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"Activity based teaching learning in EngineeringEducation, a course on: Embedded Systems"

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Abstract— **The activity-based teaching and learning approach is presented in this paper for undergraduate engineering students. The primary goal of this undertaking is to maximize the student learning. The conventional teaching-learning environment induces monotonicity due to repetitive nature of teaching and absence of activities which does not provide much beneficial effects on increasing students' levels of knowledge. The activity-based teaching-learning circumvents the shortcomings of the conventional approach in transmission of educational content. In this paper, various modes of progressive pedagogy to increase the student participation in active learning are explored. Activitybased teaching-learning is anything related to course in which all the students in a class to participate actively rather than to simply sit, watch, listen and take notes. This paper explains various activities developed and practiced in order to accomplish the goal. The activities described in this paper were implemented with the students majoring in Electronics and Communication Engineering (ECE) in their sixth semester mandatory course called "Embedded Systems". After examining the efficacy of the activities it was observed that the recommended strategy of active learning offers additional possibilities to learn outside of the traditional classroom setting. The performance of the Continuous Internal Evaluation (CIE) serves as the metric for determining theeffectiveness of these activities.**

***Keywords*— Activity-based teaching, learning approach, Electronics and Communication Engineering, embedded systems**

According to Svinicki and McKeachie (2011), lectures are still the most widely used form of instruction in higher education worldwide). When taught by a gifted speaker who is also eloquent, it can be mastered. However, while actively using their mobile devices, completing other class assignments, or recording experiments, students frequently sit passively away from the classroom. Lectures, on the other hand, continue to exist because they are a convenient and efficient method of teaching a large number of students, particularly in large auditoriums.

Some of the advantages of lectures are that they (i) allow instructors to add up-to-date material to the textbook; (ii) Even if the student is passive or distracted, it may not actually interrupt the flow of the material, but the instructor is perceived to be in "control" in the classroom (iii) enable teachers to present important information to which (possibly) all students are exposed at the same time; (iv) provide inspirational teachers with opportunities to enhance student learning; Additionally, qualities such as teamwork, communication, critical thinking and effective presentations are promoted. [7].

Even though these benefits are thought to be good, a lot of research over the past few years, especially in cognitive science, psychology, and neuroscience, has shown that the results don't agree with John Dewey and many other people who teach early childhood. According to Weimer (2002), the emphasis on what is now commonly referred to as "learner-centered" or "learner-centered" education includes active learning [1-5]. Active learning is an important part of effective teaching if teachers want their students to learn better. In an interview with NPR, Hestenes (2012) stated that "students need to be active in acquiring knowledge." [8]

Their comparison studies indicate that learning-positive educational activities are a crucial component in raising student satisfaction with both individual and group learning processes. In research [9], only a few authors have looked at ways to increase student engagement by incorporating techniques into course design. By contrasting the results with those obtained in a conventional classroom setting, this study compared the effects of the use of the online Active Learning Education Portal (Pear-Deck) on student learning outcomes. When compared to typical classroom settings, the findings indicated that active learning activities were a significant contributor to improve student performance. A small number of authors discovered that active learning environments had little impact on student performance and that active learning and teaching had significant positive effects [10].

Students should develop multi-level thinking such as Understand, apply, analyze, evaluate, and create as described in Bloom's Digital Taxonomy. Learning at these levels requires adding a variety of activities to traditional teaching methods. A specific task for students (learners) to build their thinking at the above levels. Students develop advanced thinking skills through the use of tools in the course.

I. ACTIVE LEARNING IN EMBEDDED SYSTEMS COURSE

The authors used a case study of an Embedded Systems course with active learning to test the hypothesis. This course is part of the Electronics and Communications Engineering (ECE), Bachelor of Engineering (BE) program. The course consists of 5 modules. Module 1 describes the architecture of the Cortex M3 ARM 32-bit microcontroller. Module 2 contains the Cortex M3 instruction set and programming. Module 3 introduces students to various components related to embedded systems. Embedded system design concepts are covered in Module 4. Module 5 covers real-time operating systems (RTOS) and integrated design environments (IDE) for the design of embedded systems. This course has the following course objectives:

1. Understand the architectural features and instruction set of the 32-bit ARM Cortex M3 microcontroller.
2. Program the ARM Cortex M3 for different applications using different instructions and C language.
3. Understand the basic hardware components and how to select them from the characteristics and attributes of embedded systems.
4. Co-design hardware and software and create a firmware design approach.
5. Explain the importance of real-time operating systems in embedded systems applications.

The author has designed a series of activities and projects specific to the activities of the various modules of the course along with the necessary tools. All activities were performed on a group of 198 students divided into three sections of 67, 66, and 65 respectively. Activities always started with a clear statement of purpose and implementation plan. Each activity was assessed and marks was allotted. The total marks scored by each student in all these activities was one of the components of Continuous Internal Evaluation (CIE). Activities specific to each level of Bloom's Taxonomy were planned and conducted and the same are explained in further sections.

A. Understand level

"Mind mapping" activity was conducted for module 1 as this module dealt with the foundation or fundamental concepts of ARM Cortex M3 microcontroller. Mind mapping is an activity in which the student will write down the concepts, terms, diagrams or anything taught in the class on a sheet of paper. The details of this activity are as follows:

i) Topic: Introduction to ARM Cortex M3 microcontroller
ii) Justification: The activity will result in better understanding of all the topics of module 1 and their inter relationship
iii) Time allotted: 35 minutes
iv) Implementation: Activity was briefed to the students in first 5 minutes. A plain sheet of paper was distributed to all the students and informed to complete the activity within 30 minutes.

The course instructors reviewed the collected sheets and found that majority of the students had tried to recollect and describe the various concepts learnt in the module in their own way. It was observed that the students were able to understand the technical terminologies, architecture, features, and data processing of cortex M3.

B. Apply level

Module 2 was deemed fit to cater to the apply level of Bloom's taxonomy. The activity planned and conducted was THINK-PAIR-SHARE. The details of this activity are as follows:

i) Topic: To write an assembly language program to find $\sum_{n=0}^{N} X_n Y_n$ where X_n and Y_n were 16 bit integers.
ii) Justification: The activity results in student to think and use the instruction set taught previously to solve a given problem and provide the solution as an optimized program.
iii) Time allotted: 60 minutes
iv) Implementation: Students were briefed about the activity in first 15 minutes. In the next 15 minutes, students discussed with their pair and produced the optimized code. In the last 30 minutes, students presented their solutions.

The best programs were selected by course leaders for laboratory implementation. Overall, students were able to apply the ARM Cortex M3 instruction set and write assembler language programs. The optimized program was effectively run in a lab session.

C. Analyze level

For the analysis level, two activities were included namely quiz and technical survey. The details of the first activity is as below.

i) Topic: To give correct solution after analyzing the given code snippet pertaining to instruction set of ARM Cortex M3 microcontroller.
ii) Justification: This activity enhances the ability of the students to think of different possibilities in a program flow and analyze the code.
iii) Time allotted: 30 minutes
iv) Implementation: The quiz included 10 questions containing code snippets along with necessary register contents. Some register contents in each question were set to last three digits of individual students' University Seat Number (USN). This ensured zero malpractice as the answers were unique depending on their USN. Students were needed to analyze the snippet and provide/tick the correct solution.

The sample copy of the quiz given is shown in Fig 1.
Since, each students' solution was unique the course instructor had to spend time to evaluate. However, this was fruitful as the instructors could assess the students learning of the module thoroughly.
The second one required students to work in teams to identify, evaluate, and report on embedded system components and operations.

i) Topic: To analyze any one of the embedded systems of their choice.
ii) Justification: The activity enhances the ability of the students to analyze the components of embedded systems such as sensors, actuators, processors, protocols and the working.
iii) Time allotted: 5 days
iv) Implementation: One day was allotted for the students to find different embedded systems they see around and list them. The course instructor allotted one embedded system per team to avoid duplication of case studies. In the remaining four days, students studied the embedded system that was allotted and submitted the report.

The sample copy of one of the report submitted is as in Fig 2.

Embedded Systems
Quiz – Module 2
ARM Cortex M3 Instruction Sets and Programming

Name:

USN:

Section:

Signature:

Note: Replace <USN> appearing in the code snippets with last three digits of your USN and proceed as per the question

Questions

```
1. MOV R0, #<USN>
   MOV R1, #0x000000AB
   ADDS R2, R0, R1
```

After execution of above code snippet, R2 = ____________________

```
2. MOV R0,#<USN>
   EOR R0, R0, #0x000000AA
   CMP R0, #100
   ITE GE
   MOVGE R2, #0x5555
   MOVLT R2, #0xAAAA
```

After execution of above code snippet, R2 = ____________________

```
3. MOV R0, #<USN>
   MOV R1, #2
   ROR R2, R0, R1
```

After execution of above code snippet, R2 = ____________________

Fig 1: The sample copy of the quiz

A Case Study
On

MICROWAVE OVEN

Submitted in partial fulfilment of the requirement for the award of the degree of

Bachelor of Engineering
In
Electronics and Communication Engineering
By

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MICROWAVE OVEN (An Embedded System)

HISTORY OF MICROWAVE OVEN

In 1945, Percy Spencer, working for Raytheon to develop magnetrons for active radar signals, noticed a chocolate bar in pocket melted while standing in front of an operating magnetron. ' He then tested popcorn in front of the magnetron and it quickly popped all over the room. ' In 1947, Raytheon made the first microwave oven – Radarange (6 ft tall, 3000 W power S3K) but did not sell well. In 1965, a countertop version was developed for $495.

Fig 2: The sample copy of one of the Technical survey report submitted

This activity had dual advantage, as the course instructor had the privilege to gauge the students' learning as well as their written communication skills by evaluating their technical reports.

D. Evaluate level

Students were asked to perform a comparative analysis of different ways of implementing various Real Time Operating Systems (RTOS) functionalities such as task scheduling, resource sharing, threads etc., and various Integrated Development Environment (IDE) available for developing embedded systems. The students were asked to evaluate different possibilities and present the best one they think through a seminar.

i) Topic: To give a seminar on comparative analysis of concepts allotted to them in team.
ii) Justification: The activity improves the student's ability to compare various architectures, versions, assembly language programs, algorithms, and resources and select the most appropriate one.
iii) Time allotted: 5 days for comparative study and 20 minutes for seminar presentation.
iv) Implementation: Each team was given a separate comparative topic to study and present. In 15 minutes, the team should present and each member of the team must compulsorily participate. Last 5 minutes was reserved for asking queries by course instructor and the students in the audience.

This activity like the previous one helped the course instructor to assess the student's involvement in working teams, oral communication skills along with their technical knowledge. Some of the topics given for comparative studies are as follows:

1. Cortex M3 versus M4 architectures
2. Round robin scheduling versus Shortest job first scheduling algorithms
3. Simulator versus Emulator

E. Create level

To evaluate create level of Bloom's taxonomy, a mini project activity was given and this activity was performed in small teams of 3 or 4 (maximum).

i) Topic: Implement the mini project in laboratory.
ii) Justification: The activity helps students to implement what they have learnt in their theory classes. The successful implementation gives students a sense of achievement, satisfaction, life-long learning and a motivation to do well in their future studies.
iii) Time allotted: 2 weeks.
iv) Implementation: The teams developed the mini-project given on embedded systems in a professional manner. After completion of project, the teams exhibited their projects and also submitted the report.

This activity lies in psycho-motor domain and involves creative thinking as solution to one problem may not fit for other problems. Majority of the students enjoyed the activity and enthusiastically participated. The intention of this activity was to give students a platform to demonstrate their creativity. A few students needed help in completing the activity which was rendered by course instructor as when required. Sample screen shot of students demonstrating their mini projects is shown in Fig 3.

Fig 3: Mini project presentation

II. OUTCOMES OF ACTIVE LEARNING

Various activities mentioned in the previous section were planned and conducted effectively. Each activity was evaluated and students were assessed adhering to rules and rubrics decided. The students participated effectively in all the activities as the marks scored in these activities was a component of their CIE.

Table 1: Activity with assessment mode

Bloom's level	Activity	Mode of assessment
Understand	Mind mapping	Simple rubric
Apply	Think-Pair-Share	Objective
Analyse	Quiz	Objective
	Technical Survey	Rubric
Evaluate	Comparative study	Rubric
Create	Mini project	Rubric

For all the activities maximum marks allotted was 10. Mind mapping activity was evaluated with a simple rubric as shown in Table 2.

Table 2: Rubrics of Mind mapping activity

Number of concepts	Marks
0	0
1 – 3	5 – 7
4 – 7	8
8 – 10	9
More than 10	10

Majority of the students scored maximum marks indicating that they comprehended the concepts well.
The marks distribution for Mini project and Technical survey are as shown in Table 3 and Table 4.

Table 3: Marks distribution of Technical survey	
Criteria	Marks
Survey	10
Time management	10
Presentation skills	20
Queries	10
Total	50
50 marks scaled to 10 marks	

Table 4: Marks distribution of Mini project	
Criteria	Marks
Synopsys	10
Literature review	10
Results	20
Presentation and Demo	10
Total	50
50 marks scaled to 10 marks	

The graphs in the Fig 4 shows the marks scored by the students in the activities

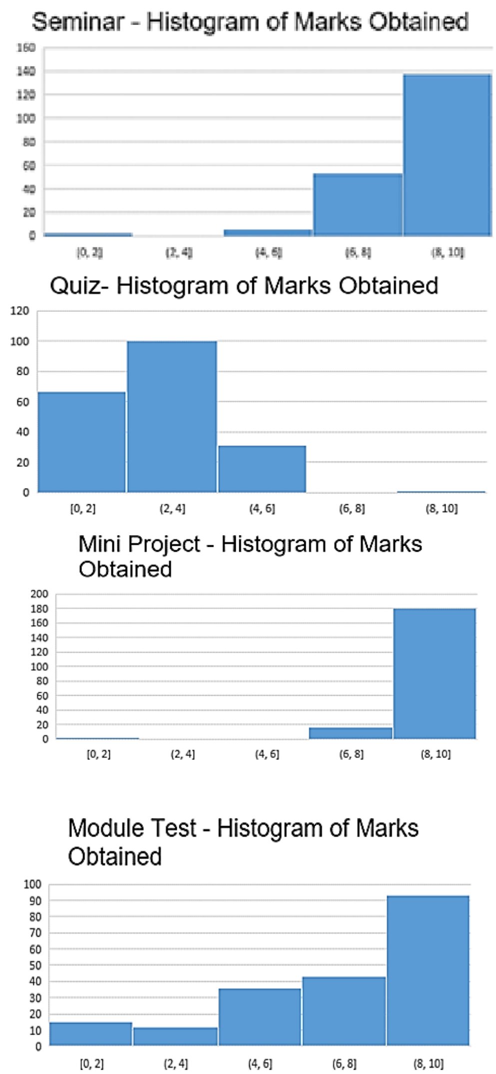

Fig 4: Marks obtained by the students in various activities conducted

The graphs in the Fig 5 shows the feedback by the students on the activities conducted.

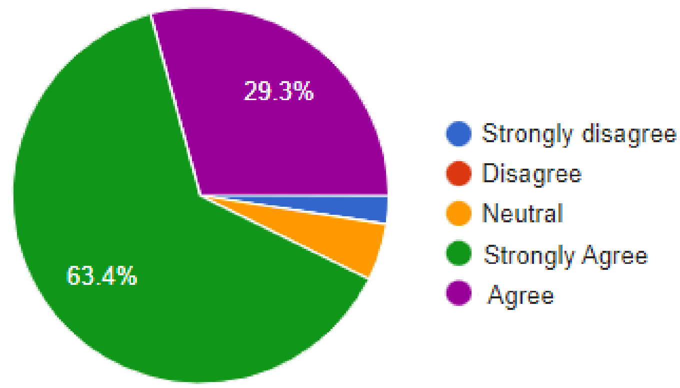

Fig 5 : Feedback by the students for activities

CONCLUSIONS

Education has certainly changed in response to the demands of society. Universities invest significant time and resources in transforming their educational models to equip students with the knowledge and skills that will help them solve key problems in different sectors of the economy. Our research shows that Active Learning can and does support this goal.

The Embedded Systems course included a variety of activities in addition to traditional teaching methods. The students actively participated in various activities conducted for them and improved their overall intellectual level. These activities also provided them with professional skills. Students understood the course well and the activities mentioned had a huge positive impact on their learning curve. Students gave us feedback that they enjoyed active learning.

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