Intensifying the Interest in Embedded Systems Programming Using LPC2148 Microcontrollers

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Abstract—**This paper presents a modality in which LPC2148 microcontrollers can be used for undergraduate laboratories. The presented case is referring to the practical project part of Embedded Systems course from Computer and Software Engineering Department, Faculty of Automation and Computers, "Politehnica" University of Timisoara, Romania. Our emphasis is on the used microcontroller and also on the existent possibilities to offer hands-on approaches for students.**

Index Terms—**Embedded systems, teaching, microcontrollers, LPC2148, industry demand**

I. INTRODUCTION

Practical laboratory or project sessions are an essential part of every computer engineering curriculum. The challenge is both for students to understand and develop practical skills in embedded systems, but also for teachers. There is a continuous research and experiment process for the teachers in order to offer a practical, hands-on approach for the students. In the same time each teacher should try to manage to infuse the students with a proper understanding of this domain.

The first challenge of offering hands-on abilities is coming from the industrial demands. Each company is demanding to obtain a high-qualified engineer after graduating the university. This is indeed to be expected from a fresh-graduate engineer. But the companies are also demanding that the engineers to be proficient in a number of specific methodologies, tools and microcontrollers. In this regard, the challenge that a microcontroller teacher has to face is a most demanding one: first of all, he has to teach the students the basic principles of microcontrollers and embedded systems. Secondly, he has to mould the academic teaching process in such a way that different industrial expectations to be met. Different companies are working on different microcontrollers. The companies are generally expecting that a fresh-graduate engineer to be proficient in their particular microcontroller. But not all these microcontrollers can be taught in a course, but rather one microcontroller can be extensive presented (and also worked on laboratory sessions [1]). In addition to this, another microcontroller can be used for practical projects.

It has been previously presented [2] the fact that a holistic approach (Fig. 1) for teaching embedded systems and microcontrollers should form industrial competences, but in

a systematic, academic approach. This means, that not only theoretical information should be offered to the students, but also practical, hands-on abilities should be developed in a step-by-step approach. In the annual dialogues that different universities are organizing with the industry [3], [4] different companies are stating that the graduates should have a more practical education. More than this, each student should be aware of the importance of following a certain process when developing an embedded system.
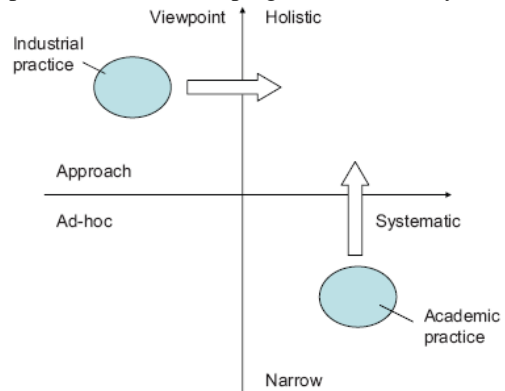

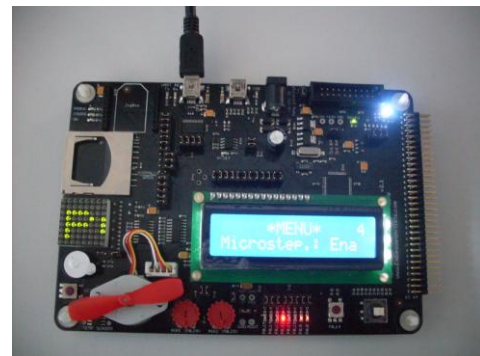Fig. 1. Balancing academia and industry approaches [2].

Fig. 2. LPC2148 used system.

This paper presents an approach into teaching practical project part of Embedded Systems course by means of LPC2148 microcontroller. The rest of this paper is structured as follows: section 2 presents the reasons why we adopted an LPC2148 microcontroller and also the structure of this lab. Section 3 presents the obtained results of using such a laboratory approach and the last section states the conclusion and future work.

II. MATERIALS AND METHODS

A. Choosing the Proper System

The Embedded Systems course which practical project part we are referring in this paper is part of the third year of

study curriculum at Computer and Software Engineering Department. The main reason for choosing a certain system based on a microcontroller was the fact that the students should obtain a practical understanding regarding this domain [5]. There are a plethora of microcontrollers with different periphery, used in different industrial products.

But the reason for choosing a certain microcontroller to implement the projects was the industrial demand. In this regard, there is a spectrum of microcontrollers being used at the present moment in different industrial products. We aimed at both providing the students with hands-on experience with a largely used microcontroller, but in the same time the used board should provide different periphery such as LCD, stepper motor, analogue inputs, temperature sensor, LEDs etc.

Having in mind the above-mentioned criteria our option was a board from Embedded Artists called LPC2148 Education Board [6]. The usage of this board in the project sessions is presented in Fig. 2. This board is based on an ARM7 microcontroller and is equipped with SD card slot, LED matrix, stepper motor, different LEDs, LCD, LM75A temperature sensor, analogue inputs, ZigBee interface, joystick. Therefore different applications can be developed, offering the students the ingredients to acquire practical abilities.

B. Project's Content

The following steps after choosing the system was the elaboration of the desired themes for the project. Our choice was to allow two students to work on a certain theme. They all have access to datasheets and examples on how to program LPC2148. As an IDE we opted for Keil [7]. In Fig. 3 is presented the board and the IDE at one of the 7 working points from the laboratory room.

Fig. 3. Keil and LPC2148 board.

The next challenge that we faced was to formulate different themes for each team. Each team had to solve the problem by using the offered documentation, example of how to develop in Keil and the board. It was assumed that each student knows basics of C programming. More than this, at the first project session we offered training on how to program a microcontroller in C. The themes we formulated are presented as follows:

- Theme 1: Realizing a thermometer by using LM75A temperature sensor and the provided LCD.

- Theme 2: Control the direction and speed of the stepper motor.

- Theme 3: Convert the analogue values from the analogue inputs into corresponding binary values. The results have to be visualized on the LCD and the LEDs.

- Theme 4: Realizing a clock on the LCD.

- Theme 5: Control the LED matrix. Visualize the correct functioning by displaying a certain text message.

- Theme 6: Connect the board to the internet by means of the provided expansion board.

- Theme 7: Realize a file-explorer for an SD card. The LCD is used to visualize the SD card content.

Fig. 4. Example of setting the parameters for theme 2.

Each team had to realize a menu where different parameters can be adjusted according to the theme. In Fig. 4 the implementation of such a menu can be visualized for Theme 2 In the following example, partial code of implementing the menu is offered.

Example: Implementing the parameters' menu for Theme 2

```
switch(dir)
{
    case 0: lcd_puts(76,"STOP"); break;
    case 1:  lcd_puts(76," CW"); break;
    case 2: lcd_puts(76," CCW"); break;
}
lcd_putnum(0,usps/10,3,0);
if(ustep_en)
{
    lcd_puts(12,"u");
    lcd_putnum(8,usps,4,0);
}
else
{
    lcd_puts(12," ");
    lcd_putnum(8,usps/30,4,0);
}
if(read_adc)
    lcd_puts(72,":EN");
else
```

> *lcd_puts(72,":DI");*
> *break;*

In solving each project's theme, the students had to take into consideration the specific peculiarities of programming an embedded system. Such constraints are of high importance in the performance problems of industrial embedded systems. Therefore, each project is considered to be completely finished only after discussing the implementation of such performance constraints.

III. OBTAINED RESULTS AND FUTURE WORK

In order to quantify the obtained results, our survey aimed at establishing the progress that each student managed to acquire. Therefore, the same survey was offered at the beginning of the project activity and also at the end.
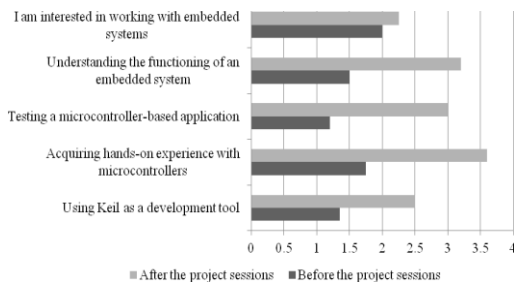

Fig. 5. Student perception of acquired competencies: before and after the project sessions.

The results are presented in Fig. 5. It can be concluded that the students appreciated the practical orientation of the project sessions, but also the better understanding of how an embedded system is functioning. However, the domain of embedded systems is still viewed as not very approachable.

As future work, we plan to introduce to students different tools and devices that are used in order to develop embedded systems on an industrial level. In this regard, specific partnerships with local companies are envisioned and planned such as that the student to have access to state-of-the-art industrial methodologies, tools and devices.

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