Effective teaching of Course on 8051 Microcontrollers through course Project

Aruna S. Nayak[1], Vishwanath G.G[2]. Umadevi F.M[3]
Department of Computer Science and Engineering
B.V. Bhoomaraddi College of Engineering and Technology
Hubli, India
arunan@bvb.edu[1] vishwanath_gg@bvb.edu[2] uma_devi_fm@bvb.edu[3]

Abstract— **Practice and application-oriented approach in education is important and some research on active learning and cooperative problem-solving has shown that a student will learn faster and understand subject in depth. This paper describes our experience in effective teaching of 8051 Microcontrollers through course project. The course project is designed to improve students' practical thinking, logical ability and to make students, work in team. The course project is aimed at exposing students to the field of embedded systems, and will provide a knowledge foundation which will enable students to pursue subsequent courses in real-time embedded systems software and computer design. Students will become familiar with the associated technical vocabulary and will learn about potential career opportunities in the field of embedded system design.**
In this paper we present our experience in using a new approach for teaching 8051 microcontroller course and it's associated laboratory.

***Key words*— course project; integrated development environment; assessment rubrics; program outcomes**

I. INTRODUCTION

The typical curriculum of undergraduate program in Computer Science contains couple of hardware courses starting with basics and going up to the study of Microcontrollers. The general observations by the course instructors are that these courses were not taken seriously by the students. A further study revealed that the courses were not aligned to the needs and expectations of Computer Science program. Making these students take interest in the hardware course was the first challenge before the course instructors. The authors have attempted a set of experiments in making these courses interesting in the first phase and subsequently making them relevant to the needs of undergraduate program.

These papers discusses the approach of the authors in making 8051 microcontroller hardware course relevant to under graduate program in Computer Science and improve the efficiency of learning the course by introduction of laboratory and course projects.

8051 is introduced as a course for CSE students which will expose them to the field of embedded systems and will enable students to pursue subsequent courses in real-time embedded systems. Students will become familiar with the associated technical vocabulary and will learn about potential career opportunities in the field of embedded system design.

The course is strengthened by introducing an associated laboratory that will train the students to effectively use an integrated development environment (IDE) for developing their application programs in assembly and C language and have a hands-on experience of hardware programming and use of microcontroller to design a prototype of Embedded System[4].

It was observed that course projects would be a viable approach for equipping students with the skills and tools that they need for prototyping embedded systems. Hence an attempt was made to introduce course projects which would enhance their design skills and enable them to work in teams.

II. BACKGROUND

The 8051 architecture developed by Intel has proved to be the most popular and enduring type of microcontroller, available from many manufacturers (Atmel, Maxmim Integrated products, NXP, Winbond, ST Microelectronics, Silicon Laboratories, Texas Instruments and Cypress Semiconductors) and widely used for industrial applications, automotive, consumer electronics, networking and telecommunication equipments. It is difficult to envision any type of digital system other than the most simple that does not incorporate a microcontroller.

The learning of this course is achieved through three stages – classroom teaching, laboratory exercises and course project implementation.

In the first stage, the students are introduced to basic concepts of 8051 that includes architecture, programming model, addressing modes and instruction set [1]. The students are further exposed to programming concepts in assembly and embedded C language [2].

In the second stage, the students gain further understanding of the above concepts by performing a set of laboratory exercises with guidance from course instructors. We use ALS-EMB-EVAL-03 (VER3.0) training boards, based on an ATMEL AT89C51ED2 microcontroller with on-chip 64Kbytes data memory, 1.792Kbytes of expanded RAM, 2Kbytes of EEPROM, SPI interface and 16 bit programmable counter array. A typical laboratory session starts with the assembly language coding on a PC followed by embedded C programs that cover the onboard peripheral interfacing of the target microcontroller to various modules such as the timers, keypad, motors, display devices, sensors, ADC and DAC.

The third stage is to educate the students on the development of microcontroller-based applications [6]. This is done by guiding the students through course projects. The problem statements for the course projects were framed and provided to the student teams in a manner that expects them to interface microcontrollers to peripherals. The students received help in selecting electronic parts, sensors, actuators, and other components from the instructor. Students were also guided to arrive at optimum solutions to their problems. Periodic project updates and final project reports were required in addition to PowerPoint presentation of the projects. A good number of projects were successfully built for this course which are evaluated and reflected in the results section, discussed later. The project reports submitted by the students illustrate that they have used the skills that they had learned in the lectures and the labs.

III. IMPLEMENTATION

The purpose of the course project was to enable students to identify and analyze a given problem statement and design an appropriate solution for the same [5]. In addition to the above the students were required to present their work through power point presentation which in turn helped to improve their communication skills. The projects also give an opportunity for the students to apply the skills learned in the lectures and the labs to build meaningful prototype systems. Each project uses the AT89C51ED2 microcontroller as a component. The most used peripherals in the projects were ADC, Hex Keypad, DIP switch, sensors and converters, DC and Stepper motors [3]. There were thirty six projects built in the 13 week duration of even semester, 2014.

The projects were done by a group of four to five students. Some of the projects that were implemented through course projects were : Single axis solar tracker which helps the solar power equipment to get the maximum sunlight thereby increasing the efficiency of the system. The solar panel tracks the sun from east to west automatically for maximum intensity of light. The project on Automatic Toll Gate as shown in Fig.1, which is used to control the flow of vehicles thereby ensuring smooth flow of traffic on the roads without human intervention. Temperature controlled fan was another interesting project done by students which automatically controls the speed of fan according to the temperature. A temperature sensor is used to sense the temperature. The speed of fan increases with the increase in temperature and vice versa and the temperature sensed by temperature sensor is displayed on the LCD. Heartbeat Monitor as shown in Fig.2 is a project which explains how a single chip microcontroller can be used to analyze heartbeat rate signals in real time. Here heart rate is measured by employing the pulse method i.e. blood flow into the finger. The blood flow into the finger can be sensed photo electrically using LDR. Gas leakage detection system as shown in Fig.3, was another project which finds applications in Automotive Industry, Storage facilities, chemical processing and Refining industries where leakage of hazardous gases can be detected.

IV. ASSESSMENT

Assessment of the course project were done as a part of SEE evaluation and evaluated for 20 marks. The assessment was done in two phases:

- Demonstration
- Presentation.

A. Demonstration

Through this exercise it was expected that every team will provide a demonstration of their working prototype explaining the functional operation, inputs, outputs and other specifications of the system and components used. The team members were also expected to identify the application areas of the project. The team members' individual contribution towards the completion of project is evaluated by examiners through viva-voce and assessment rubrics.

B. Presentation

The team is expected to make a five to ten minute powerpoint presentation which should include topics like introduction of the problem statement, criteria for selection of components, block diagram, design issues and applications of the project. A five minute question-answer session is allowed that enables peer-to-peer learning and better understanding of the projects. It was also observed during the session that the audiences were able to propose alternate solution approaches for the problem statement to the target team and hence everyone was involved in active discussion.

TABLE I. RUBRICS FOR COURSE PROJECT ASSESSMENT

Criteria 1	*Excellent(2M)*	*Average (1M)*
Problem identification	• Effectively identified problem. • Identified desired solutions or options. • Completed project on time. • Organized and well planned	• Uncertainty in problem identification. • Problems not stated clearly

Criteria 2	*Excellent(4M)*	*Good (3M-2M)*	*Average (1M)*
Presentation	• Information is presented in a logical sequence. • Presentation contains accurate information. • Visual aids are well prepared, informative, effective, and not distracting. • There is an obvious conclusion summarizing the presentation.	Any 2 or 3 of excellent criteria is met	Any 1 of excellent criteria is met

Criteria 3	*Excellent(4M)*	*Good (3M-2M)*	*Average (1M)*
Viva	Answers all the questions correctly.	Answers only 50% questions correctly.	Answers 25% questions correctly.

Criteria 4	*Excellent(4M)*	*Good (3M-2M)*	*Average (1M)*
Model Implementation	• Ideas fully explored. • Significant gain in knowledge or skills. • Challenging to Student • Student demonstrates full knowledge by answering all class questions with explanations and elaboration.	• Ideas explored to partial extent. • Partial gain in knowledge or skills. • Student is uncomfortable with information and is able to answer only rudimentary questions	Any one or two of excellent criteria is met

The assessment for both the phases was done through pre-defined rubrics as listed in the TABLE 1 below:

V. SNAPSHOTS OF SOME COURSE PROJECTS

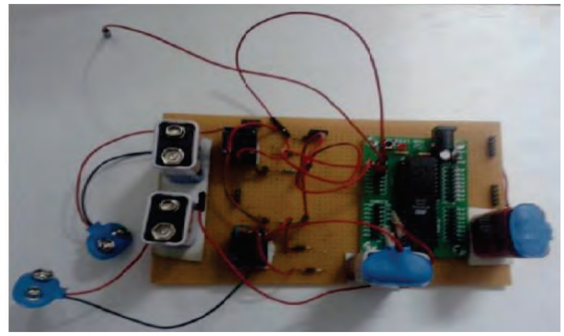

Fig. 1: Automatic Toll Gate

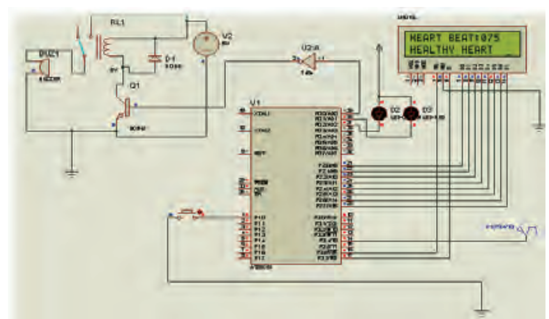

Fig. 2: Heart Beat Monitor

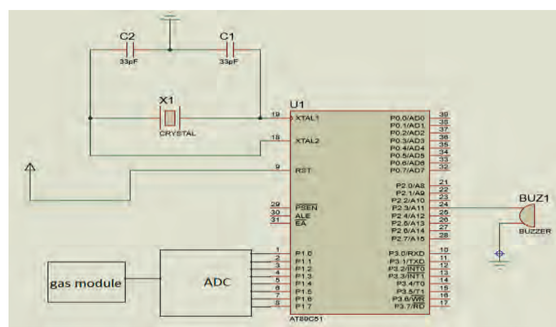

Fig. 3: Gas Leakage Detection

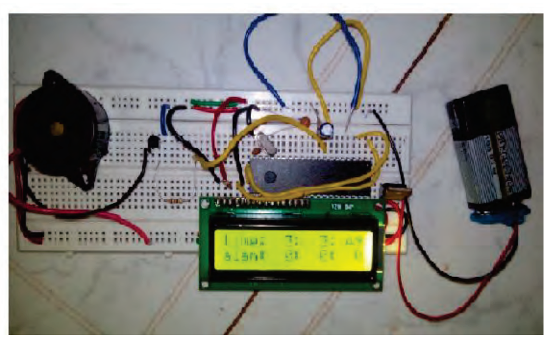

Fig. 4: Alarm fitted Digital Clock

VI. RESULTS

The main objective of this approach was to attain the ABET program outcomes ‗c' and ‗g' and accordingly rubrics were decided and assessment was conducted.

Out of the 36 course projects we found that four were of excellent quality, fifteen could be categorized as good and remaining seventeen were found to be of average quality

The ABET outcome ‗c' focuses on strengthening the ability to design and implement a controller based system. Evaluation of outcome ‗c' was based on assessment of problem identification and model implementation metric goal of 8 was chosen to evaluate this outcome since the result analysis of the pre requisite course on digital electronics showed an 80% score. Our chosen value of metric goal was justified with an attainment of 8.4. as shown in Fig.5.

Our activity also intended to improve the communication skills of the students which maps to ABET outcome ‗g'. A metric goal of 6 was fixed as a performance measure with due consideration to the fact that, about 40% of our students come from a rural background. The average attainment which was evaluated through viva and presentation was found to be 5.8. as shown in Fig.6.

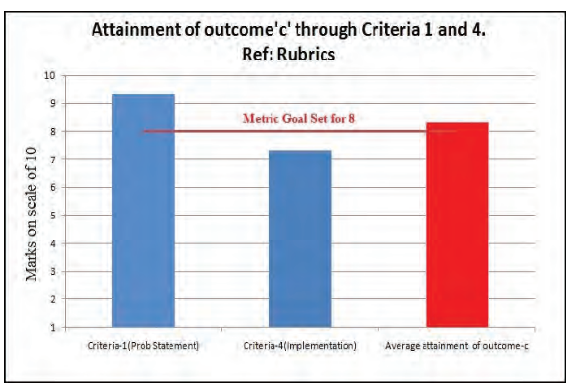

Fig. 5: Attainment of outcome ‗c'.

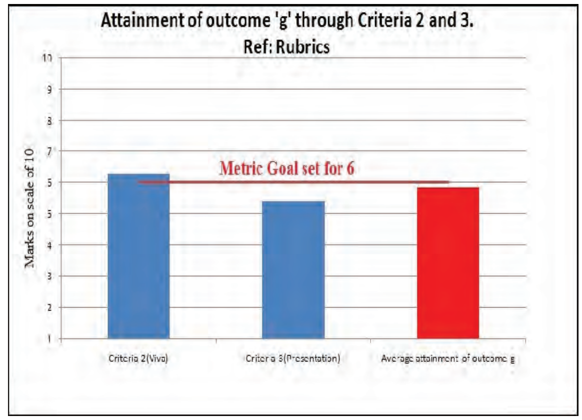

Fig. 6: Attainment of outcome ‗g'.

VII. CONCLUSION

The results obtained represent that through the course projects, the course instructors were able to inculcate design skills to a satisfactory level and it is also observed that there is always a scope to improve on the same. But it is observed that the metric goal set for outcome ‗g' is not achieved to expected margin. In the upcoming academic year, innovative approaches should be introduced to improve upon the outcome attainments.

References

[1] Ayala.K.J, ―The 8051 Microcontroller Architecture, Programming & Applications", 2ed., Penram International, 2006.

[2] Mazidi.M.A, Mazidi.J.G and McKinlay.R.D, ―The 8051 Microcontroller and Embedded Systems-using Assembly and C", 2ed, PHI 2006/Pearson, 2006.

[3] Ayala.K.J., Gadre D.V., ―The 8051 Microcontroller & Embedded Systems using Assembly and C", 1ed., CENGAGE Learning, 2010.

[4] V. Udayashankara, M.S. Mallikarajunaswamy, "8051 Microcontroller Hardware, Software and Applications", 1ed., Tata McGraw Hill, 2009.

[5] Chiu Choi, ―A Microcontroller Applications Course and Freescale‗s Microcontroller Student Learning Kit.",2008.

[6] J. D. Booker, C. L. Wishart and K. Alemzadeh ―Implementation issues and benefits of integrating microcontrollers in an existing design and build project" ,2006.