Improved Student Learning of Microprocessor Systems Through Hands-On and Online Experience

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Overview

In this work, an approach is presented to assess and improve the understanding of microprocessor systems for electrical and computer engineering students by developing measurement based lab experiments. During fall semester of 2009, we assessed the level of understanding of microprocessor systems on a control group using five learning objectives. We measured the level of understanding using a set of assessment tools that included weighted multiple choice questions, short answer questions and self surveys, . These assessments set a baseline measure on the five learning objectives for our current microprocessor curriculum.

In fall of 2010, we will introduce measurement-based laboratory experiments using logic analyzers on subsequent student groups and assess whether understanding of the five learning objectives improves compared to the control group. The measurement-based experiments will be introduced in two forms, hands-on and remote operation. Assessment data will be collected for both experiment groups to determine if the level of understanding of microprocessor systems can be improved by adding hands-on measurements and if a remote laboratory experience can maintain or improve the level of understanding compared to the control group.

Experiment Groups

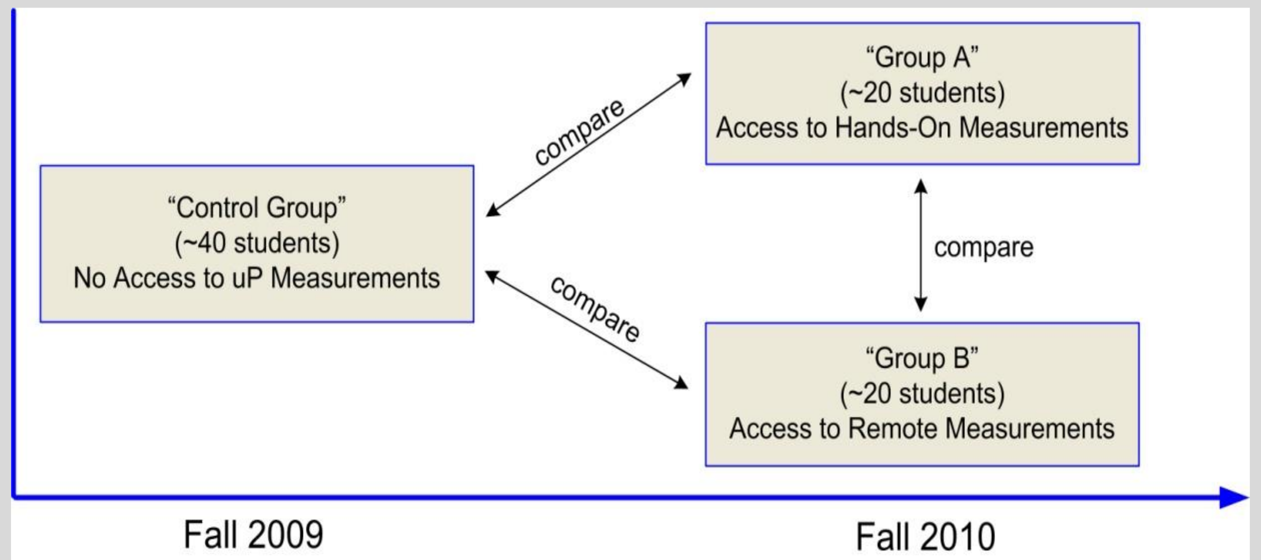

Fig 1. Student groups that will be compared in this project.

Learning Objectives

1) Describe the basic architecture of a stored-program computer.
2) Describe the addressing modes of a microprocessor.
3) Describe a typical I/O interface and understand its timing.
4) Analyze a timing diagram of the interaction between the microprocessor and memory.
5) Synthesize a timing diagram of a READ/WRITE cycle between the microprocessor and memory.

Assessment Tool Development

1) Weighted Multiple Choice: To reduce the variance in the outcome score due to all-right or all-wrong answers, multiple-choice questions were developed that had answers with different levels of correctness . This allowed a more accurate measure of the level of student understanding.

Ex) Which of the following statements best describes why you should use indexed addressing instructions instead of direct addressing when accessing data in a table? (Objective 2)

A) Direct addressing instructions can be modified in a loop by the program but it is more difficult to do than modifying indexed addressing instructions. (0 points)

B) Indexed addressing instructions are shorter than direct addressing instructions. (2 points)

C) Indexed addressing instructions can be used in a loop because the offset can be modified by the program while Direct addressing instructions cannot. (2 point)

D) Your program will be shorter if you use indexed addressing instead of direct. (3 points)

E) Indexed addressing instructions can be used in a loop because the effective address can be modified by the program while direct addressing instructions cannot. (5 points)

2) Short Answer Questions with Scoring Rubric: SA questions with a corresponding grading rubric were developed. The SA questions allowed the students to express their understanding of the topic in their own words. The scoring rubric was developed which gives varying levels of points to the answer depending on the correctness of the answer. The scoring rubric was tested by having multiple graders (2 faculty, 3 grad students) compare scores to verify its clarity.

Ex) Describe the memory architecture of a microcontroller that allows your program to run in an embedded system application. (Objective 1)

Full credit (3 points) Microcontrollers have two types of memory, RAM (volatile) and ROM (non-volatile). In an embedded system the application program resides in the ROM so that it is there when the microcontroller is powered-up. In addition, the ROM must have a vector or starting address of the application program to allow the program to start correctly. A stack in RAM must be available when subroutines are used in the program because jump-to-subroutines store the return address there. The program may use the RAM to store variable data.

Partial credit (2 points) ROM is used for the program and RAM is used for variables and the stack.

Partial credit (1 point) ROM is used for the program and RAM is used for variables.

No credit (0 point) "None of the elements of a correct answer listed above are present"

3) Self Evaluation Surveys: Students were asked to evaluate their own understanding of the five learning objectives before and after the labs covering those topics.

Measurement-Based uP Labs

The existing microprocessor laboratory setup at MSU includes a FreeScale project board with an HCS12 processor. Student use the CodeWarrior development environment to design programs in assembly to accomplish laboratory tasks. Students debug their code using solely the built-in debugger within CodeWarrior.

In this project, each lab station will be augmented with a Tektronix TLA5201B Logic Analyzer. This instrument has the capability of displaying 34 digital signals up to 250MB/s. This instrument will allow the students to physically measure the signals that are coming into and out of the microprocessor.

The Logic Analyzer can also be controlled remotely using Windows *Remote Desktop*. By installing CodeWarrior on the Logic Analyzer, students will be able to conduct the entire lab remotely including: (1) Code development; (2) Program download to the project board via USB; and (3) Taking physical measurements on the signals on the project board.

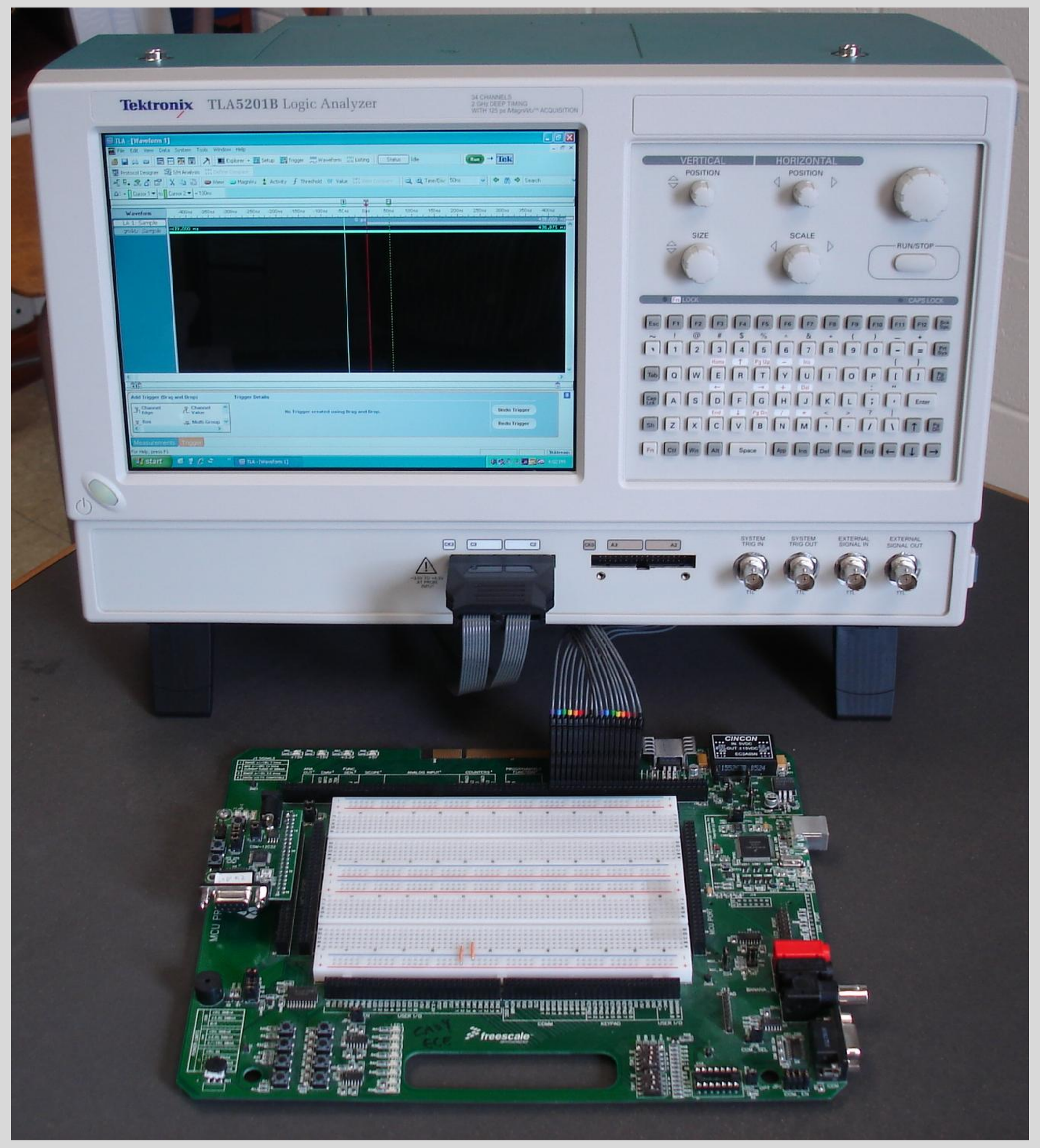

Fig 2. Laboratory Setup which includes FreeScale Project board and Tektronix Logic Analyzer. CodeWarrior is installed on the Logic Analyzer and the probing connection to the project board is pre-defined. This setup will be used in both hands-on and remote experiments

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