Effective Implementation of Project based learning in Microcontroller Course

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Abstract—The paper outlines the views on effective implementation of project-based learning through microcontroller theory course. Project based learning imparted in microcontroller course has enabled the students to imbibe higher order thinking, problem solving ability, time management, leadership & teamwork. Through PBL students interact and learn by doing with others. It also offers teachers the chance to develop relationships with their students by serving as their facilitator for hands-on learning. The course project introduces students to the field of embedded systems where students will familiarize themselves with relevant technical vocabulary and learn about future opportunities in embedded design.

Keywords—Project based learning (PBL); Active Learning; Rubrics Based Assessment; Microcontroller.

JEET Category—Choose one: Practice.

I. INTRODUCTION

TRADITIONAL classroom teaching is mainly followed in engineering education which is mainly teacher centric, this approach is very effective in many cases [1]. However, here is also a possibility to change our focus from teacher centric to learner centric education system. Most students choose engineering to solve real time problems in the subjects they study. A conventional teaching approach which includes chalk and talk, assignments, module test don't inculcate critical thinking which leads to boring or lack of interest among the subjects taught as they do not involve students. Therefore, it is necessary to teach engineering subject by relating to real time problem solving.

The inclusion of real time problems as projects in engineering curriculum provides a distinct experience. This incorporation of projects into the curriculum is commonly known as project-based learning [2].

The key feature of project-based learning is that: they are part of the course, it requires students to apply the knowledge acquired, student centered, and finally real-time problems. The Engineering educators have used project-based approach in teaching the subjects they teach to relate the concepts they taught to the real-time examples in the early years of engineering.

Microcontroller is an important professional core course in Electrical and Electronics Engineering. It is a programming subject which emphasizes the applications at the same time. The 8051 Microcontroller is one among the foremost popular general-purpose microcontrollers specially designed for embedded systems. Introduction of 8051 course in Electrical and Electronics Engineering course will expose the students to the embedded system field. This course enables the students to familiarize with the associated technical vocabulary and will helps them in embedded system design and hence can pursue their career [3].

The objective of the course is, first students should know all the instructions available in 8051 for programming. Second, they must write programs in the ALP and C for various operations. Third, they must design timers and counters for the required time delay, Fourth, they should be able to interface hardware with software.

Microcontroller is a foundation course for design and development of embedded systems Hence, improving microcontroller curriculum teaching effectiveness in Electrical and electronics profession will have a positive impact [3]. In order to achieve the objectives of the course, the authors have proposed teaching reform by introducing Project-Based Learning Model in the curriculum which enhance the students' ability of practical application.

A. The need for change in engineering education

Engineering schools traditionally have accepted responsibility for inculcating deep Knowledge of a discipline and the competency to apply it in practice. They have placed less emphasis on professional skills. While graduates in the past could expect to acquire those skills on the job, many of today's companies seek skilled employees and not require additional training. Universities have not compulsorily kept pace with this trend. By introducing projects in the microcontroller course will help students with equipping skills and tools that are needed for prototyping embedded systems [4-7]. Therefore, the concept of the Project based learning enable professional engineers arose out of a requirement for university curricula to respond to industry demand.

II. MODEL FOR PROJECT BASED LEARNING

In project-based learning students are given the flexibility to

choose real time problems of their choice which will be solved with the concepts they study in the course [8]. They are instructed to define objectives, brief description of the project, the methodology used to solve the problem & tools used. Project based learning is student centric where students learn through solving real time problems on their own, through active participation. Problem solving, Time management, Critical thinking, communication and decision making are integral part of project-based learning, where each team discuss, collaborate and solve real time problem to get meaningful solution

Project based teaching is student centred & inquiry driven. Here lectures, role is to facilitate the learners than the direct knowledge transfer. By solving real time problems, students practice learning rather than memorizing.

Each group will present the result and submit the report of their respective project. At the end of the semester each project group is graded based on the Originality of the idea, relevance, Innovation, Quality of content, results and presentation skills. Students may face difficulties initially as they are not used to for such assignments.

A. Approach for project-based learning

The delivery of this course is achieved with the following stages.

1) Stage 1: Classroom teaching

Students are introduced to the basic concepts of 8051 microcontroller which includes architecture, addressing modes, instruction set, programming using assembly language and embedded C [3]. The students were further given an idea of timers, interrupts, serial port communication and external hardware interrupts.

2) Stage 2: Workshop

Students gain further knowledge of the concepts by doing a set of exercise projects under the guidance of course instructors, where students were trained on the following: writing code using Keil software, compile the code, debug the same and how to generate a hex file. Once the hex file is generated students were also trained to simulate the circuit using Proteus software followed by validating the output. Finally, it is tested using the required hardware.

3) Stage 3: Project Implementation

Project groups are made with a minimum of 2 and a maximum of 4 in a team. Each team was instructed to define problem statement, objective & scope of the project. They also need to do a literature review, define objectives, methodology, tools used, and expected outcome. Project groups are guided in selecting sensors, actuators and various other components. Each group will present the result and submit the report of their respective project. At the end of the semester each project group is graded based on the Originality of the idea, relevance, Innovation, Quality of content, results and presentation skills. Students may face difficulties initially as they are not used to for such assignments. Project based learning helps students to effectively use modern engineering hardware/software tools which are needed for engineering practice. Hence it is necessary for an engineering student to use the modern engineering

hardware/software tools to complete the projects which provides efficient results.

B. Implementation

TABLE I
STEPS TO IMPLEMENT PROJECT-BASED WORK IN MICROCONTROLLER COURSE

Week	Activity	Process
1	Students are allowed to choose real time problem	Students are instructed to choose real time problem of their choice and to find optimal solution using the required hardware and software tools.
2	Students apply the knowledge gained to arrive at new knowledge	To solve the real time problem chosen, students are needed to do a literature review to understand what has already been done by other researchers.
2	Responsibility of completing the task is held by students	The students need to book system and hardware components on a particular day of a week to solve the real time problem chosen.
3&4	Course Instructor facilitates to complete the task.	Each group students are addressed to complete the task separately.
5	Analyze the problem	Students are informed to do a detailed examination of the various elements used such as sensors, actuators, etc., Through their datasheet to arrive at a systematic solution.
6	Teamwork	They need to understand the strengths and weaknesses of each member of their team and share the work accordingly.
7	Journal	Briefly discusses the final solution and its feasibility.
8	Assess learning Outcome	Learning outcome is assessed through oral presentation and Question and answer.

C. Assessment

The weightage given for the project is 20% of the total marks allocated for internal assessment. Assessment of the project can be made in two stages: Demonstration and Presentation.

1) Demonstration

Each team will give the demonstration of the working model, where the members explain input, output, components used and its operation. The Contribution of each member of the team is assessed through face-to-face interaction.

2) Presentation

Each team has to present their project work through power point presentation which includes topics like Introduction, Objectives, Project description, Tools used, results and discussion, conclusion and future work. A question-and-answer session are held at the end which leads to better understanding of the project. Also, the audience was allowed to give alternate feasible solution to the problem, hence all are actively involved in the discussion. The below Table II shows the rubrics for the assessment of both the stages.

D. The following skills were developed in the due course of project-based learning.

1) Teamwork Skills

Project based learning enables learners to develop leadership skills, time management skills & communication skills. However, in some typical cases, one or two students do all or most of the assignment and all group members get same marks, which can also be overcome through face to face interaction.[4]

TABLE II
RUBRICS FOR EVALUATION OF PROJECT

Score	Topic Knowledge			Presentation Skills		Preparation of reports	Carrying the Project
	Relevance	Innovation	Quality of Content	Slide Preparation	Presentation	Report	Teamwork
9 to 10	The topic is more relevant to the specialization	The topic is completely latest. References are excellent and recent	Quality of content is excellent.	As per the template. Well organized. Aesthetically very good.	Confident, used notes well, at ease, good audience attention.	Significant contribution towards preparation	Collaborates and communicates in a group situation and integrates the views of others
6 to 8	The topic is relevant to the specialization.	The topic is latest. References are good.	The Content is clear.	As per the template. Well organized. Aesthetically satisfactory.	Fairly confident, used notes fairly well, acceptable audience attention.	Moderate contribution towards preparation	Exchanges some views but requires guidance to collaborate with others
3 to 5	The topic is somewhat relevant to the specialization.	The topic is not latest. References are good.	The content needs some more clarity.	As per the template, but not well organized. Aesthetics needs improvement.	Read parts, fumbled with notes, several distracting mannerisms.	Little contribution towards preparation	Makes little attempt to collaborate in a group situation and rarely exchanges views
0 to 2	The topic is not relevant to the specialization	The topic is very old. References are not good/ no proper references.	Content is not clear	Not as per the template. Poorly organized. Aesthetically poor	Unprepared, awkward, shuffled papers, turned from the audience to read overheads	Very little or no contribution towards preparation	Makes very little or no attempt to collaborate in a group situation

2) Writing Skills

Project based learning facilitates the development of writing skills where learners effectively write for about a few paragraphs on what they actually do, whereas in conventional method they may end up as an unsuccessful writer.

3) Communication Skills

At the end of the course student give presentation on the project they have completed. The other students of the class listen and they post questions. The communication skills of the students improve if a student teaches what he or she leant to a small group.

4) Leadership Skills

Leadership skills are necessary to manage projects, team leader should plan the task and must effectively execute tasks as well as encourage and motivate team members to complete the project successfully.

5) Time management skills

Each project has several tasks which need to be completed well before the deadline, team leader must schedule the tasks and motivate team members to work accordingly.

6) Critical thinking skills

In project-based learning, students engage in solving real time problems which are local with no exact solution. In order to solve such problem, they critically think and analyze large volume of information to make a decision on the right methodology to be used.

7) Problem solving skills

In Project based learning faculty acts as a facilitator and students have a greater dependency on their peers, where they engage themselves to determine the source of the problem and find novel solution to it.

8) Lifelong learning skills

In project-based learning students have a responsibility to complete all the tasks of the project by themselves.

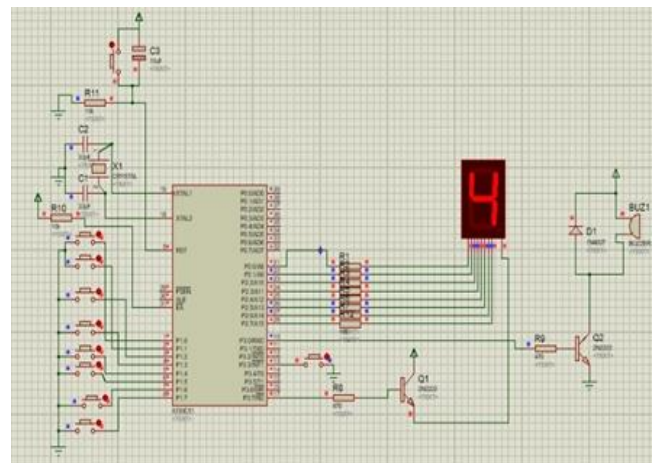### E. Sample Course Project Snapshots

Fig. 1. Quiz Buzzer using 8051 Microcontroller.

Fig.1 shows the Proteus simulation model of Quiz Buzzer in which 8051 Microcontroller is used for taking inputs from different push buttons and display the number of a button pressed first on LED segment and also to trigger buzzer through transistor switch.

Fig.2 shows the Proteus simulation model of simple calculator using AT89C52 microcontroller where input is taken from 4x4 keypad interface and LCD is used for displaying.

Fig.3 shows the Proteus simulation model of password-based locker system using AT89C51 microcontroller where password is entered through keypad interface which will be displayed on LCD and motor is used to open/close the locker.

Fig.4 shows the Proteus simulation model of water level indicator using 80C51 microcontroller where set of switches are used to indicate/simulate the level of water in place of sensor. Motor with relay is used to show the operation of water pump. The level of water is displayed on LCD.
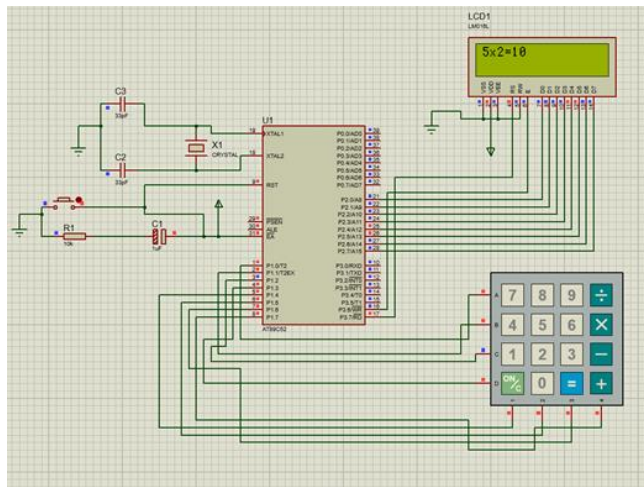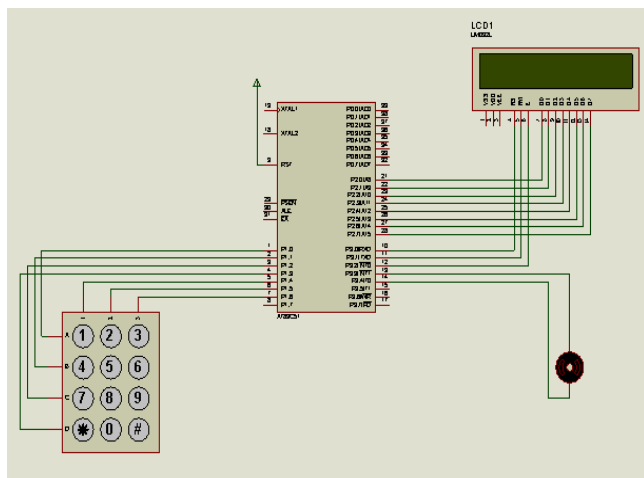
Fig. 2. Simple Calculator.
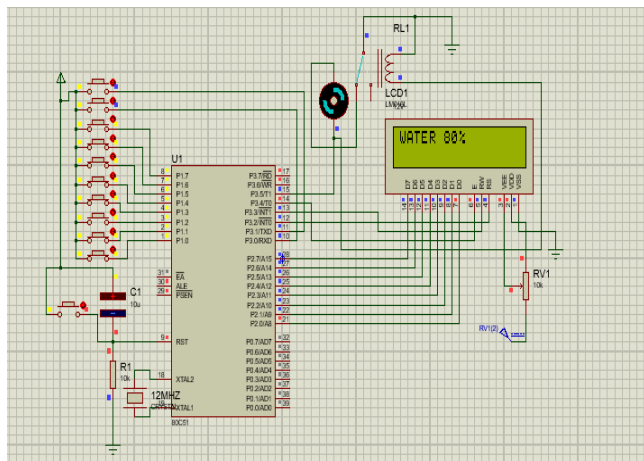

Fig. 3. Password based locker system

Fig. 4. Water level indicator.

F. Students' feedback on Project based learning

Students' feedback on Project based learning was taken at the end of the course from 60 students who were involved in projects. Table 3 lists the questions.

TABLE III
FEEDBACK QUESTIONS

| Q. No.	Questions
1	Will project based learning help in better understanding of the course
2	Project based learning will enhance once ability to analyse, design and interpret the result
3	Project based learning enhances higher order thinking
4	Project based learning enhances team building capability
5	Project based learning enhances problem solving and critical thinking skills
6	Will you recommend Project based learning for your Juniors
7	Do you want to experience Project based learning in other subjects
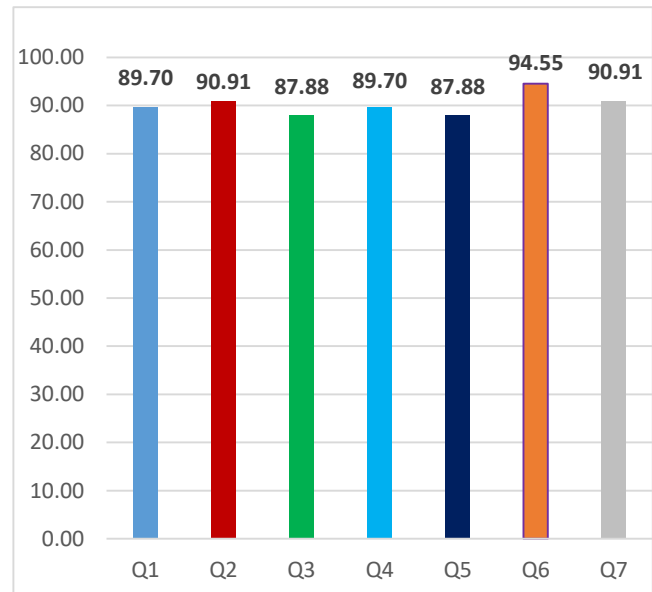
Fig. 5. Students' feedback on Project based learning.

Feedback acquired from students on project-based learning was acceptable as shown in Fig. 5. Majority of the students have agreed that Project based learning has helped them to understand the concepts better and also help them to improve their skills and higher order thinking.

III. THE OUTCOME OF TEACHING REFORM

Today's engineering profession not only demands knowledge but also skills and technical competencies, Project based learning is one the best way to imbibe skills and technical competencies in the course. It is the process of transformation from teacher centric to student centric where students solve real time problem by thinking, researching and practicing by themselves. The learning activity helped the students to improve their skills related to Writing, Teamwork, Communication, Leadership, Time management, Critical thinking Problem solving & Time long learning. Hence it is suggested to introduce mini project in the microcontroller course. In this paper steps to introduce mini-project in microcontroller course was discussed. Learning through solving real time problems is one of the effective ways that enables students to learn both fundamental knowledge and principles thereby applying the same to come out with the feasible solution. This approach can be used in similar courses

like Analog Electronics, Digital Electronics, Programmable Logic Controllers, Embedded Systems, etc. where students can learn come out with projects giving solutions to real time problems.

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