Work in Progress: Retooling a Microprocessor Course for a Real-World Example Project

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Abstract

The author's institution offers a Microcontrollers/Microprocessors class, which is required for juniors and seniors in electrical and computer engineering majors. The topics covered in this class follow the IEEE Computing Curricula for Computing Engineering recommendations [1]. These topics deal with basic processor architecture, memory structure, I/O and buses, interrupts, timers and counters, and digital to analogue (D/A) and analogue to digital (A/D) conversion.

Currently, these topics are taught by presenting them first in class lectures and then letting the students apply individual topics in labs. However, student feedback (through formal evaluations and informal discussions) indicates that many students often struggle to connect these topics to real-world applications.

In this paper, we propose that the cause for the students' difficulty relating their learning to real-world applications stems from the current method of presenting these topics; that is, presenting them each individually without a cohesive overall application. Moreover, learning about the minutiae first from the lecture before actually "seeing" the need for them presents another hurdle for the students.

In this paper we present a work in progress for an application to help the students relate the topics they learn to a real-world example of an intelligent home thermostat. We discuss how the different aspects of this application can relate to all the topics covered in class. As the students learn each topic, they can augment the application functionality with a cohesive objective. The application would then provide contextual glue to all the topics covered. The hope is that students will be more motivated to learn the topics in real context. And once they enter the professional world, they will have a good chance of applying the topics they learned.

1 Introduction

Educators have been reporting the benefits to student learning by adopting project-based approach in microprocessors classes [2]. Other educators have also shown the benefits to student learning by adopting real-world examples, such as problem-based learning or active learning, in microprocessor and computer engineering courses [3, 4, 5].

The author's institution offers a Microcontrollers/Microprocessors class, which is required for juniors and seniors in electrical and computer engineering majors. For three semester credits, the course covers microprocessor structure, registers, RAM and ROM addressing, machine cycles and timing relationships, input and output ports and addressing, assembly level programming, timer systems, analog-to-digital converters, serial and parallel communication. The class is accompanied with lab activities that apply the subject learned in lectures.

1.1 Current Laboratory Approach

Currently, these topics are taught by presenting them first in class lectures and then by letting students apply each topic in a series of 10 to 11 labs. **Error! Reference source not found.** shows the current topics and their lab setup.

Lab	Topic	Lab setup
1	Assembly language	Intro to programming environment
2	Addressing modes	Assembly programming
3	Delay	Loop (polling)
5	Delay	Keypad interfacing
6	Interrupts	LED control
7	Timer—output compare	Stepper motor
8	Digital to analog conversion	Waveform generation
9	Timer—input capture	Period measurement of external waveforms
10	Serial communication	LCD control
11	Analog to digital conversion	Waveform generation

Table 1, Lab topics and setup for the current Introduction to Microprocessors course.

1.2 Observations and Feedback

In the class evaluation survey from fall 2013, students overall indicated they were satisfied with their learning. Although the course objectives were being met, the evaluations showed that the students had one main concern: being exposed to more real-world examples. The students wanted to see how what they learned in class could be applied in a real-world project.

1.2.1 More examples

Consistently, the students in their evaluations asked for more examples about each of the topics. Although examples were mentioned in the lectures, the challenge the students had is that they were not actually applying these examples in the lab. For example, when students learn about timers and interrupts, they are first presented with minutiae of a timer and interrupt functions for a particular microcontroller version (e.g. the Freescale HCS12). They are then asked to apply those functions to drive a stepper motor in the lab. Although the stepper motor can be used in many real-world applications, the students are not in reality doing any of those applications.

1.2.2 Lack of Project Approach

Although currently each individually exercises the covered topics well, the labs do not relate to each other in one cohesive topic. This makes it harder for the students to appreciate the importance or usefulness of each topic.

2 Proposed Application: An Intelligent Home Thermostat

In order to remedy the students concerns, we propose a project-based approach for the lab. This approach would allow the students to incrementally build on their project each week by applying the individual topics into one overall application.

The intelligent home thermostat would provide the overall application. The application would feature sensors to control the temperature in a home setup. The heating and cooling would be implemented on a house mockup setting through a heating element (representing a furnace) and a small fan (possibly a computer fan representing air-conditioning). A temperature sensor would provide the main input temperature control. An LCD and a keypad would provide a user interface to display current temperature and input desired temperature and schedule. A light sensor would provide inputs as to whether a day or night schedule should be applied, and a motion sensor would provide information as to whether the home is occupied.

We envision relating the class topics to the home thermostat application by dividing the home thermostat application into the lab subprojects shown in Table 2 .

Lab	Topic	Lab setup
1	Assembly language	Read values from input switches
2	Basic I/O	Control cooling fan/ Heating element
3	Analog to digital conversion	Read values from temperature sensor
4	Serial communication	Display temperature on LCD
5	Parallel I/O	Read values from keypad to enter desired temperature
6	Structured programming	Maintain desired temperature by controlling heating element and cooling fan
7	Interrupt	Read motion and light sensor during main temperature control loop to change desired temperature settings (based on night/day and occupancy)
8	Timer	Maintain desired temperature based on schedule
9	Timer—output compare	DC motor control to open and close vents or shades
10	Digital to analog conversion	Alarm generation for malfunction or speech synthesis

Table 2, Topics and lab sub-projects for the intelligent home thermostat project.

By having the labs contribute to one cohesive project, we hope that students will be motivated to complete the sub-projects to see their overall design working together. We also hope that the students will realize the benefits for each topic by seeing it work in real-world context.

3 Challenges and Future Directions

Besides retooling the lab topic to fit into a project, logistical issues have to be addressed in terms of providing material support in the lab. Moreover, the course load should remain three credits to maintain consistency with the overall curriculum for both electrical and computer engineering students.

Collecting data on students' feedback and performance will be carried out for the next few iterations of the class. Once this data is collected, findings on students learning will be presented in national conferences such as ASEE or the IEEE Transaction on Education.

4 Conclusion

In this paper we presented a concept of a work in progress to improve student motivation and learning an introductory microprocessors class. The current lab setting exercises each topic separately without context to real-world examples. The students' feedback has indicated that they needed more real-world examples. We would like to introduce a project-based approach to the class with a real-world example. The intelligent home thermostat application would serve and as cohesive project in which student can apply the individual topics they learn.

References

1. IEEE Curricula, Computer Engineering, available at: http://www.eng.auburn.edu/ece/CCCE/CCCE-FinalReport-2004Dec12.pdf

2. D. R. Surma. "Teaching Microprocessors Utilizing a Project-Based Approach". ACM Journal of Computing Sciences in Colleges, 2003.

3. A. Carpeno, J. Arriaga, J. Corredor, and J. Hernandez, "The Key Factors of an Active Learning Method in a Microprocessors Course", IEEE Transactions on Education, Vol. 54, No. 2, 2011.

4. A. Striegel and D. T. Rover, "Problem-Based Learning in a Introductory Computer Engineering Course", 32nd ASEE/IEEE Frontiers in Education Conference, 2002.

5. J. Kim, "An Ill-Structured PBL-Based Microprocessor Course Without Formal Laboratory", IEEE Transactions on Education, Vol. 55, No. 1, 2012.