

AN IMPLEMENTATION OF ACTIVE LEARNING STRATEGIES FOR EFFECTIVE USE OF IN-CLASS HOUR TO ACHIEVE COMPLETE KNOWLEDGE TRANSFER IN AN ENGINEERING COURSE

B. SUNIL KAMATH¹

¹Assistant Professor Gd-III, Department of Information Science & Engineering, NMAM Institute of Technology, Nitte, Karnataka, India -574110

DOI: 10.47750/pnr.2022.13.501.59

Abstract

Active Learning encompasses a much wider scope in teaching than conventionally presumed in current teaching learning scenarios as it has the potential to identify and fuel learning of students at the under graduate level. It includes the ARCS model, effective lecturing, active learning activities, dynamic classroom considering various learning styles, flipped mode of learning, simulations planning, smart board learning, collaborative learning and finally evaluating the outcomes with rubric creation. Each of these is a challenge to understand and implement for teachers nonetheless worth the effort. The paper discusses Implementation of each of these paradigms in greater detail, which helped engineering teachers excel at their work by knowing how to carefully prepare, plan and implement effective lecture sessions using these techniques. The paper holds an optimistic view for active learning when compared to traditional classroom learning which do not involve students in activities in classroom. The implementation details with corresponding results have been discussed.

Keywords: Active Learning, effective lecture, learning styles, collaborative learning, simulation in learning, rubrics for evaluation.

INTRODUCTION

Traditional classroom learning involves teaching in a classroom with students listening to the instructions being given or theorem being explained. Teacher is hardly able to ascertain whether the principles have entered the minds of the students. Students tend to copy down the points in their books or sketch the diagram on board as it is with less of understanding (in haste) and tend to revise or revisit only during the ensuing examinations. Hence there is a lag in terms of lecture and the actual assimilation of the subject. In contrast the active learning strategies proposes a medium of instruction which reduces this lag and speeds up the understanding of the subject within classroom itself.-

The paper is organized into following sections: background, implementation of active learning strategies and conclusion. The topics are organized as the ARCS model, effective lecture, active Learning, dynamic classroom, flipped classroom, simulations, virtual labs and smart boards, collaborative learning and creating rubrics.

BACKGROUND

Desai (2016) "Quality of technical education is not just impart technical knowledge but also to impart diverse set of skills". John (2017) emphasises team learning to face real life problems. Lokare and Varsha (2020) show how collaborative approach has been applied for enhancing the knowledge of the students related to the course by developing application layer protocols in a group. Salimath (2018) conducted sessions to assess team based learning and the results obtained were analysed by applying T-test and chi-square test which showed that it is the better learning method compared to traditional learning methods.

Sirigiri (2015) states early use of computer code and open ended projects strengthens the understanding of analysis and design techniques in the context of engineering analysis and design. Natarajan (2010) does a swot analysis of our contemporary technical education system and indicates the following i.strength identified was funding agencies like AICTE, DST, SERB. Weakness identified was lack of qualified faculty in engineering. Opportunities identified was information technology as a tool for expanding technical education and distance education possibilities for continuing education. Threat perception for information technology related course over other disciplines and improper and ineffective ways of administering the educational policies.

Azzalis (2009) concludes that classroom teaching is passive and non-interactive while active learning allows students to work in group and learn from each other. Alabay (2012) “Traditional teaching is teacher centric with rules set by teacher. It is autocratic in style and students have no voice in classroom management. Students are passive and learning aims are decided by teachers. Students are expected to memorize the knowledge”.Siregar (2018) ”In direct learning, teachers give explanations and narratives to the students verbally, while students listen carefully, and record the principle expressed by the teacher”.

Siregar (2018) “TAI(team assisted individualization) model is a learning model that forms a heterogeneous small group with different backgrounds and ways of thinking to help each other in need”. In TAI, a responsible student guides a weak or clever student. Therefore it can increase student participation in small groups. The learning model of TAI provides better learning achievement compared to direct learning model. Zetty (1992) states after experiencing small cooperative group learning, both the STAD(student teams- achievement divisions) and jigsaw groups reported increased preferences for whole class and individualized instruction and decreased preferences for small cooperative group settings. Qualitative data recorded during the study, however, revealed a change in the teacher's attitude from a preference for lecture/demonstration teaching to the use of the jigsaw cooperative learning method.Harvey (2011) TGT (team games tournament) also improves the collaborative work among participants and builds team spirit.

THE IMPLEMENTATION OF ACTIVE LEARNING STRATEGIES

In this section we are going to discuss some of the ways the approaches mentioned so far have been implemented. The details of planning and execution are listed out to help teachers familiarize with these approaches. Courses and topics for sample class are from computer science domain. Again topics are discussed in the order listed in introduction.

THE ARCS MODEL

Keller (1987) states planning for ARCS model of class needs to be done first by drawing up a lesson plan and then sharing with students. We discuss the ARCS model for computer networks course under computer science domain. The computer networks has the following course outcomes

1. Explain the Frame formats and addressing schemes of different protocols of data link layer.
2. Apply the basic algorithms to route the packets using network layer algorithms.
3. Experiment with the concepts of IP addressing and congestion control.
4. Explain the concept of internet control and transport layer protocols.
5. Identify the working of RPC, RTCP, RTP and other transport layer protocols.

To achieve this objective, a thorough preparation as per the ARCS model is done as given in table I.

Table I: A UG course (Computer networks) introductory preparation involving ARCS model

ARCS components	Implementation strategies
Attention	Computer networks is a field that involves knowing communication between hosts via routers, switches and hubs. Hence knowing the fundamentals of it helps one understand the details of any digital communication intricately. The applications of computer network involves home, business, mobile and copyright applications. These things were told in the very first class along with course objectives to drive the attention of students.
Relevance	Subject’s relevance was also briefed to students like in R&D, in understanding many of higher communication networks, clearing competitive exams, industry relevant project planning and understanding modern devices and communications.
Confidence	All classes werebacked by quizzes, viva, assessment and feedback to ensure the student interest in the subject were kept alive and they were made to work in small groups so as to assimilate the content with ease.
Satisfaction	Proper evaluation of quiz and tests with rubrics to give full marks for right answers and 50% marks for partial answers(not dissuading wrong answers but correcting them) has lead to great learning experiences for students.

EFFECTIVE LECTURE

To conduct an effective lecture, we had identified a topic of moderate complexity which is known to be difficult for students in past. Such topics only need to be dealt under effective lecture as teachers can preplan the solutions to these difficulties and problems. The topic for effective lecturewascontext free grammar (An introduction) under the course finite automata in computer science domain. The topiclevel outcomeswere

1. Underst and the context free grammars.
2. Understand the concept of substitution rule.
3. Illustrate derivation of a terminal string from a grammar
4. Familiarize with a few well known grammars

The table II summarizes the preparation for the class with time line for completing the session. The first session briefed them about the foundations of grammar. The second session had an activity- think pair and share i.e. students were given a problem and given two minutes to think about the solution and then next two minutes they were sharing their solutions with their neighbors and finally once a solution is reached by a group, they were asked to present before the class.

Table II: Effective lecture implementation with two short sessions and an activity in between.

Items	Implementation Strategies	Time Allotted : 35 min
Justification for selection of topic	Students were briefed as follows: Context free grammar is the very basic of many systems like compilers, assembler design. If this topic is not understood then students fail to recognize proper syntax in computer language programs which is essential to develop a compiler or an assembler.	5min
How do you propose to open the lecture?	The following discussion happened in class. Concept of CFG (C-for context, Free-less Grammar-Rules) was explained. The importance of CFG i.e. it forms the core of designing the recursive descent parser (syntax checker of many high level language constructs/ programming constructs like if-else structure or variable declaration) was explained with an example grammar. stmt \rightarrow if (condition) stmt else stmt id=const ; condition \rightarrow id > id const \rightarrow 0 id \rightarrow a b Input: if(a > b) a=0; else b=0 ;	5min
Description of key points / Concepts to be covered in Segment – 1	The following points were disseminated in class 1. Introduction to re-write systems involves simple replacement of right hand side of rule set by its left hand side in the string. 2. Simple rewrite(R: Rule set, w: input string) Rule set: S \rightarrow ABC A \rightarrow aAB \rightarrow bB C \rightarrow cC Rewrite: aaAbBcC \Rightarrow aAbBcC \Rightarrow AbBcC \Rightarrow ABcC \Rightarrow ABC \Rightarrow S 3. Derivation (Top- Down) : S \Rightarrow if(condition) stmt else stmt \Rightarrow if(id > id) stmt else stmt \Rightarrow if(a > id) stmt else stmt \Rightarrow if(a > b) stmt else stmt \Rightarrow if(a > b) id=const; else stmt \Rightarrow if(a > b) a=const; else stmt \Rightarrow if(a > b) a=0; else stmt \Rightarrow if(a > b) a=0 else id=const; \Rightarrow if(a > b) a=0 else b=const ; \Rightarrow if(a > b) a=0 else b=0 ; 4. Grammar- Grammar formalism G (V, T, S, P) where V is Variable, T is Terminal , S Start symbol and P is production	10min
A short activity for engaging the students	Think-pair-share: Hetika (2018) Students were given 2 minutes to think 2 minutes to share and a minute to present. For a sample grammar shown earlier, show the derivation of a string shown below which demonstrates recursive derivation: If(a > b) if(a > c) a=0; else c=0; else if(b > c) b=0; else c=0; (explained the strategy and expected outcomes)	5 min

Description of the key points/concepts to be covered in Segment – 2	Second session involved discussion of CFG formal structure and sample grammars under it. Context free grammar- only single non-terminals allowed in left hand side in the production or rule set. i.e. $A \rightarrow aA$ is ok while $AB \rightarrow aA$ is not. 1. Formal structure $G(V,T,S,P)$ 2. Balanced parentheses grammar $B \rightarrow (B) BB ()$ 3. Even-lengthed palindrome $S \rightarrow aSa bSb \epsilon$ 4. $a^n b^n$ language $S \rightarrow aSb \epsilon$ These topics were continuation of the topics in session 1 and hence could be more easily understood by students.	10min
How do you propose to close the lecture?	So lecture concluded with concise summary of learning as follows: You have learnt about grammars, the formalism, how to derive a string from start symbol. These form the basis of compiler constructs like assignment or control/looping statements. As a supplement, you may work out derivations of a few sample strings for few different CFG's like expression grammar or variable declaration grammar.	5min

The final outcome of the entire session was encouraging. Many students had familiarized themselves with context free grammar and were interested in post classroom work on it.

ACTIVE LEARNING ACTIVITIES

These are many active learning approaches like think pair share or brainstorming or team games tournament or jigsaw which can be chosen for a session. This section looks at how jigsaw can be applied to learn the topic of mass storage and disk structures under the course operating systems in the computer science domain as per the cult of pedagogy (2015). The table III summarizes the conduction of jigsaw activity.

Table III: Jigsaw applied to a computer science class on operating systems

Items	Implementation Strategies	Time Allotted 35 min
The name of the course	Operating system	
The topic for which the activities are designed	Mass storage structures, disk Structures, disk scheduling	
The activity jigsaw	Jigsaw In class, team work was tested for the above topics. There were 55 students who were clubbed to form 18 teams of 3 members (this took 5 minutes). Six groups noted mass storage structure, six groups' disk structure and remaining six group's disk scheduling for 10 minutes. and then the mixed groups were formed (every team having one member each from mass storage structures, disk structures and disk scheduling) and were allowed to discuss inter-topic for 5 minutes and then again they were rearranged by topic for final discussion topic wise to have the clear understanding of all three topics, to discuss actual information collected on each topic and to clear misconceptions across topics for 5 minutes and then one person from each group who was a reporter spoke out the actual digest of matter discussed – total 10 minutes.	35min 5+10+5+ 5+10
What questions were asked to the students at the end?	1. What is seek time, rotational latency, access time, transfer time? 2. Distinguish storage area network (SAN) from Network attached storage (NAS)? 3. What does disk scheduling mean? 4. What are the various techniques of disk scheduling?	10min

Details of implementation – group size, discussion timing, how to choose the reporter (person who will take notes and present if asked), how the responses were shared with the class etc.	Group size was decided as 3 and numbers 1,2,3 was called out by students(each one remembering their number).1- represented mass storage structure, 2- disk structure, 3-disk scheduling. Initially students of group 1,2,3 collected points about their topic from slides displayed in split screen mode, memorized those topics after watching a video for 10 minutes then formed mixed groups with one member from each topic 1,2 and 3 and discussed inter-topic i.e. between mass storage structure, disk structure and disk scheduling for 5 minutes and then they assembled back in their seats topic-wise i.e. all 1's together and soon and they related to each other topic specific findings and a reporter in each group wrote down points discussed for 5 minutes and reporters of each group spoke when prompted in concluding 10 minutes. Only enthusiastic participants were asked to present their findings in class the response of this activity and unique points from each group was collected and listed on board.	35 minutes 5+10+5+5+10
The time allotted for the activity	Team formation 5 minutes, 1's only, 2's only, 3's only group observation and discussion- 10 minutes 1-2-3 mixed group formation and discussion- 5 minutes, reassemble back and form 1's only, 2's only, 3's only group and revisit the topics -5 minutes speak out the findings (a reporter from each group) and observer summarizes- 10 minutes	35 minutes 5+10+5+5+10
Pre-implementation reflection: (What you thought would work well and what challenges did you anticipate? How would you address those challenges during the class?)	This grouping should work well If they feel lazy/lethargic to discussion then display the videos with sound Or If there are less number of students then smaller number of teams can be formed for faster discussion Challenges here would be if the students fail to understand disk structure then we plan to give hint to those teams silently so it won't affect other team's progress. Second challenge is if they don't understand the total head movements per request technique, plan to give a simpler sequence of disk requests to improve understanding.	
Post-implementation reflection: (reflect on what worked well for the given activities. What were the challenges? How will you improve each activity for next time?)	The students were participating in groups and understood the basics very well. Students keenly took down points from the video. I plan to improve next time by asking students to voluntarily accept invite and form groups and have them understand and read out rather than the entire class.	

DYNAMIC CLASSROOM CONSIDERING THE LEARNING STYLES

The classroom experience can be made pleasurable by identifying the learning styles of various students in advance and tailoring the content preparation to suit it. Some may be passive sequential learners while other active and global. Although all the traits of students cannot be accommodated in a class preparation, still one style may be chosen depending upon majority and tested. Some of the do's and don'ts of each style are given. Some of the observations about learning styles are as follows

- i. Learning styles vary with subject.
- ii. Learning styles may change over a period of time and need to be ascertained again at intervals
- iii. Learning styles may not be the same across the subjects for a student

Table IV: Some suggestions followed for carrying out the teaching using the different learning styles

<p>ive Learning style</p> <ul style="list-style-type: none"> • Proper preparation before the class • If architectural diagrams/some known easier problems was given in class to solve, it enthused the students. 	<p>ive Learning style</p> <ul style="list-style-type: none"> • Gave simpler versions of a problem or defined the problems in advance before the lab to allow students to understand the programming well.
--	--

<ul style="list-style-type: none"> Allowed some time in class after 15 min (pause) for students to reflect on topic Only drawing or writing on board was time consuming. Hence prepared the slides in advance and shared Did board work whenever necessary Used sound amplifiers when needed if two or more classes need to be engaged in a day Gave ample tasks from outside text book helped students familiarize with variety of problems Used flip classroom to bring teaching closer to students 	<ul style="list-style-type: none"> Allowed the students to work out the problem on board/ asked them to work out and answer in class. Discussed only one category of problem per week
<p>Sensing Learning style</p> <ul style="list-style-type: none"> Like the 1st year under graduate Laboratories (chemistry involving acid/base/alkaline Ph.-measurement or physics involving prism, light and interference, resistor etc. or workshop involving welding, wood work, metal cutting, boilers and furnaces, lathe operations) can be considered under sensing styles Proper instruction was given before the experiment with regard to the method of conduction, observations and results tabulation scheme (physics laboratory). Potential hazard of sipping a liquid/ inhaling a gas was told in advance(chemistry laboratory) Standard procedure for demarking, cutting, filing and fitting was told in advance(mechanical workshop) 	<p>Active Learning style</p> <ul style="list-style-type: none"> Needed preparation of study material accordingly. Some of the below mentioned things were considered in the process. Give problems having two or three methods of solving and noted which one students choose. Disassemble a toy and ask them to assemble it back again. Collect a few games based on size /shapes/ gravity etc.
<p>Sequential Learning style</p> <ul style="list-style-type: none"> Learn the basics first, then programming and then attempt projects. Topics in syllabus were also arranged sequentially(like in operating system course files, types, attributes, operations and soon) Helped them relate any new topic to the existing ones (since they knew unix relate it to operating system topics or since they knew context free grammar then relate it to compiler design etc.) 	<p>Global Learning Style</p> <ul style="list-style-type: none"> In this style, staff was prepared in advance and complete knowledge of the subject was a must. Gave learning materials/pamphlets/ questionnaire that showed the big picture Gave topics for self-study in advance Motivated students by asking questions on topics from different angles

After following these steps in courses like operating system in computer science domain, students achieved the following course outcomes.

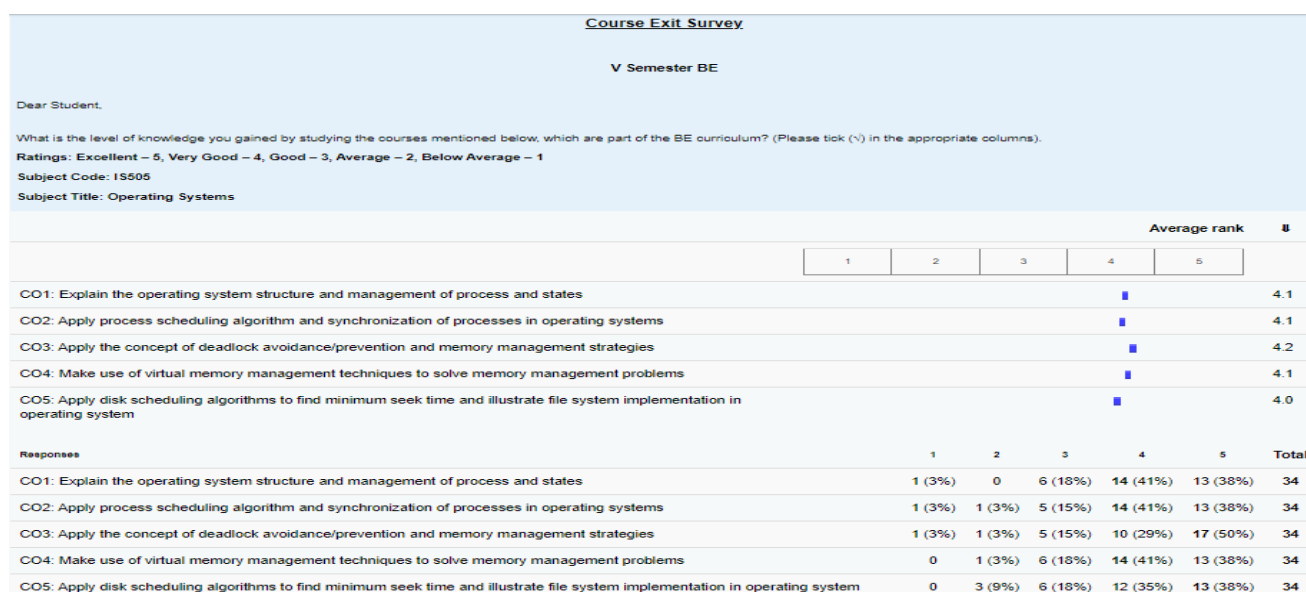


Figure I: An attainment of course outcomes achieved for operating system assessed with a course exit survey

FLIPPED CLASSROOM

Common sense education (2016) states flipped classroom allows the students to spend more time to interact with faculty in class. Still the challenge remains if the students volunteer for home preparation, but if teachers persist with flipped mode for a few sessions, they may entuse the students to learn by online videos and kindle some interest in the subject.

Table V: Some suggestions followed for effective flipped classrooms given by subject experts

- Curate not create content already available on internet. For bright students its self-study.
- It's also about learning experience of student's i.e. have the students interact with the learning content
- It could be a 2 minute video which pauses at 30 sec and a question pops up to know if the user is really watching or who is watching and then again a question at 1 min and soon. This greatly enhances the learning of students
- If it is not a video then a work sheet then a video then a worksheet and soon may be presented
- Learning content is effective when it is prepared by the teacher.
- Active time for any video lecture may be 20 minutes with 3 minutes self-check quiz and have some classroom assignments (programming in random pairs)
 - 15 minute video classification followed by 45 minute discussions.
 - Don't conduct all the sessions in a week in the flipped mode (just one or two)
 - Persist with flipped classroom (for two or three sessions) resistance to change if any will subside.
 - Like in online flipped session, give them some time to report learnings (at least a day) so they can plan their data (mobile data) usage.
 - Don't conduct flipped sessions for very cutting edge or volatile courses which tend to change with paradigm shift in technology.
- Share the lesson plan with students in advance

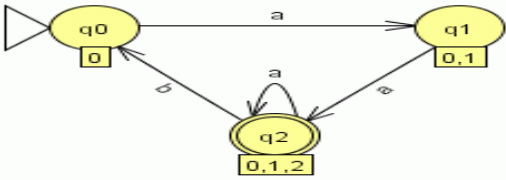
The above suggestions have led to great results as faculty achieved a better response from students in class during the tasks, intervening examinations and finally a good overall feedback from students.

SIMULATIONS USING VIRTUAL LABS/SMART BOARDS

Simulations help the students in understanding a physical or electrical phenomena by designing circuits and testing it without an actual circuit. Hence they have found a place in many of the laboratory experiments in undergraduate level. These is no risk of equipment failure or fault in case of erroneous design and itlets students conduct experiment on system rather than on physical boards (Example VHDL using Xilinx software [24] lets you design logic circuits at undergraduate level). The preparation of such software's by hardware vendors is common. The table VIIists one such simulation tooljflapused to simulate finite automata and help with the automata related problems.

Table VI: Depicts the use of simulator tool to design finite automata and simplify it

Topic chosen for activity	<p>Automata</p> <ul style="list-style-type: none"> • Design a non-deterministic automata graphically with any simulator tool • Convert it to Deterministic model • Minimize the above deterministic model • Convert it to regular expression • Write a grammar for a minimized DFA
Topic learning outcomes	Understand NFA and DFA along with its equivalence to regular expressions and grammar
<p>Regular languages - create</p> <ol style="list-style-type: none"> i. Deterministic Finite Automata ii. Non deterministic Finite Automata iii. Regular grammar iv. Regular expression 	<p>Such diagrams can be easily created with drag and drop UI.</p>

<p>Regular languages - conversions</p> <ul style="list-style-type: none"> i. NFA -> DFA -> Minimal DFA ii. NFA <-> regular expression iii. NFA <-> regular grammar 	 <p>Conversions(NFA to DFA) can be initiated with a button</p>
<p>Justification for choosing this topic</p>	<p>Availability of simulating tool which lets you draw the transition diagram and label all edges.</p>
<p>Link of the simulation/virtual lab used as perRodger (2009)</p>	<p>www.jflap.org</p>

The simulator tool helped the students solve complex problems and hence boosted their confidence in the subject. It also helped instructors to write solution manuals for certain problems.

COLLABORATIVE LEARNING

Jigsaw technique: In class two different topics namely TCP and UDP in computer networks domain were given and students were evaluated in the following way. First students (two in each desk) were asked to call out numbers one and two. The whole class was divided this way into two halves one and two. Then the two topic slides were displayed separately on projector for five minutes (split screen mode) then on request for a minute extra. The students noted down their respective topics, the frame format and details. Then the one group students were moved with two group students to form mixed group. Another five minutes were given to discuss each other's topic and clarify the doubts amongst themselves and then they were asked to return back to their original group.

Now they were quizzed with a few questions like distinguish between TCP and UDP and sketch the frame format of TCP and UDP. In answer to the first question ,a response of 14 differences were received one each from each group and two students were called on board to write the frame formats and they wrote correctly and answered the queries satisfactorily and every one contributed with the answers. Students appreciated the activity that let them involve with neighbouring students in the class and they had the opinion that they understood better when taught this way.

CREATING RUBRICS

Chowdhury (2018) states designing a rubrics is an important part of introducing a new learning style as a new experiment needs evaluation and assessment to be acceptable. It helps fix the expectations of the students and allows teachers to evaluate them fairly. This may greatly motivate the student to further pursue the studies and generate interest in the subject. Rubrics can be created for oral presentation or group activity or research or communication skills or self-evaluation.

Table VII: Sample rubrics for a technical seminar or presentation [20][21].

Dodge (2001) and Wilson (2006) describe rubric writing and assessment instrument	Sophisticated (3 points each)	Competent (2 points each)	Not Yet Competent (1 point each)
Research			
Quality (e.g. use of varied sources, evaluated and validated sources, accuracy of information)	Information is accurate; resources are legitimate; resources are varied enough to cover a large set.	Information is mostly accurate with only a few minor errors; one resource may be questionable; resources good but not varied enough	Information is unreliable and/or inaccurate; resources are not varied
Broad spectrum of information] (e.g. on political, economic, social, historical and geographical dimensions)	Includes all five dimensions	Includes four of the five dimensions	Includes three or less dimensions

Content of Presentation			
Substantive use of information	Explanations of dimensions are complete and helpful and indicate how the dimensions interact with each other; draw conclusions, make connections and inferences	Explanations aren't quite as complete or helpful but there is an indication of interaction among dimensions; draw some conclusions and make some inferences but miss obvious ones	Incomplete and/or not helpful explanations with little or no indication of interaction among dimensions; presents others' information without analysis (e.g. drawing, conclusions, making comparisons, connections and inferences)
Effective slides (e.g. coherent, logical progression, well organized, include main points not details, "tell a story")	Slides clearly aid the speaker in telling a coherent story	For the most part slides are helpful in telling the story with only a few glaring problems	Slides interfere with the story
Communication			
Clarity	Presentation is coherent, with clear introduction, transitions, language use, and conclusion; speaker demonstrates intimate knowledge of the subject responds well to questions	Presentation is coherent for the most part, but missing 1 or 2 important elements. Does partly answer the questions	Presentation lacks coherence and misses the central theme. Does not answer questions posed
Style	Presentation is polished, speaker uses sentences, enunciates well, is fluent in the delivery, maintains an effective pace and eye contact, doesn't run over allotted time	Presentation is polished, for the most part, and fluent in most part and maintains a pace good enough to maintain the allotted time.	Presentation is coarse and sentences are spoken discontinuously and does not convey the theme of presentation and runs out of time
Self-Evaluation			
Analysis of group process and individual role within it	Clearly articulates what worked well and why, what did not work well and why, and ways to increase effectiveness and efficiency of group process in the future, considering self as well as others	Discusses only two of the three; discusses group without discussing self; discusses self without discussing group	Does not articulate any of the three – what worked well and why, what didn't work well and why, how to improve

CONCLUSION

Clearly the active learning strategies mentioned in the paper enhanced the students as well as teachers alike as clear planning, documentation and execution is involved in these approaches. It made teaching students in engineering courses look a lot easier. The eight active learning approaches showcased improved the student interactions in class and have improved off class learning. The active learning strategies showcased namely effective lecture, different learning styles, flipped classroom, simulations with virtual labs/smart board, collaborative learning and creating rubrics have yielded encouraging results with pass percentage of 98% in semester wise results in an engineering course. It has led to effective implementation of learning methodologies in engineering education. As a future enhancement, we would do precise measurements of learning (in terms of

scores) with figures showing improvements in interest and understanding with implementation in lecture sessions of engineering courses.

ACKNOWLEDGEMENTS

Author is grateful to NMAM Institute of Technology, Nitte University, for providing financial assistance to carry out this research work.

REFERENCES

- [1] Desai, T. S., & Kulkarni, P. P. (2016). Cooperative Learning' tool for optimizing outcomes of engineering education. *Journal of Engineering Education Transformations*, 30(Special Issue).
- [2] Manohar, S. J. (2017). Team Learning' as an Innovative Pedagogical Tool: A Study among 'EE Generation'in Bangalore. *Journal of Engineering Education Transformations*, 30(Special Issue).
- [3] Lokare, V. T., Jhetam, M. I., & Netak, A. K. D. L. (2020). A Blended Approach for Teaching Laboratory Course: Internet Technology. *Journal of Engineering Education Transformations*, 34(1), 41-51.
- [4] Salimath, S., Vijayalakshmi, M., Shettar, A., S., (2018 January) A Comparative Study of Team Based Learning and Individual Learning. *Journal of Engineering Education Transformations*, ISSN 2394-1707
- [5] Sirigiri, M., & Rajan, S. D. (2015). A Flipped Classroom Approach to Teaching Engineering Mechanics Courses. *Journal of Engineering Education Transformations*, 28(4), 109-113.
- [6] Vinodhin, H., Fusic, J., & Bhagyalakshmi, P. (2021). A Smart Board Approach in Teaching Engineering Mathematics Course. *Journal of Engineering Education Transformations*, 34, 271-276.
- [7] Natarajan, R. (2010). 2. A SWOT ANALYSIS OF OUR CONTEMPORARY TECHNICAL EDUCATION SYSTEM. *The Journal of Engineering*.
- [8] Siregar, I. I., & Slamet, I. (2018, November). Team Assisted Individualization (TAI) in Mathematics Learning Viewed from Multiple Intelligences. In *Journal of Physics: Conference Series* (Vol. 1108, No. 1, p. 012073). IOP Publishing.
- [9] Zetty, N. (1992). A comparison of the STAD and Jigsaw cooperative learning methods in a college-level microcomputer applications course. *West Virginia University*.
- [10] Azzalis, L., Sato, S., de Mattos, M., Fonseca, F., & Giavarotti, L. (2009). Active learning versus traditional teaching. *Journal of Biochemistry Education*, 7(2), 415-436.
- [11] Alabay, E., Zorba, M. (2012) Teaching English to Young Learners: An Activity- based Guide for Prospective Teachers / Classroom Management
- [12] Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of instructional development*, 10(3), 2-10.
- [13] Keller, J. M. (2000). How to integrate learner motivation planning into lesson planning: The ARCS model approach. VII Semanario, Santiago, Cuba, 1, 13.
- [14] Hetika, H., Farida, I., Priatnasari, Y. (2018) Think Pair Share (TPS) as Method to Improve Student's Learning Motivation and Learning Achievement. In *Dinamika Pendidikan* vol. 12 10.15294/dp.v12i2.13561
- [15] Chowdhury, F. (2019). Application of rubrics in the classroom: A vital tool for improvement in assessment, feedback and learning. *International Education Studies*, 12(1), 61-68.
- [16] The Cult of pedagogy (2015) The Jigsaw method <https://www.youtube.com/watch?v=euhtXUGBEts>
- [17] Stephen Harvey (2011) Team Game Tournament <https://www.youtube.com/watch?v=ZDJhNULQNIA>
- [18] Susan H. Rodger (2009) JFLAP Version 7.1 <https://www.jflap.org/>
- [19] Common sense education (2016) what is flipped learning https://www.youtube.com/watch?v=Ot_dKs_LRf0
- [20] <https://www.cmu.edu/teaching/resources/Teaching/CourseDesign/Assessment-Grading/Rubrics/HistoryGradingRubric.doc>
- [21] <https://www.niu.edu/citl/resources/guides/instructional-guide/rubrics-for-assessment.shtml>
- [22] Dodge, B. (2001). Creating a rubric on a given task. <http://webquest.sdsu.edu/rubrics/ rubrics.html>
- [23] Wilson, M. (2006). Rethinking rubrics in writing assessment. Portsmouth, NH: Heinemann.
- [24] [https://www.xilinx.com/\(2022\)](https://www.xilinx.com/(2022))