attainment of the course.

The best tool used for assessment was on the basis of simple rubrics developed by the faculty. This rubric is simple designed with generalized parameters and 60% weightage to group and 40% to Individual.

Table 1: Rubrics for Evaluation

Course Name: Theory of Machine
Evaluation for total 10 Marks

| | **Excellent Level** | **Good Level** | **Average Level** |
|---|---|---|---|
| **Marks out of 60% for performance in a group activity** | (5-6) Report has very good self-explanatory content and is well organized as per given format. | (3-4) Report has very good self-explanatory content. | (1-2) Report is as per defined title. |
| **Marks out of 40% for performance in an oral/ presentation** | (4) Major contribution (Active) in team of micro project work, and intend to answer maximum questions asked by the course in charge. | (2-3) Average contribution in team of micro project work and micro project presentation. | (0-1) Passive in a team with very less contribution in micro project work and presentation. |

On the basis of the rubrics mentioned in the Table 1: Rubrics for Evaluation, assessment was done the most of the groups and individuals could gain maximum marks. Hoverer learning was ensured from the feedback taken through google form taken with designed questions by the faculty on the basis of task performed.

*C. Feedback to ensure learning*

Assessment through the rubrics as well as evaluation through a general feedback was taken to ensure and find the learning and student interest to have such teaching learning method in their such course and academics.

The feedback was taken on google form and students were asked to respond anonymously as well as thy were also asked to give suggestion for improvement.

The questionnaires were as listed below,

1. At the end of this active learning method of learning how was your experience with such numerical course than the numerical course learned in the past semesters. For the options, Excellent, very Good, Good, No any difference.
2. Did you experience learning numerical course with such learning approach in the past? For the options, yes, No.
3. Would you like to recommend such teaching learning for other numerical courses? For the options, highly recommended, recommended, No recommendation.
4. Did you enjoyed the designing and developing models? For the options, yes, No.
5. Was there learning for the numerical solved? For the options, yes, No.
6. How easy did you feel when you were demonstrating the model based on numerical solved. For the options, very easy, Easy, not easy, Hard to learn.
7. Was there any relation between numerical solved and the real field of engineering applications? For the options, yes, No.
8. Is it comfortable for the students for having such learning approach for analytical, Numerical, Calculation based courses? For the options, yes, No.
9. Please write and suggest how this teaching learning method could improve with more in teaching learning processes.

These were feedback surveyed question which could give a student direct survey information and their true responses from their perspective towards implemented teaching learning

method.

*D. Analysis of the feedback questionnaires*

The survey cum feedback form was asked to be filled by the 65 students' class strength of which 51 gave it, feedback to get a response and it was validated with the evaluation, also the suggestion was taken which could improve ourself implementation too.

The response in line with the questionnaires are mentioned in the figures below.

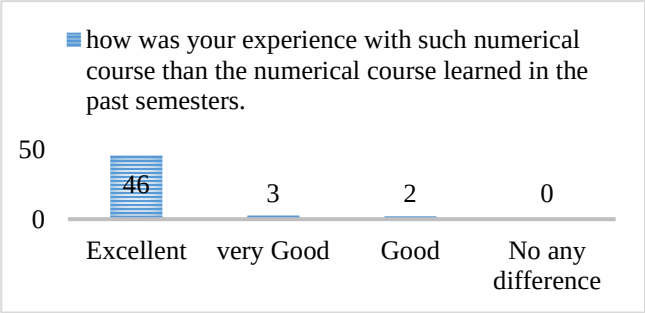


Figure 2 : a) Responses to the Questions

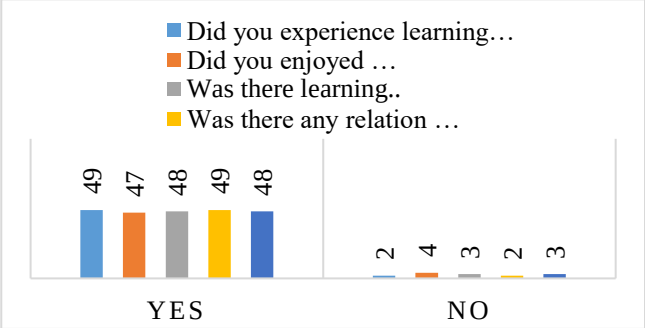


Figure 3 : b) Responses to the Questions

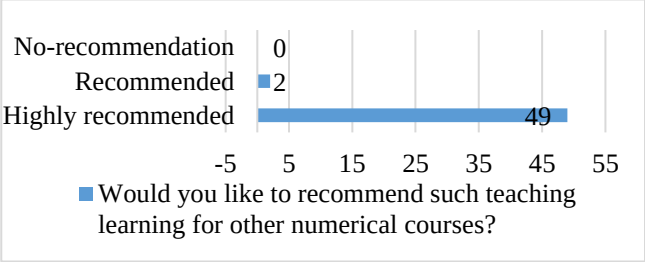


Figure 4 : c) Responses to the Questions

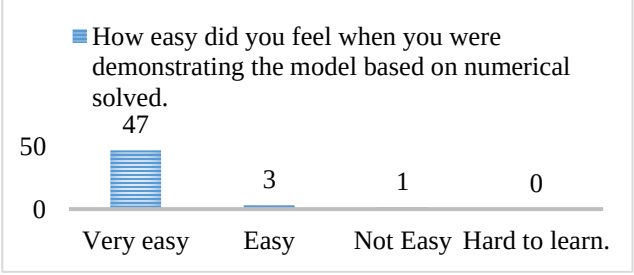


Figure 5 : d) Responses to the Questions

The figure 2 to figure 5 shows the student's responses to the survey questionaries. Figure 2 shows more than 90% excellent response saying that student have not experienced such learning to the numerical courses. Figure 3 is the responses received for the yes-no type question, which shows 95% of positive Yes responding saying students have not experience such teaching learning method, they have enjoyed and are comfortable to have such practices. Figure 4 and Figure 5 shows the students comfort of ease of learning and their recommendation for similar other numerical based calculative courses. Students have given their suggestions in the text form such as,

*"Solving Numerical and preparing model with same gave great experience. We experience many problems while preparing model, Sir helped us. While solving numerical we did not corelate unit and dimension, but it was understood in model preparations. We were given chance to present and make videos of our models, Thank you Sir. Please take similar type of learning to other courses".*

These are above few suggestions and students text replies which found be motivating for such teaching learning processes. The 14 students who did gave the feedback at that time, were addressed, these students required time due to complete the medical COVID 19 reasons. later on, the feedback of these students was taken and the similar responses were observed.

## III. ACKNOWLEDGEMENT

This experiential learning could not be possible without the student's active participation. Authors would like to acknowledge the support and responses provide by the students and the Academics, Best practices in the Rajarambapu Institute of Technology.

## IV. CONCLUSION AND OUTCOME OF THE PEDAGOGY IMPLEMENTED

Learning Numerical Theory to Practical Working Model Approach is implemented as a teaching learning method to facilitate the students' learning and comfort in numerical calculative based courses. In numerical-based courses, the students were interested to have such a learning approach. The rubric-based evaluation provided both individual and group evaluation, as well as stating the overall learning results of the implemented learning method. The students' feedback for this pedagogy active learning was extremely positive since the scaled models could allow students to connect theory with field engineering applications. Models based on numerical calculations are challenging and can give an industry perspective as a solution provider. This learning method can be used with other courses and evaluated to give credit for efforts. The mode of transforming Numerical to the working model or animation can vary according to the courses of various programs. It is up to the instructor to find the best way, the method to transform Numerical as mere calculation to industry experience model development.

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