Project Oriented Course in Mechatronics

Scott Kiefer
Tri-State University

Abstract

This paper describes a multi-disciplinary, hands-on, project oriented course in mechatronics. The course relied almost entirely on active learning techniques using student project work, and included the development of oral and written communication skills. Student and faculty assessment of the learning objectives of this course are included in the paper.

Although open to all engineering and technology students, the mechatronics course was composed of two groups: undergraduate mechanical engineering students and graduate level technology students. The students were divided into groups of two or three and given a new project to complete for each of the first ten weeks of the course. At the completion of each project, the students were required to prepare a ten-minute PowerPoint presentation describing their project. The projects included material such as building an analog to digital converter, using a transistor H-bridge for motor control, construction of digital logic circuits, the use of proximity sensors, and the creation of music using a microprocessor. The final six weeks of the semester were used for the students to complete a design project of their choosing. They were required to submit a written project proposal, complete with deliverables and a timeline, before beginning the project. At the completion of their final projects, the students were required to prepare an oral presentation of their project and present it to a group of other students and faculty.

Introduction

This course in mechatronics has been offered twice, once at the University of Puerto Rico at Mayaguez (UPRM) and once at Tri-State University in Angola, Indiana. Both times it was offered as an elective course open to all engineering undergraduates, and at Tri-State it was also offered to masters level students in the technology program. The class at UPRM consisted of eleven mechanical engineering students, and the class at Tri-State consisted of eight mechanical engineering students and two masters level technology students.

The course was divided into two parts. The first ten weeks of the course covered introductory material and included weekly, hands-on projects in mechatronics. The last six weeks of the course involved a design project where the students applied what they had learned to design and build a working mechatronic device.

Active Leaning and Oral Presentations

What makes this class unique is the complete immersion in active learning and the use of frequent oral presentations. The first ten weeks of the course involved the students working in groups of two or three to complete basic projects in mechatronics. Each week the students were given a handout detailing a project along with oral instructions and demonstrations on how to complete it. The students were then given one week to complete the project as a group at their own pace. There was a designated meeting time later in the week that they could attend to get help from the instructor (or from other groups), and of course the students could also get help during the instructor's office hours.

After completing the project, each group was required to prepare a ten-minute PowerPoint presentation. When the class met the next week, two students were then chosen at random to give their presentations. The students were not told ahead of time who would be presenting, and the entire project group was graded according to the presentation of the group member that was chosen to present. This encouraged every student to no only make sure that they understood the material, but that the other members of their group also understood the material. In addition to the group project grades, two exams were giving during the semester to insure that the students were getting individual assessment. Also, a peer evaluation was conducted at the end of the semester to judge the participation of all group members.

Basic Projects

The microprocessor chosen for this course is manufactured by Netmedia, and is called the "BasicX". The BasicX is about the size of a postage stamp (shown in figure 1) and is programmed in a form of Basic making it relatively easy for students to learn how to program[1]. Some of the students who were taking the mechatronics course had programming experience and some did not, so the weekly project handouts assumed that the students had never programmed before. A development board made by Netmedia was also used for this course (shown in figure 2). The BasicX is similar to a processor called the Basic Stamp, produced by Parallax, that is used by many universities who are teaching mechatronics courses. The BasicX was chosen over the Basic Stamp for several reasons. The BasicX is capable of floating-point arithmetic, supports interrupts, has an on-board analog to digital converter, and has more EEPROM.

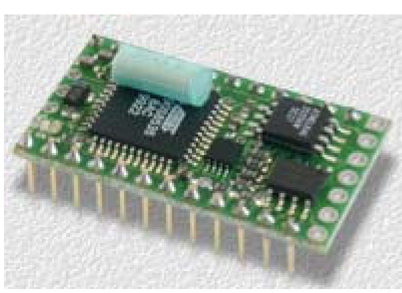


Figure 1: The BasicX

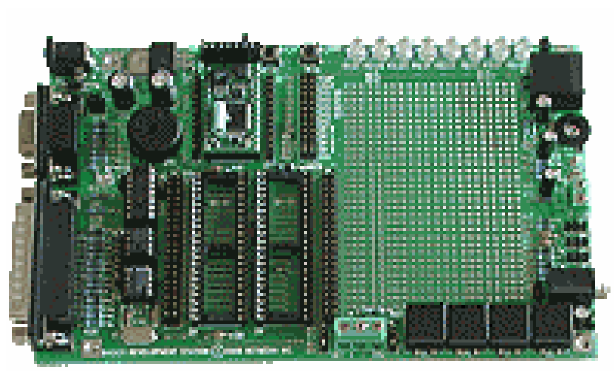


Figure 2: BasicX Development Board

Because this course was taught in the Mechanical Engineering Department, the students had very little experience in building electric circuits and no experience using microprocessors. To compensate for this lack of experience, the first projects of the course included an introduction to programming the microprocessor and building basic circuits. The coursework then progressed to include projects with RC circuits, voltage divider circuits, LEDs and switches, infrared sensors, seven-segment displays, timing functions, analog to digital conversion, H-bridges and motor control, digital logic, Hall-effect sensors, and frequency and sound control. A complete list of the projects is given below in table 1, and the complete handouts can be found at the author's web site[2].

Mechatronics Weekly Projects
1) Programming the Microprocessor
2) Lights, Switches, and Infrared
3) Buttons, Timing, and Numeric Displays
4) Conversion Between Digital and Analog
5) Using Timing for A/D Conversion
6) Motor Control Using an H-Bridge
7) Digital Logic
8) Measuring Motor Speed
9) Let the Music Play

Table 1: Mechatronics Projects

Final Projects

After completing the first ten weeks of simple projects, the students were feeling comfortable using the microprocessors with different sensors and actuators and were ready to apply what they had learned to more substantial projects. The project groups were allowed to come up with their own final project or choose from a list of example projects. They all were required to write a project proposal and have it approved by the instructor before they could begin their projects.

One group of students decided to construct a portable weather station[3] using a microprocessor to interpret data from various sensors. The station included the measurement of temperature, wind speed, and relative humidity. Relative humidity and temperature was measured using a Philips humidity/temperature sensor, and wind speed was measured with a Hall effect sensor and magnet. The Hall effect sensor determined the RPM of a shaft that was connected to three wind cups. Calibration curves were created for all sensors so that the microprocessor could calculate the proper values. The sensors were checked every 2 minutes and the results were displayed using an LCD readout (see figure 3).

Figure 3: Weather Station Project

A second group chose to construct an industrial sized, hydraulically operated, automatic can crusher. The device included several safety precautions to insure safe operation. First, a chute was constructed to hold up to four cans, and a proximity sensor was incorporated so that the device would not operate unless there was at least one extra can in the chute. This extra can insured that there was always something stopping the operator from putting their hand in the crushing mechanism. Another proximity sensor was used to insure that the can had fallen from the crushing chamber after being crushed. A control system with switched was also developed to control the stroke of the hydraulic cylinder.

Figure 4: Automatic Can Crusher

A third group altered a traditional radio-controlled car to become completely autonomous. First, the group used H-bridges to allow for microprocessor control of the steering and drive motors in the car. Next, they added infrared sensors to detect objects in front of it, and light sensors to enable the car to come to a flashlight. The control code was written so that the car would move around the room randomly until the vehicle sensed an object in front of it, or it sensed the light from the flashlight.

Figure 5: Autonomous Vehicle

Another group chose to automate a manually operated mill to facilitate the drilling of holes through several pieces of tubing at one time. This project was sponsored by a local company. Other projects included a table-top basketball game, a light and switch game, and an automatic drink mixer.

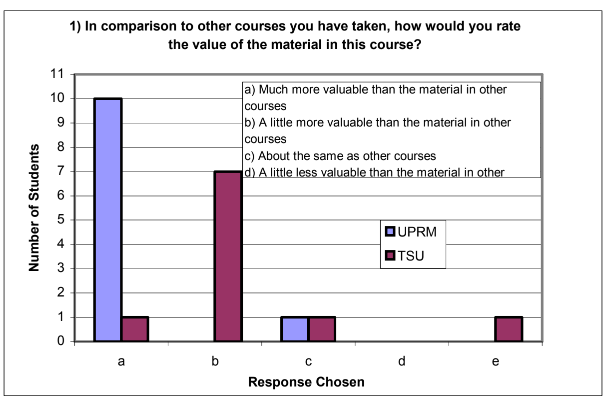
Instructor Observations

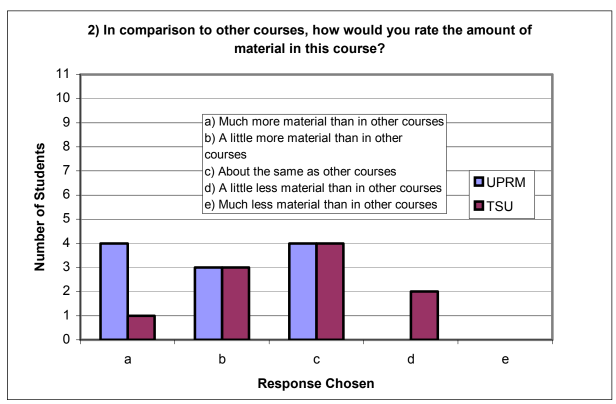
Overall, the instructor was very satisfied with the outcome of this course. Once the project handouts were written, the time commitment to this course was minimal considering the benefit to the students. The final projects were a great way to insure that the students truly understood the course material. Often the instructor would observe that the students had either forgotten or missed some of the subtle points of the weekly projects. After struggling for a few hours on a part of their final project, and asking for help, the instructor was able to point out exactly where that material was covered and could observe that the students truly understood the material at that point. Furthermore, they were reminded where to find the reference if they needed that information again in the future. The students were also motivated to continue working on future projects in mechatronics because they saw an immediate benefit to the knowledge that they were gaining.

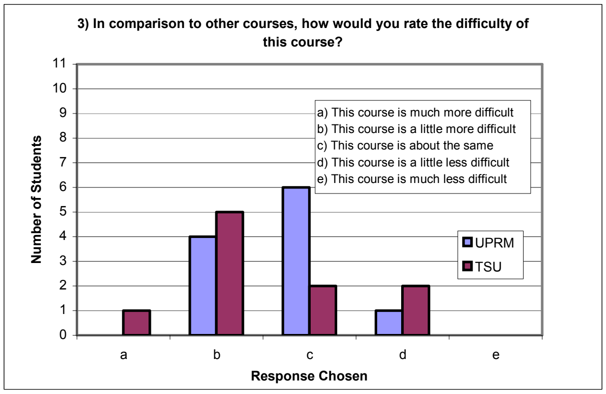
Giving the students a good oral description of each weekly project and adequate reference material was a very effectively way to keep the students in an active learning environment, and helped to motivate them toward life-long learning. Many of the students were able to find outside sources of information that the instructor had not considered using. One group of students was even able to apply the knowledge (and the microprocessor) they used in this course to complete a final project for another course they were taking.

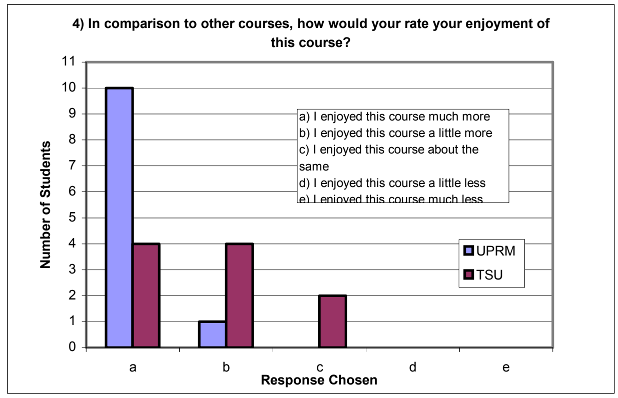
Student Feedback

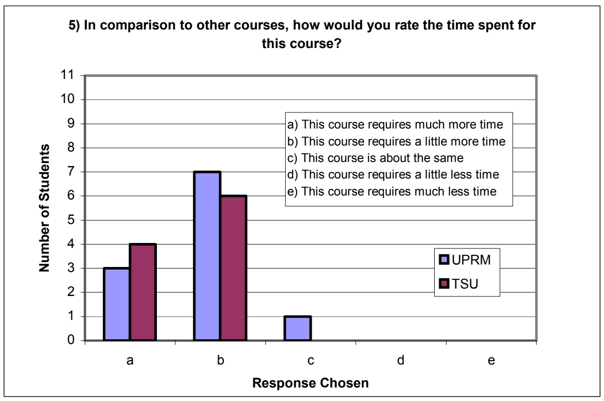
To get an accurate assessment of student perception of this course, a course survey was administered to both the students at UPRM and Tri-State. The results are given below in graphical form in figure 5.

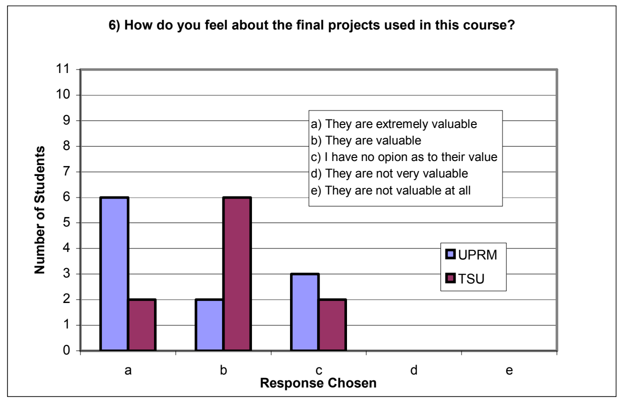


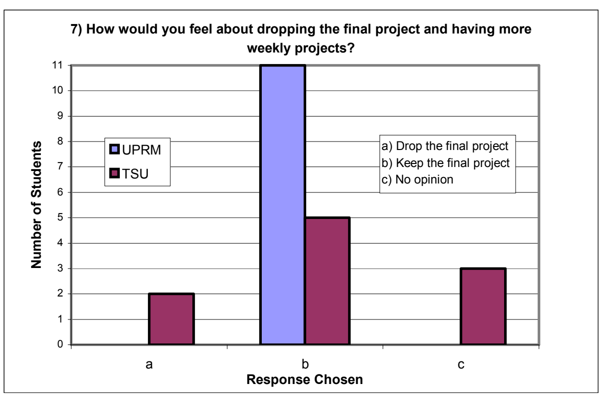


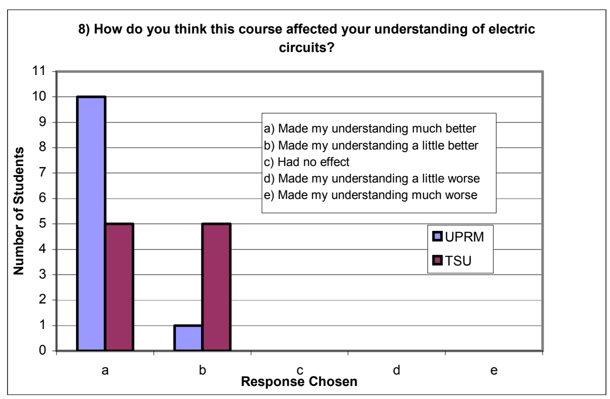

3) In comparison to other courses, how would you rate the difficulty of this course?
a) This course is much more difficult
b) This course is a little more difficult
c) This course is about the same
d) This course is a little less difficult
e) This course is much less difficult
UPRM
TSU
Number of Students
Response Chosen

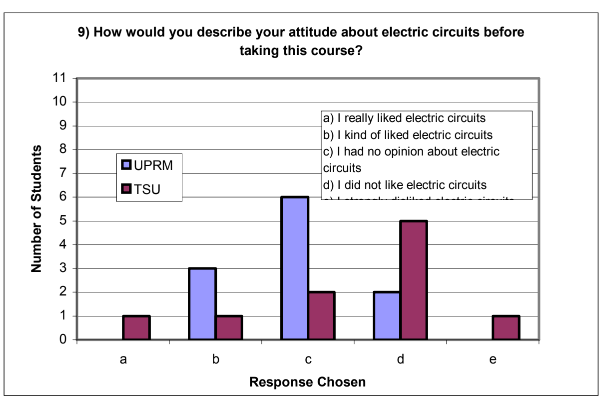

4) In comparison to other courses, how would your rate your enjoyment of this course?
a) I enjoyed this course much more
b) I enjoyed this course a little more
c) I enjoyed this course about the same
d) I enjoyed this course a little less
UPRM
TSU
Number of Students
Response Chosen

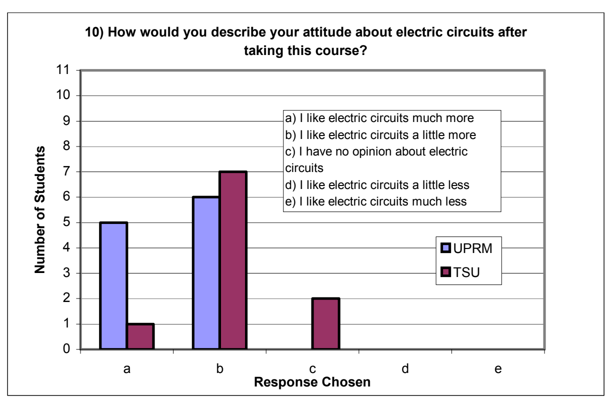

5) In comparison to other courses, how would you rate the time spent for this course?
a) This course requires much more time
b) This course requires a little more time
c) This course is about the same
d) This course requires a little less time
e) This course requires much less time
UPRM
TSU
Number of Students
Response Chosen


6) How do you feel about the final projects used in this course?
a) They are extremely valuable
b) They are valuable
c) I have no opion as to their value
d) They are not very valuable
e) They are not valuable at all
UPRM
TSU
Number of Students
Response Chosen


7) How would you feel about dropping the final project and having more weekly projects?
UPRM
TSU
a) Drop the final project
b) Keep the final project
c) No opinion
Number of Students
Response Chosen


8) How do you think this course affected your understanding of electric circuits?
a) Made my understanding much better
b) Made my understanding a little better
c) Had no effect
d) Made my understanding a little worse
e) Made my understanding much worse
UPRM
TSU
Number of Students
Response Chosen


9) How would you describe your attitude about electric circuits before taking this course?
a) I really liked electric circuits
b) I kind of liked electric circuits
c) I had no opinion about electric circuits
d) I did not like electric circuits
UPRM
TSU
Number of Students
Response Chosen


10) How would you describe your attitude about electric circuits after taking this course?
a) I like electric circuits much more
b) I like electric circuits a little more
c) I have no opinion about electric circuits
d) I like electric circuits a little less
e) I like electric circuits much less
UPRM
TSU
Number of Students
Response Chosen

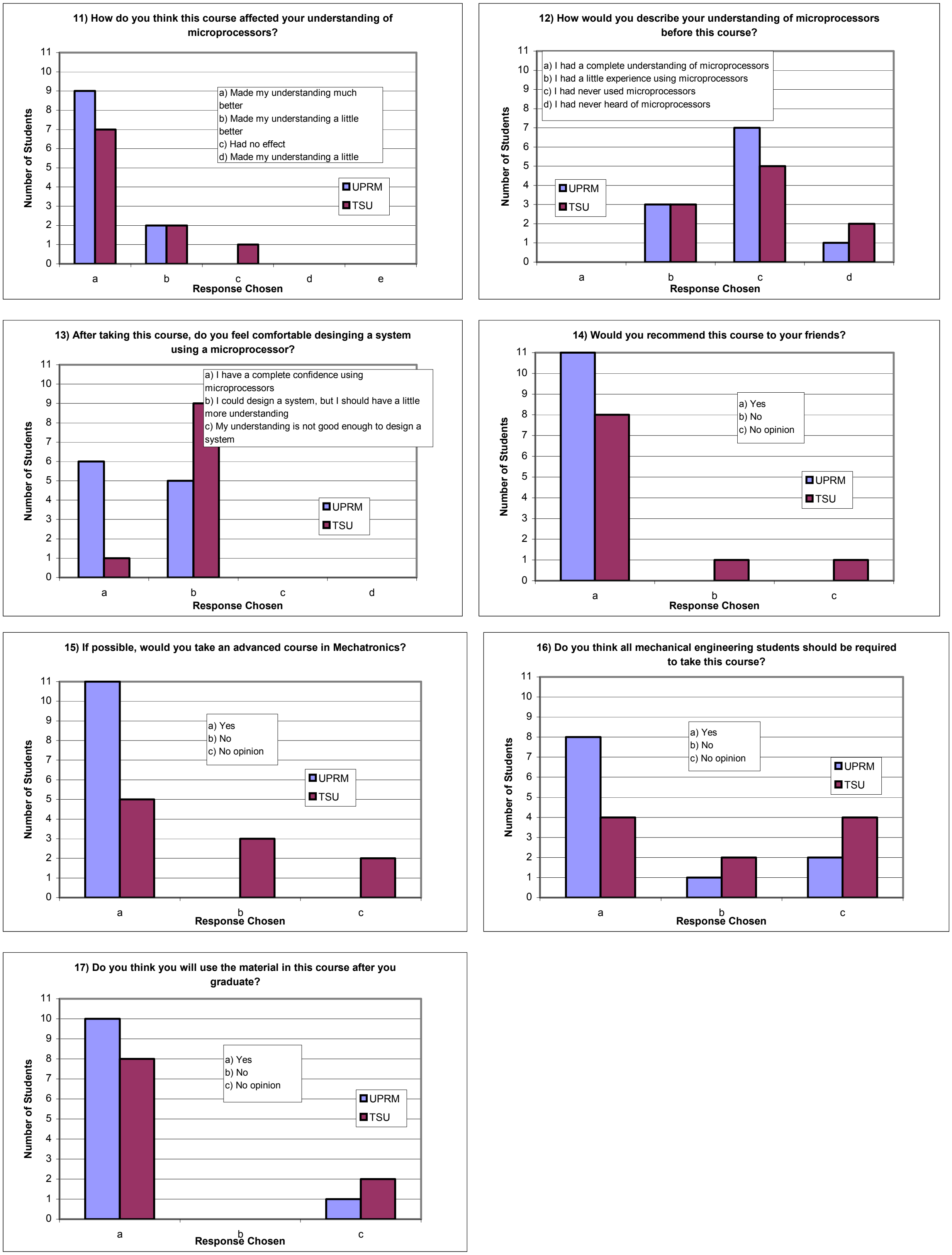


Figure 5: Student Responses

Faculty Feedback

In addition to the students who completed the course at Tri-State, there was also a faculty member from the Department of Mechanical Engineering who also attended the course and completed the weekly projects. After completing the course material, this faculty member became a proponent of including this mechatronics course as a regular part of the curriculum. This faculty member often teaches the capstone senior design course, and he felt that requiring this course would be a great benefit to our students and would improve the quality or their senior design projects.

Feedback was also received from faculty members who attended the presentations of the final design projects. They were impressed by the understanding expressed by the students and with the quality of the projects that were designed and built in only six weeks. In addition, another of the faculty who teach senior design became a proponent for requiring the course.

Results

All things considered, this course in mechatronics was very successful. The project work kept the students in an active learning environment where they could see the direct use of the concepts that were covered in the course. Through this work, the students were able to acquire valuable skills in mechatronics and apply them to real situations in the final projects. The presentations were a good forum for the students to practice their oral communication skills, and by the end of the semester, they were quite good at giving the ten-minute project summaries. The final projects helped to reinforce the material that was covered in the weekly projects, and the students were able retain the knowledge they had gained because of the reinforcement through applications.

The final projects were also a good way to motivate the students for future learning. The students learned how to independently find information about specific sensors and actuators that were necessary for their projects even though they may not have used those specific sensors in the smaller projects. They also had a great feeling of accomplishment as their projects came together and most were glad they had taken the course.

Bibliography

1. Netmedia Inc., Support Documents for BX-24 Basic Express Microprocessor version 1.46, Tucson, AZ, 2000.
2. Kiefer S., Tri-State University Faculty Web Site, www.tristate.edu/faculty/kiefer/MAE4003.htm.
3. Culbreth W., "Meeting the Needs of Industry: Development of a Microcontroller Course for Mechanical Engineers", Proceedings of the 2001 ASEE Annual Conference, 2001.

SCOTT KIEFER

Scott Kiefer is an Assistant Professor of Mechanical Engineering at Tri-State University. He received his B.S. degree in Mechanical Engineering from the University of Wisconsin at Platteville, and his M.S. and Ph.D. in Mechanical Engineering from North Carolina State University. He taught at the University of Puerto Rico at Mayaguez for two and a half years before joining Tri-Sate University in the Fall of 2002.