Teaching of microcomputer technology through practical robotic ground vehicle application

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ABSTRACT – Teaching of microcomputer technology to beginner students is not an easy task as it requires a clear understanding of what really happens in the "brain" of microcomputers. This paper presents how the problem is addressed by practical application during a microcomputer course. The application is a robotic ground locomotive vehicle. It involved the assembly and integration of mechanical, electrical and microcontroller components along with the use of two computer software – Flowcode and Proteus. An average of 80% checkpoints reached by the vehicle was obtained which indicate very well mastery of the targeted course content.

1. INTRODUCTION

Teaching of microcomputer technology to a group of beginner students is not an easy task, especially if the students are not of adequate information and communication technology background knowledge. Explaining different levels of computer language along with different number system incorporated within the brain and interface of microcomputers are not enough to prepare them sufficiently-versed, even as a young undergraduate.

Traditionally, the teaching of microcomputer technology (i.e. microprocessor and microcontroller) are done through classroom lectures. This involves a thorough lecture on the architectures and programming aspects of microcomputer, with little emphasis on real hardware interface. However, many has taken the step to overcome this through different approaches. Bolanakis *et al.* [1] explained three different approaches taken by tutor: (1) through simulation, (2) through computer unit operation, (3) use of commercial training kit. He mentioned that there is opinion on how the last approach is better than the others.

Ibrahim [2] reported the benefits of having practical session in microcomputer course. He taught the application of microcomputer in temperature monitoring, pressure monitoring, electronic piano etc. Such assignments apply generally to many engineering students. Yin and Zhang [3] also reported a practical approach in the teaching of microcomputer. He explained the approach based on a demonstration on a digital display.

For mechanical engineering students, the application of microcomputer on mechanical instrument is more appealing. This paper reports the teaching of microcomputer technology course (Microprocessor Technology) coded BMCG2212, to 2nd year students of Faculty of Mechanical Engineering in Universiti Teknikal Malaysia Melaka. The paper explains how a suitable curriculum is developed for these students to integrate theoretical aspects and practical implementation of microcomputer technology. The curriculum had to be suitable for a one semester course and for only a 2 credit graduation requirement.

2. METHODOLOGY

Careful thought was given in providing the students with adequate knowledge of microcomputer's architecture and internal bit communication, coupled with a practical application. The semester is divided into two parts, where the first part is focused on teaching the fundamentals of microcomputer, which include short history, architecture knowledge and, arithmetic and logic operation. The second part is devoted to preparing them for practical assignments – which is development of robotic ground vehicle application. The second part includes teaching, with real demonstration of, computer programming using Flowcode software and simulation of source code execution using Proteus software (refer to Table 1).

Table 1 Microprocessor Technology course content.

Semester	Content
First part	• History and components of microcomputer • Microcomputer architecture • Arithmetic and logic operation • Computer number system • Microcontroller characteristics
Second part	• Flowcode programming • Proteus simulation • Embedded application on robotic vehicle • Assignment Troubleshooting

The PIC16F84 microcontroller was selected for the application. It is an 8-bit microcontroller of 18 pins. It is based on FLASH/EEPROM technology and compatible with many programming software [4]. The characteristics are taught in the first part of the semester.

Two software were introduced and these were

Flowcode and Proteus (a.k.a. Proteus Design Suite). The Flowcode is an easy programming software that is based on graphical programming style (such as flowchart) in code development. The students do not need to learn common programming language such as C to develop the codes. It is friendly to non-programmers and also provide simple simulation to help verify the correctness of the codes.

Following this, the codes were then saved and imported to Proteus software where the students learn on electronic design and assembly. After simulated assembly, the codes may be tested as an embedded instructions in a PIC16F84A simulated microcontroller to perform required tasks. The tasks of LED lighting, LCD display, motor operation etc. may be verified through simulation. Throughout this second part, as the assignment is given to groups of 5-6 students each, hints were given as to how to carry out the assignment.

The assignment was to build a robotic vehicle based on a hobbyist car chassis (which can be bought online from GI Electronic as a 2WD Smart Robot Car Chassis coded R0100006) [5] and program it using PIC16F84A microcontroller to move through 5 ground checkpoints within an area of about 2 m × 2 m. Once the source code was ready, the instructors provided the facility to import the file into the hardware PIC.

3. RESULTS AND DISCUSSION

On the day of the evaluation, the vehicle was tested on a number of aspects i.e. number of checkpoints reached, time taken and distance error between vehicle and checkpoints. Figure 1 shows the assembled vehicle of one of the group. Figure 2 shows one of the vehicle on the test day. The students showed high enthusiasm since the beginning of the process until the test day. At the end of the evaluation, an average mark of 5.9/8 for all aspects is obtained, where within this mark, an average of 4/5 checkpoints arrived was recorded. The mark indicates that the student have mastered the blocks in Flowcode very well, proper timing of straight and turn motion (which requires understanding of microcontroller processing frequency and wheel synchronization) and understanding of bit transfer communication, as in Proteus simulation.

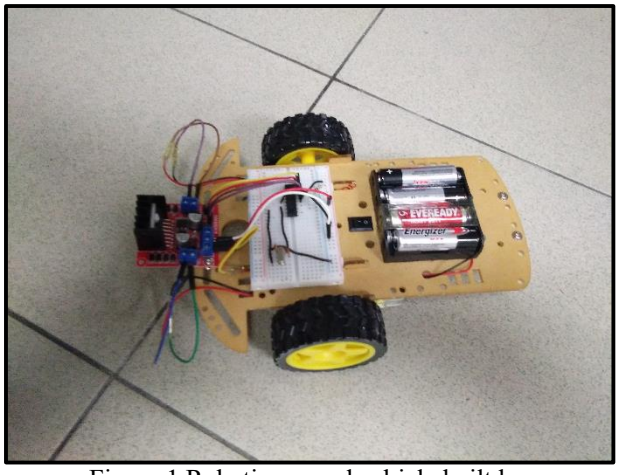

Figure 1 Robotic ground vehicle built by microcontroller course student.

Figure 2 Robotic ground vehicle during evaluation.

The project-based learning approach really enhanced the student's understanding and enabled them to explore and troubleshoot much more than expected such as:

- how to overcome ground surface obstacles
- how to efficiently assemble and integrate the mechanical and electrical components
- how to make accurate turns and distance of travel

It is observed that the project also improved their communication, interaction and teamwork skills.

4. CONCLUSION

The teaching of microcomputer technology through practical application enabled students to clearly grasp and appreciate the capability of microcomputer technology. Particularly, for a group of students of early mechanical engineering background, the teaching of microcomputer course through practical assignment is hereby reported. With an emphasis on real mechanical instrument, students experience much satisfaction in applying their knowledge, enhancing their soft skills and preparing them better for formal exam-based assessment.

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