Engaging Students Actively for Effective Teaching-Learning

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Abstract: Due to the current pandemic situation all across the world, the education sector is undergoing a transformation. Engineering education is changing its face, too, as it is the need of the hour to impart knowledge and skills remotely to the students. At our Institute, we had not attempted the online teaching-learning methodology before the pandemic because students daily travelled to the Institute, and the need did not arise. Currently, we have adapted to MS Teams as our online platform for the conduction of classes and software laboratories.

The major challenge in online teaching is to engage the students actively and ensure that learning is happening. Active learning is defined as "educational methods in which students are involved in higher-order thinking (analysis, synthesis, evaluation)." This work is a report on the methodologies adopted by the authors in the ongoing semester, involving some of the well-documented active learning strategies for two undergraduate courses in Mumbai University curriculum.

The paper describes the adopted teaching methodologies with statistics collected during the ongoing semester and summarizes the outcomes of these experiments in terms of students' "Learning Coefficient (LC)" in the undertaken courses based on the feedback collected by the course coordinators. Learning Coefficient is a number between 0 to 1 where 0 indicates non-interactive sessions and 1 indicates the highly interactive and highest level of learning. In this paper, we report a learning coefficient of 0.7 for one course and 0.64 for the other course through active learning techniques. These coefficients are indicative of "learning happening".

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1. Introduction

Most of the content of this section is the authors' interpretation from their experience, clubbed with some important points retained through the general articles they have come across. "Metacognition" – the process in which a learner thinks about his/her learning is an important step in establishing link between activity and learning. It is an essential step for students to learn and teachers need a feedback on that, to complete the teaching-learning loop. Most of the times, the teaching methodology adopted by Technical teaching fraternity is "inductive" (meaning the traditional lecturing method). As the Internet age prevails, the student fraternity gets a glimpse of various resources to understand many concepts on their own. Due to plenty of resources available, that too most of it as capsules of short videos stuffed with lot of visual information, the attention spans of students in long lectures are on the downside, but at the same time their grasp and their zest to learn through "doing" something is on the rise. This very fact makes it essential to apply activity-based learning in students. "Active learning" is classically defined as activities that students do, to construct knowledge and understanding. The form of activities may differ, but this kind of learning has the objective of instilling higher order thinking in the students.

According to the National Survey of Student Engagement (NSSE) and the Australasian Survey of Student Engagement (AUSSE) model, activities for active learning are: working with other students on projects during class; making a presentation; asking questions or contributing to discussions; participating in a community-based project as part of a course; working with other students outside the class on assignments; discussing ideas from a course with others outside of class; tutoring peers.

The importance of active learning has been established by many theorists like Bransford et.al. As per these theories, learners either enhance their learning or learn to overcome misconceptions through active learning which gives the learner opportunities to connect with new ideas/experiences. Learners absorb new ideas in the existing framework or change their current mental model to replace misconceptions, when actively engaged.

The objective of this paper is to share the experiences of the authors in engaging their pre-final and final year engineering students in the course-matter using active learning techniques, quantify this experience through different tools and present a conclusion based upon these results about effectiveness of the methods that the authors adapted. The University of Mumbai curriculum is carried out in a bi-semester pattern spanned over an academic year, and student completes engineering in eight semesters. The activities

reported are all "online" because they have been carried out during the "pandemic semester" that is July 2020 to November 2020.

The paper is organized as follows. Section 1 gives the introduction. Section 2 is about the related work. In section 3 we describe the methodology adapted for achieving the stated objectives. The results quantified are discussed in section 4. Lastly, we conclude in section 5.

2. Related Work

In [1], the authors have studied the impact of active learning in seventeen universities in Asia and Europe. The paper introduces to new a digital active learning platform that acts as a repository of different active learning activities. This repository also introduces services for educators and students, including the structuring and publishing of learning challenges that deploy digital tools in the forms of simulations, serious games, or applications. After implementation of this repository, primary finding suggests high student engagement and hands on experience building.

Authors has carried out a case study on active learning implementation for one of the undergraduate courses and academic performance is compared with the feedback [2]. The authors have concluded that the top-two learning methodologies are project-based learning and conference publication. They also concluded Active Learning Methodologies to be one of the motivating factors to enhance the project-based learning among engineering students.

In [3], authors point out that implementing different active learning strategies may not necessarily improve student's learning. It depends on a multitude of factors, including question and activity design, faculty prompts, student incentives for participation, and group dynamics. Author discusses the ICAP (Interactive, Constructive, Active, Passive) framework for student engagement and how it manifests in various active learning formats.

In [4], authors share two active learning strategies viz. Case study based Active Review Sessions and Skillathon, which are guided with some definite suitability to address the prior discrepancy of course attainments and improve its outcome. The implementation of these activities concluded that case study-based reviewing aspect provides a 360-degree angle of overall class across the given assignments where as Skillathon has concretely methodized to impart a wholesome view of entire syllabi while tracking the relation of concept with a unique answer.

The authors in [5], conduct a survey in the form of interviews and through online forms to test effectiveness of various strategies. The results indicate that with better learners' engagement the learning is more effective. The challenges mentioned by authors during the implementation as mentioned, is to keep the students motivated throughout the course.

In [6], author discusses the use of "kahoot" as assessment tool in undergraduate engineering education. Authors have explained the detail procedure about creating kahoot quiz from the teacher's point of view as well as from the student's point of view. The effectiveness of this technique is stated to be found out by taking feedback survey from the student. Authors have also shown statistical result of kahoot by plotting the histogram for different questions asked in the survey. One important observation mentioned by authors that ten seconds could serve as the optimum time limit for answering questions compared to 20 sec used in the quiz, as it forces the students to race amongst each other to get the right answer first and reduces the scope of any help obtained through internet or peer.

Shelke et al propose the method of open-ended quiz [7] to motivate students' creativity and to guide students to think deeply about the material covered in lectures. The goal of presented work is to make students think about what other information may be needed and how they might go about obtaining the needed information, when they are asked to solve problems that do not specify all the information. Students' performance in pre-test post-test showed that open-end quiz strategy had improved their problem solving and critical thinking skill.

S. A. Soundattikar et all points out that students possess different learning styles and suggests that accordingly teaching methods should also vary [8]. The paper deals with the learning styles and five innovative teaching methods like Project including poster design and presentation, Group discussion, Photograph or Diagram or Graph, Survey and Questionnaire, Seminar designed on the basis of Bloom's Taxonomy. The effectiveness of these selected innovative teaching methods is then evaluated on the basis of knowledge, comprehension, application, analysis, synthesis and evaluation i.e. domains of Bloom's Taxonomy. Results conclude that students found project method most effective as almost all learning styles of students can be handled with this method and they can gain learning experience in all the domains of Bloom's Taxonomy whereas seminar was least rated by students.

In [9], the authors implement Activity Based Teaching Learning (ABTL) to overcome the limitations of traditional mode of course delivery. In this paper, authors have assessed effectiveness of these activities through academic performance of the students. It is stated to be observed that ABTL is an effective method for improving the academic performance as well as bridging the gap between the theoretical concepts and real time scenarios.

Thus, the literature survey spans different settings and tools, but we observe that there are very few papers on active learning with online methodology. Therefore, the contribution of this work is in strengthening the belief in active learning irrespective of online teaching-learning.

3. Set Up and Methodology

During the pandemic situation, we were required to deliver lectures through the online teaching mode. Since, all of us were very new to this mode of teaching-learning, it was very natural to become sceptical about the effectiveness of content delivery and understanding of students. That lead us to dig for various methods to engage students actively even in online mode, so that learning happens. In this paper we consider Theory and Laboratory courses in "Neural Networks & Fuzzy Logic (NNFL)", (semester VII) and "Data Compression & Encryption (DCE) (semester V) for

the Electronics & Telecommunication branch at our Institute. The theory and laboratory courses are considered together because learning of theory is re-enforced in laboratory, at least it is expected that way. In the framework provided by the University, we state our course objectives and most of them are about students being able to demonstrate their understanding and skill-set. Tools for achieving these objectives are identified at the beginning of the semester. In order to facilitate active learning, the following activities were carried out in the stated courses.

1. The "pause-think-share" tactic
2. Self-paced learning and informal writing
3. Online class notebook problem solving
4. Online meeting room discussions
5. Setting up experiments on recently taught concepts in theory
6. Interactive quizzes
7. Time bound active quizzes on LMS
8. Presenting group seminars on some topics in syllabus as well as some beyond the content of syllabus
9. Simple random questioning method

A. Description of activities in the NNFL course:

This course is for the final year engineering students in the seventh semester. These students typically have seasoned learning styles, are adaptable to lecturer's teaching style, are quite mature in their behaviour (even online) and are eager to enhance their skill set hence co-operative (this is qualitative observation of the Instructor, from experience). This is a departmental elective course and out of 87 students on roll, 56 have opted for this course. The activities are planned in such a manner that around 60% of the subject matter is taught in active learning mode. Most of the activities are solo, some are in small groups and others in bigger groups. Quizzes are conducted on the topics that are learnt actively and quiz scores are recorded. A survey is conducted after two months, to understand students' opinions about active learning and "Learning Scores" are calculated which are indicative of "how much learning really happened in the class?". We describe the methods in detail in the following paragraphs.

I. The "pause-think-share" tactic

Taking pause in the lecture after every 10 to 12 minutes and asking students to summarize in the meeting chat or verbally. Introspecting on the concept taught, over short intervals compels students to analyse the content, encouraging them to discuss/ask questions boosts their confidence and sharing what they have understood enhances their technical communication skill. Besides, it resets their attention span for the next concept. There is no documentation maintained, but the lecture meeting recordings are available on MS Streams.

II. Self-paced learning and informal writing

In this method, students were provided the link for a video on the topic "Gradient Descent Algorithm" and they were asked to submit summary of the learning from the video in limited number of words. The objective of this activity was to judge student's listening skills, grasping and technical expression. The video is by Prof. Somnath Chatterjee from IIT Kharagpur and is not very trivial to understand. One has to invest some good time and thinking to understand the algorithm. Figure 1 is a screenshot of the Teams assignment.

Assignment_2 Immersive Reader

AY 2020-2021

Assignment 2 (CO-1)

Topic: Gradient Descent Method

Method: Video Lecture Summary **Date August 11, 2020**

Objective: To test listening skills, grasping and summarizing skills.

Resource: NPTEL Lecture by Prof. Sengupta, IIT Kharagpur

Available at https://nptel.ac.in/courses/117/105/117105084/ (NPTEL Link, Lecture 3)

https://youtu.be/KshIEHQn5ZM (YouTube Link)

check that you are watching the "gradient descent algorithm Lecture"

Task: Carefully watch the video lecture. Summarize gradient descent algorithm and its intricacies as explained by Prof. Sengupta and submit.

Addressing Bloom's levels 1 to 4.

Rubric:

Summary is to the point	Summary covers the video lecture	Explanation of the algorithm

Figure 1 Screenshot of self-paced video lecture assignment

III. On-line class-notebook problem solving

In this activity, MS Teams platform which our Institute has chosen for online teaching learning mode has been used. There is a feature of class-notebook in MS Teams, in which the Instructor can set a classwork and assign to student, individually or group-wise for solving problems or answering questions. Students were given a small exercise to identify different neural networks, they wrote the answers in their individual notebook and Instructor could see each one of them, for evaluating. This method is just like "taking a round in a digital classroom" and not rigorously evaluated. If anyone is found doing mistakes, s/he is corrected then and there. Figure 2 is a screenshot of the notebook of a particular student.

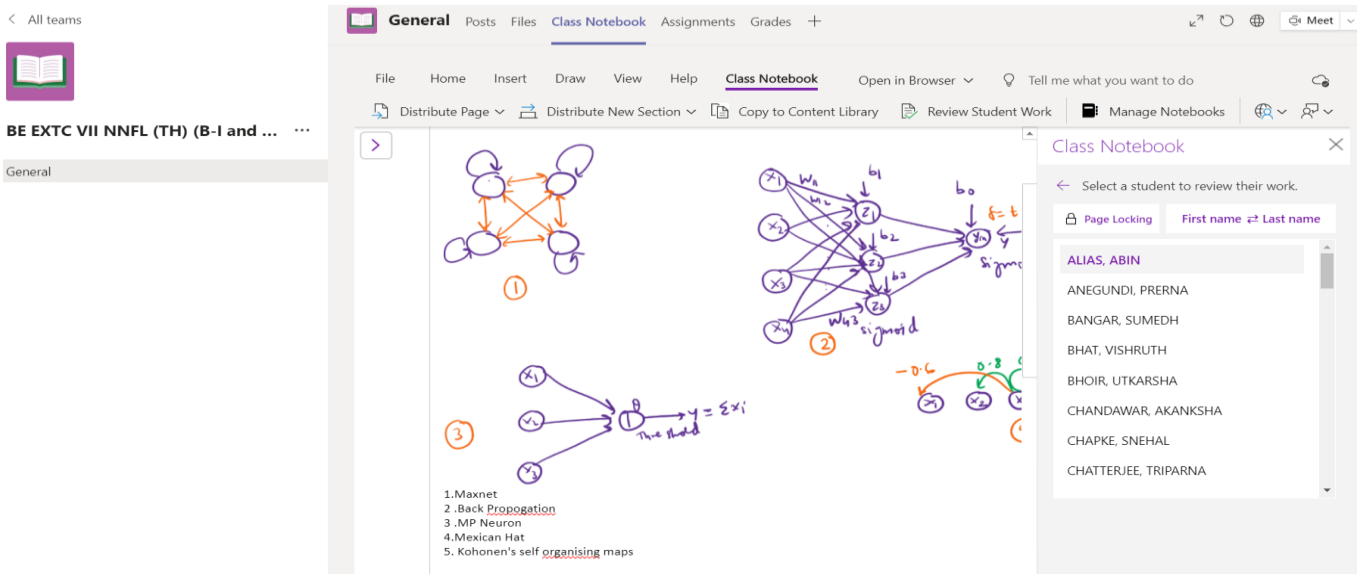


Figure 2 Screenshot of online class notebook (1) of selected student

In another instance, Instructor had provided all steps of the "Back Propagation Network" solving to the students and the students were expected to solve the given problem following the steps. This experiment is very successful, as students got very comfortable with the complex topic and gained confidence in solving such problems (verbal feedback, immediately after the experimental method). The screenshots of this exercise are given below.

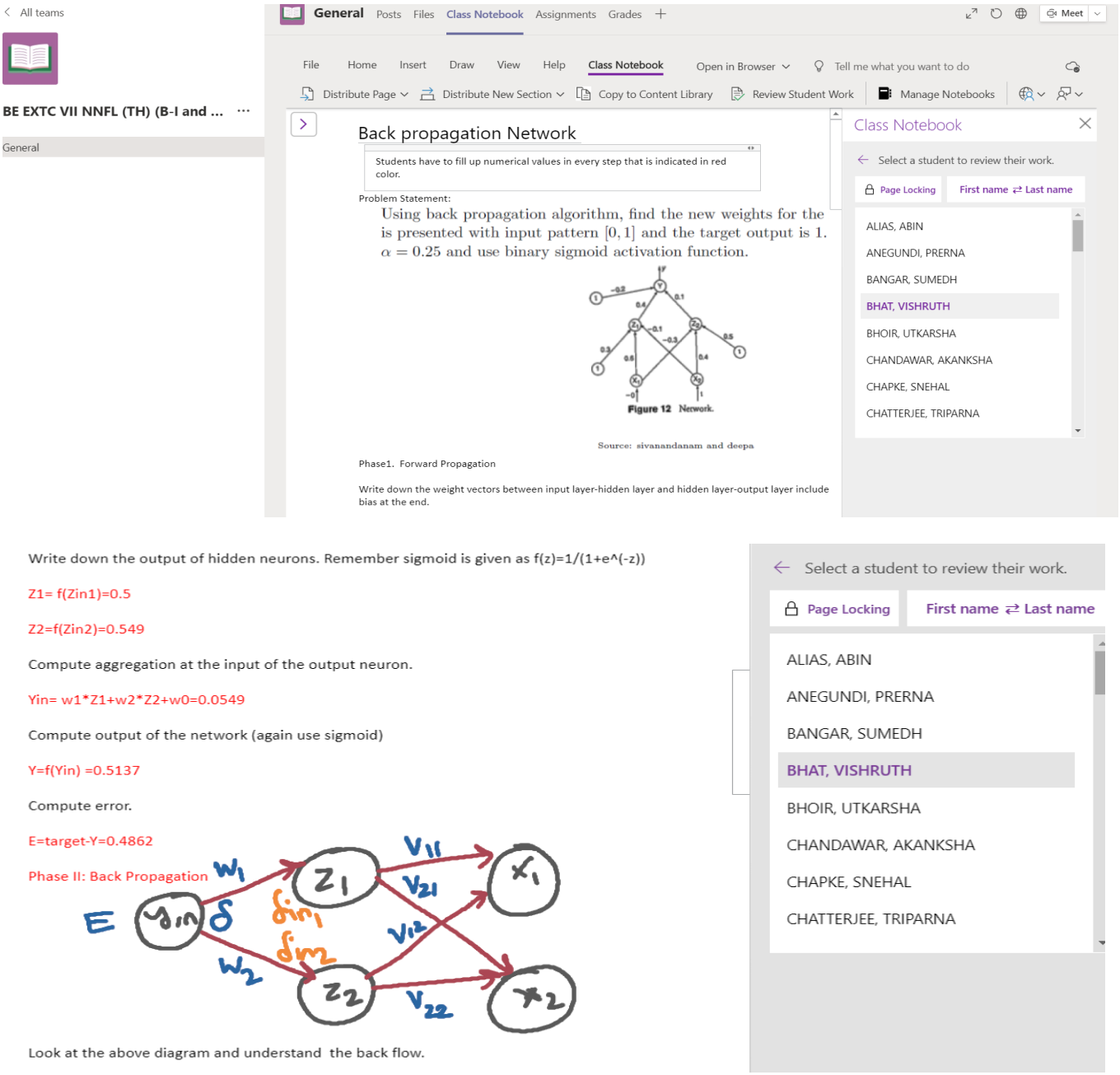


Figure 3 Screenshots of online class notebook (2) of selected student

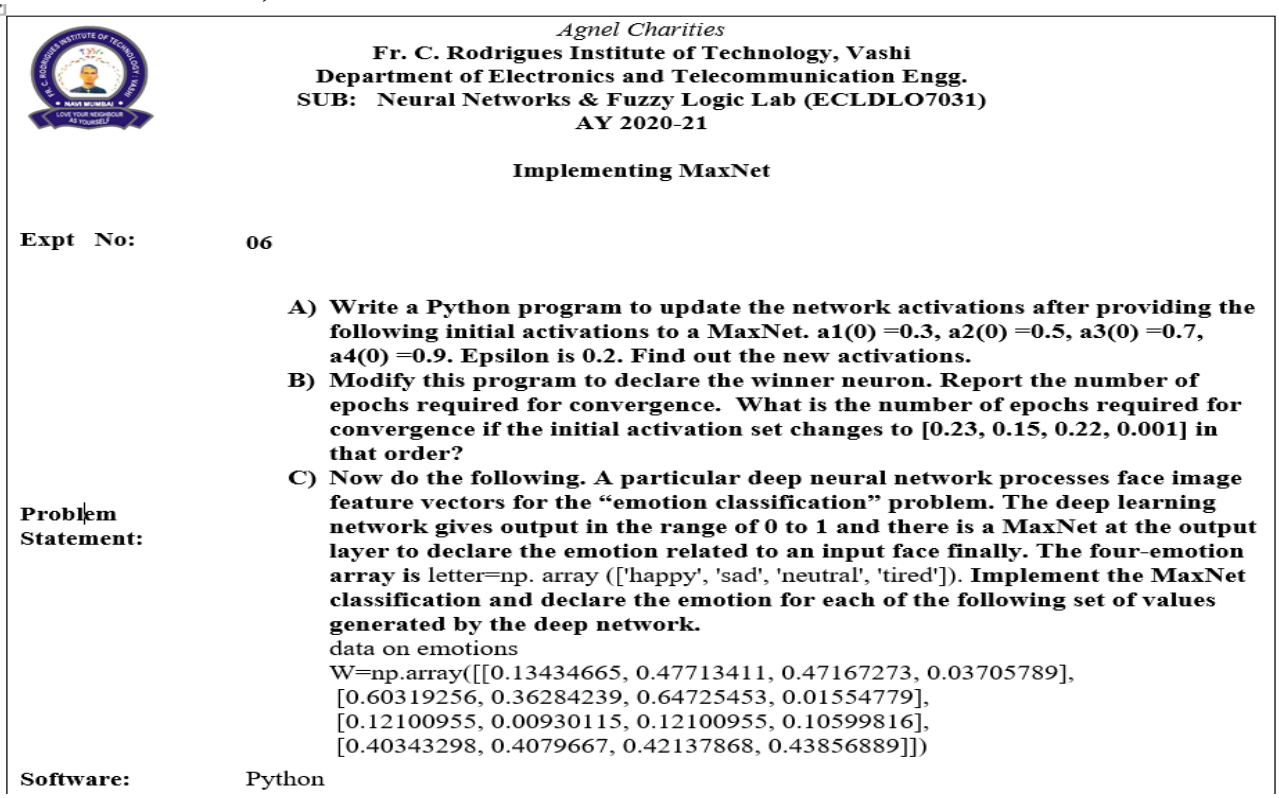
IV. Online Meeting Room Discussions

In this activity, students were divided into 5 smaller groups. (total strength of class is 56 so each group had around 11 students). The Instructor had made groups. Five meeting rooms were scheduled during regular lecture meeting. General instructions were provided to the students in the lecture meeting and then students disbursed to the meeting rooms assigned to them to discuss the topic "Mexican Hat Net". Instructor could visit each room turn by turn, to get to know the discussions and clearing doubts. Students, were found to be engrossed in learning and doing the task. Though some of them felt rooms should not be made by the teacher, a sample opinion is provided below.

48	anonymous	Making rooms roll no. wise was not a good idea according to me but making rooms of friends (Like minded people) will be more efficient as they can share problems and convey to each other more efficiently and actual learning would take place. In labs when you dont understand the problem statement properly it is difficult to code and not as good as learning in class.

V. Setting up experiments on recently taught concepts in theory

One of the advantages for a software-based laboratory is that it can be conducted seamlessly even in online mode. The laboratory course is being conducted in open source language: Python. From the first week the Instructor followed the policy of setting an experiment based on the theory that is learnt in the same week. On the "Neural Network" part of the course, ten experiments covering ten topics and one programming assignment was given. Students are divided in two batches, lab is conducted on two different days, which give the Instructor an opportunity to interact with each student on one to one basis. Record keeping in an Excel sheet, about involvement of the student in the lab is done by the Instructor, after the student has shares his/her screen and discussed status of the experiment. All students are made presenters in the laboratory meeting, so that they can share screen. Figure 4 is a screenshot of one of the experiments write-up.



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SUB: Neural Networks & Fuzzy Logic Lab (ECLDLO7031)
AY 2020-21

Implementing MaxNet

Expt No: **06**

Problem Statement:

A) Write a Python program to update the network activations after providing the following initial activations to a MaxNet. a1(0) =0.3, a2(0) =0.5, a3(0) =0.7, a4(0) =0.9. Epsilon is 0.2. Find out the new activations.

B) Modify this program to declare the winner neuron. Report the number of epochs required for convergence. What is the number of epochs required for convergence if the initial activation set changes to [0.23, 0.15, 0.22, 0.001] in that order?

C) Now do the following. A particular deep neural network processes face image feature vectors for the "emotion classification" problem. The deep learning network gives output in the range of 0 to 1 and there is a MaxNet at the output layer to declare the emotion related to an input face finally. The four-emotion array is letter=np. array (['happy', 'sad', 'neutral', 'tired']). **Implement the MaxNet classification and declare the emotion for each of the following set of values generated by the deep network.**

data on emotions

W=np.array([[0.13434665, 0.47713411, 0.47167273, 0.03705789],
[0.60319256, 0.36284239, 0.64725453, 0.01554779],
[0.12100955, 0.00930115, 0.12100955, 0.10599816],
[0.40343298, 0.4079667, 0.42137868, 0.43856889]])

Software: Python

Figure 4 Screenshot of lab write-up in NNFL

VI. Time-bound Active Quiz on Learning Management Software (LMS)

LMS (Moodle) provides various ways to engage students actively. There were two activities conducted. First was crossword on basic terminology. In any course, students take time to grasp the new terminology and use it correctly. In crossword activity, Instructor had set up the puzzle using a web based downloadable app "hot-potatoes" and students see it as follows with appropriate clues.

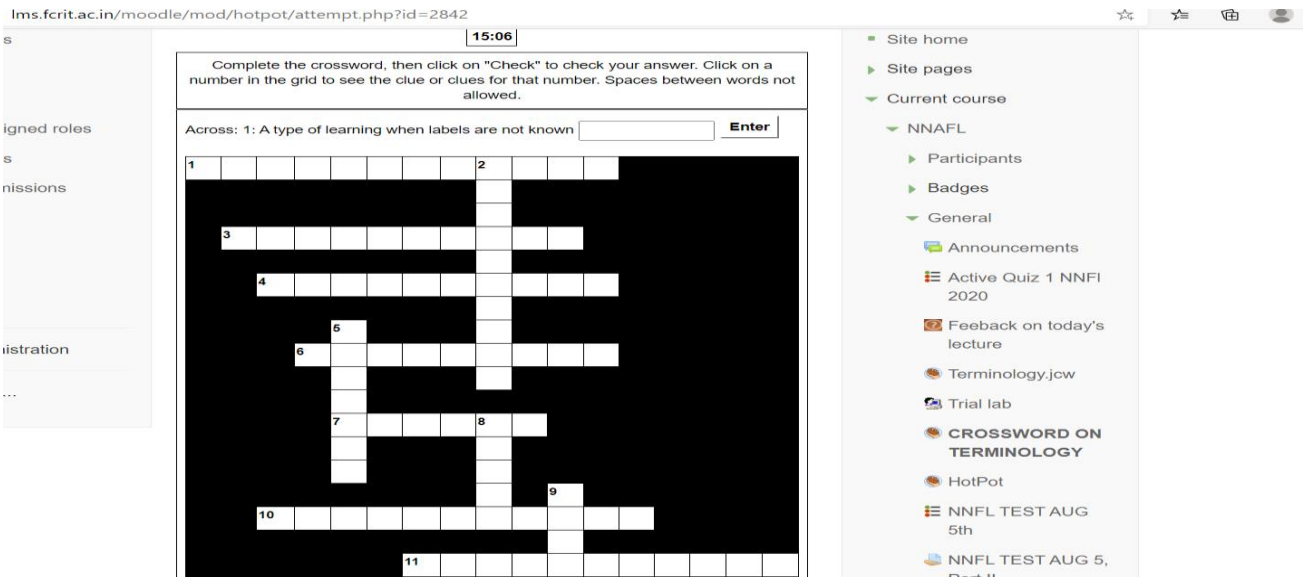


Figure 5 Screenshot of crossword setting on LMS

The second activity on Moodle was an "Active Quiz" which is a timed quiz, meaning every question has stipulated time and the student has to answer within that time. It has to be conducted live and Instructor has to ensure that all students are connected to the site before opening the question. This method was found very useful in order to avoid unfair means but students' feedback was it builds lot of pressure on them due to connectivity issues.
Figure 5 and 6 depict these LMS activities.

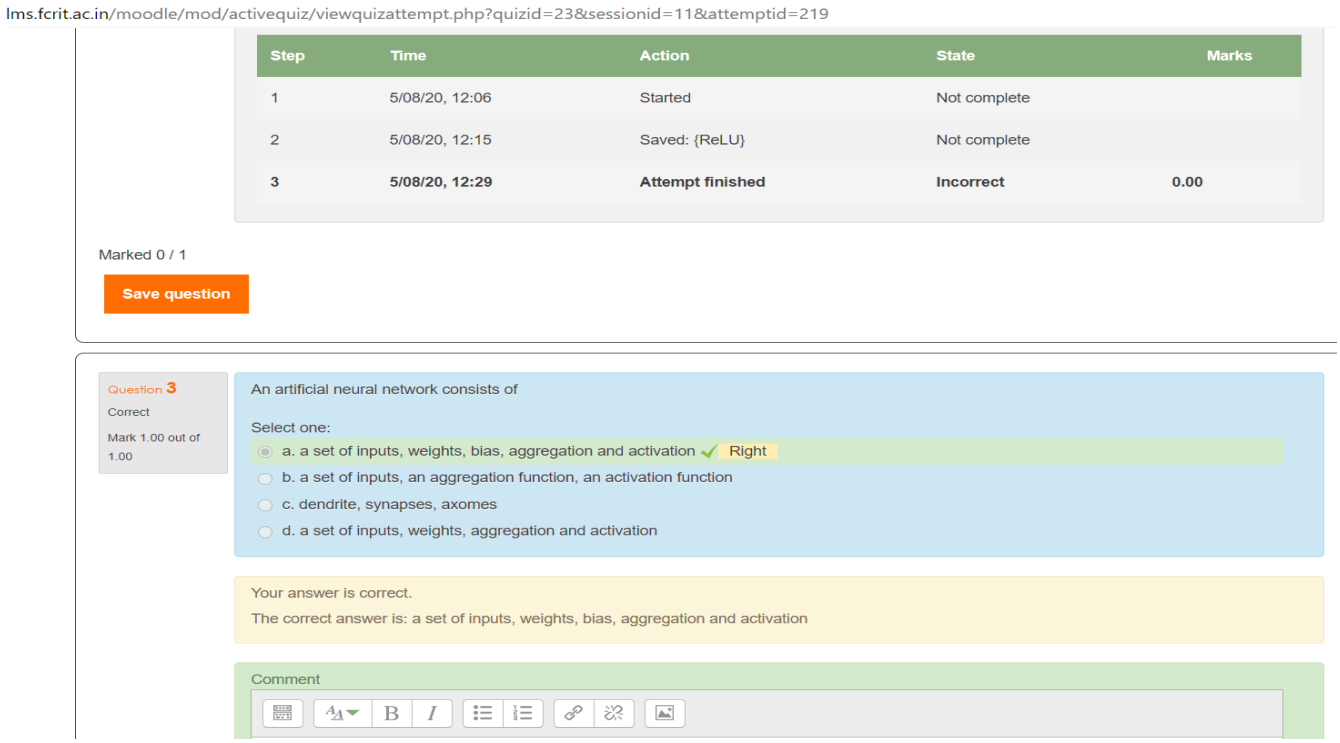


Figure 6 Screenshot of active quiz setting on LMS

VII. Group Seminars

The final year students are expected to have developed the skills for self-learning and presenting a given topic. Instructor decided to allot applications of Neural Networks and Fuzzy Systems for self-study and presenting, to the students. The feedback for this activity is not yet taken, as the presentations are ongoing. A group of four to five students is required to go through resources made available to them, or found by them, understand the topic thoroughly and present in an effective manner. All the sessions are recorded for the benefit of students and are available on MS Streams. Another group of students is asked to evaluate the presenters. Instructor found this exercise useful as the evaluators very keenly follow the presentations, interrupt and ask questions, and later submit the evaluation sheet to the Instructor. Higher order thinking, developing on-the-spot analysis, and criticism skill is enhanced in this activity. Figure 7 is a sample of one of the presentations by students, recorded on MS Streams.

Figure 7 Screenshot of recorded video of one of the presentations

VIII. Simple Random Questioning Method

This is just like asking questions in class, taking names of students to check students' attentiveness, randomly. It is a well proven method to engage students actively in classroom-digital or physical.

B. Description of extra activities in the DCE course:

In the DCE course, apart from the above-mentioned activities, one more activity was conducted, which is described below.

Real time active quizzes

Many online software like mentimeter, kahoot allow teachers to carry out interactive quizzes in real time. These online quizzes were used to revise the chapters in a very fun filled environment. The results of the quiz are shown immediately giving the formative assessment tool to the teacher. It was observed that students enjoyed this anonymous activity and teacher also gets the honest feedback about questions asked.

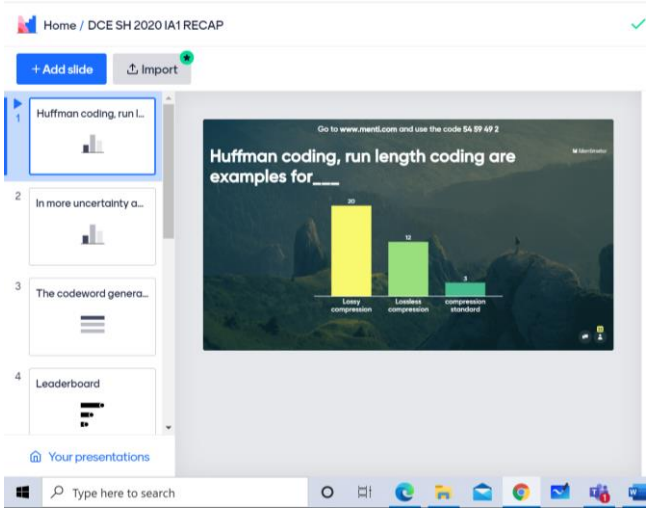


Figure 8 Screenshot of mentimeter quiz responses in the course DCE

4. Analysis of Methods and Interpretations References

The methods described in section 3 need to be quantified to get a certain idea about success/failure in achieving the objective. Enhancement in learning is the clear objective and so, the whole effort is to get numerical indicators for these methods. The scores and preliminary statistics are shown in Table 1. (Given in Appendix due to space limitation).

Methods 2,5,7,8 given in section 3 are evaluated with quiz based on the content, while the remaining methods are qualitative. Therefore, an opinion survey was conducted to judge the effectiveness of the methods too. The following table describes the score statistics in methods that were evaluated numerically. The score sheets are available with the Instructors.

A survey on the effectiveness of these methods was conducted and opinions are recorded. The survey questionnaire, pie diagrams and calculations are available with the authors. Here, we are interested in the effectiveness of the methods and that is summarized in Table 2.

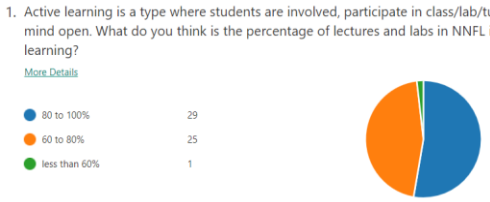
Table 2. Effectiveness Statistics (NNFL)

SN	Methodology	Effectiveness (0 to 1)
1.	Class notebook	0.8072
2.	Group learning (meeting room)	0.7272
3.	NPTEL video self-paced learning and informal writing	0.789
4.	Active quiz	0.76

Further, we define the numerical quantification of learning as an index called as the "Learning Coefficient". It is given as

Learning Coefficient= avg effectiveness*percentage of interactive classes

Note that the percentage of interactive classes is calculated from the opinion scores. For example, in the NNFL course, it is as follows.



According to this pie-chart, ((1*29) +(0.7*25) +(0.4*1))/55=85.27% lectures students consider to be interactive. Weightage of 1 to 80-100%, 0.7 weightage (avg of 60 to 80) to second slot and a weightage of 0.4 to rest.

For the course NNFL, the Learning coefficient is found to be **0.8005*0.8527=0.6826** which is approximately 0.7. A similar analysis is done for the course in DCE (see appendix) and the learning coefficient is found to be 0.64.

The descriptive feedback by students in NNFL and DCE is interesting to note and act upon. Some of the suggestions include:

1. Individual exercises with pseudocodes (possible in some group activity)
2. Demonstration of real-world applications (YouTube videos, guest lectures)
3. Flipped classes
4. More group activities are recommended by many.
5. One significant opinion was to give self-paced learning with advanced topics made available to good grasping students who feel their learning boundaries coming down with the rest of the class.

5. Conclusion

The objective of this paper is to give an account of active learning activities for engaging students in order to instil higher order thinking skills in them; carried out at the Department of Electronics and Telecommunication Engineering, FCRIT. The experiments of active methods carried out in two courses are described and an attempt to quantify the learning that happened through these experiments is made. A learning coefficient above 0.6 is obtained in the two courses that are taken as case study and we believe that this value is quite indicative of "learning happening". However, also considering the descriptive comments in the feedback, we feel that we should aim for a mixed basket of strategies in active leaning which is tailor-made for all categories of students. For that, a very close involvement of faculty with the class is expected and faculty should be observant about learning style of each and every student. It is only then, that "learning" will take place for all.

As teachers, we would like to highlight that our experience on tools like "online class-notebook", "Live timed LMS Quiz" and "Interactive quiz on Kahoot" was found very gratifying. Without any statistical evidence, the authors further would like to comment that in the online mode of teaching-learning, students tend to learn more in hands-on laboratory session rather than through recorded videos or live lectures. Hence it becomes very important to set the laboratory experiments wisely.

In future, we plan to extend quantification of learning through other means reported in literature and verify the same through some feedback mechanism.

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References

1. Hariklia Tsalapatas, Carlos Vaz de Carvalho, Olivier Heidmann, Christina Taka, Siti Salwah Salim, Aishah Abu Bakar, Raja Jamilah Raja Yusof, Tri Ratna Bajracharya, "Active learning in engineering education: experiences in Asia and Europe" Shree Raj Shakya, EduLearn 2020 Conference, July 6-7, 2020
2. R. Senthil, "Enhancement of Engineering Education by Incorporating Active Learning Methodologies" Journal of Engineering Education Transformations, Volume 34, No. 1, July 2020, ISSN 2349-2473, eISSN 2394-1707
3. Linda C. Hodges, "Student Engagement in Active Learning Classes" chapter 2, In book: "Active Learning in College Science", February 2020
4. Sachin S. Patil, Nagaraj V. Dharwadkar, "Improving Students Engagement Through Active Learning Strategies: Case study based Active Review Sessions and Skillathon" Journal of Engineering Education transformations, Volume 33, January 2020, Special issue, eISSN 2394-1707
5. Dr. Deepak H. Sharma, Ms. Anjali Chachra "Effective learners' engagement for learning "Journal of Engineering Education Transformations, Volume 33, January 2020, Special issue, eISSN 2394-1707
6. Shweta Dhawan Chachra, Amrita Naiksatam, Khushi Khanchandani "Use of Kahoot As A Formative Assessment Tool in Engineering Education" Journal of Engineering Education Transformations, Volume 32, No. 4, April 2019, ISSN 2349-2473, eISSN 2394-1707
7. Rupali J. Shelke, Trupti S. Indi "Open Ended Quizzes - A Strategy to Enhance Critical Thinking of Student in Engineering Education" Journal of Engineering Education Transformations, Volume 31, No. 1, July 2017, ISSN 2349-2473, eISSN 2394-1707
8. S. A. Soundattikar, V. R. Naik, "A Case Study on Teaching and Learning Innovations Applied to

Engineering Education" Journal of Engineering Education Transformations, Special Issue, October 2016, eISSN 2394-1707

9. Ujwala Patil, Suneeta V. Budihal, Saroja V. Siddamal, Uma K. Mudenagudi "Activity Based Teaching Learning: An Experience" Journal of Engineering Education Transformations, Special Issue, January 2016, eISSN 2394-1707

Appendix

Table 1. Quiz Scores Statistics

Method Name	**Maximum score**	**% of students scoring more than 80%**	**Average score**	**% of students scoring less than 50%**	**Remark**
Self-paced learning and informal writing	9 on 10	69.09%	7.69	7.2%	Remedial class was conducted for low scorers
Setting up experiments on recently taught concepts in theory	Sample Experiment: Lab 6 on Max-Net 10 on 10	80%	8	None	close monitoring of every student through screen sharing results in good scores.
Time bound active quizzes on LMS	8 on 10	54.3%	6.34	23%	students attribute their low scores to sudden disconnectivity as it was a live quiz.
Presenting group seminars	In progress				