Introducing Mechatronics in a First-Year 
Intro to Engineering Design Course

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Abstract

This paper describes an effort to integrate principles of mechatronics into the first-year engineering curriculum at the University of Detroit Mercy. A newly designed introductory curriculum is aimed at improving the retention of first-year engineering students by providing them with hands-on, team-oriented, project-based, multidisciplinary instruction in engineering design. The course is taught in four sections, with an instructor from each of the four engineering departments, and includes instructor rotations, so that students are exposed to design activities in each of the four disciplines offered at the university. A unique feature of the course is its development by a team of faculty members.

1. Introduction

This curriculum development initiative is part of a broader effort to make mechatronics a major theme throughout the electrical and mechanical engineering programs at the University of Detroit Mercy (UDM). Mechatronics is concerned with the integration of mechanical, electronic, and control systems. Because of the university’s location in an urban manufacturing center that requires engineers conversant in both mechanical and electrical design, it makes sense to bring this multidisciplinary area into focus in UDM’s undergraduate and graduate engineering programs.

To this end, the students in the author’s section of a first year introductory engineering course completed a mini-capstone project that required them to build and program a robot to move sand from one location to another. This project is described in Section 3.

2. General Course Description

Before the 1998-99 academic year, first year engineering students at UDM took a three credit hour course that exposed them to engineering graphics and engineering design. A second three credit hour course was devoted to an introduction to engineering computing. Because of the heavy graphics component in the design course, it was taught mainly by faculty from the Mechanical Engineering department, and sometimes by Civil Engineering faculty.

In an effort to improve retention of first-year engineering students, a group of faculty and administration began to examine the first-year engineering curriculum to find ways to get more faculty involved and to provide a more varied set of hands-on design activities. Since the first year is critical for retention\textsuperscript{1,2}, getting students excited about engineering design via course activities was a major goal in the development of the course.
This long-term collaboration among faculty from all four engineering departments at UDM has resulted in a restructuring of the first-year curriculum. Instead of two 3-credit hour courses as described above, there are now three 2-credit hour courses. The engineering computing course was reduced to 2 credits. The engineering graphics is now taught in a stand-alone 2-credit course. The remaining 2 credits apply to a new course developed by the team of faculty over a period of more than a year before its launch in January 1999. The collaboration continues in order to make continuous improvements to the curriculum.

The new course, titled *Intro to Engineering Design* (E 106), is taken by students in the second semester of their first year. Many of the students will have taken both the engineering computing and graphics courses in their first semester, and so E 106 includes opportunities to use skills learned in both areas.

The course is taught in four sections, with approximately 25 students per section. The sections are taught by a faculty member from each of UDM’s four engineering departments: Chemical, Civil and Environmental, Electrical and Computer, and Mechanical Engineering. Careful coordination of the course activities among instructors ensures a level of consistency across sections. At the same time, each instructor has the freedom, through the choice of some activities, to give his/her section a unique “flavor”. In particular, a mini-capstone design experience provides the agenda for the last 4 weeks of the course. Because the faculty team could not agree on a common design project for all four sections, it was agreed that faculty members would select their own preferred design activity to conduct. The mini-capstone project was used by the author to introduce students to concepts in mechatronics, and will be described in more detail in the next section.

Topics and activities common to all sections include an overview of different engineering majors and careers, an introduction to the design process, teaming skills, time management and project management, competitive product assessment, criteria testing, and reverse engineering of a common household item. In addition, each instructor prepares a one-week hands-on design activity that is relevant to his/her discipline. A four-week segment of the course is devoted to conducting each of the discipline-specific activities in each section, so that students can experience a variety of instructors and design methodologies.

3. The Mechatronics Component

Because projects with a mechatronics focus require the interaction of more than one engineering discipline, the author chose to develop a design activity that introduced some of the concepts of mechatronics system design to her students. Working in teams of three or four, the students were charged with the task of designing, building, and programming a simple robot to move sand from one location to another. Students were given a performance criterion, which was based on the amount of sand the robot successfully transferred from one stationary container to another in a given time, with a penalty for the amount of sand spilled in the process.

To accomplish the design goal, the students used a robot kit that consists of servomotors, a controller, a serial cable, programming software, and mechanical linkages that can be assembled in various configurations, depending on the range of motion needed to complete the task. The
native programming language for the robot is rather crude, in that commands to position each servo independently are issued, and the controller takes care of coordinating the motion so that the motion of all servos begins and ends at the same time. (See Figure 1 for a code sample.) The kit provides software that allows the students to “train” the robot; that is, they can from the keyboard of a PC exercise each servo to attain a desired position, and then let the software generate the appropriate servo position information. Because of this training feature, sophisticated programming skills are not required. A shortcoming of the kit is that the native language does not allow the integration of sensors to provide feedback to the system. It provides some C and Pascal libraries that can be used to integrate sensors, but since the language taught in the engineering computing course is Visual Basic, the integration of sensors was not pursued in the initial offering of the course.

```
# servo 1 is tail of snake, servo 6 is head.
# make commands more symmetric for this robot
invert all off; invert 1,3,5 on

maxpos all release; maxpos all xxxx # xxxx determined by testing
minpos all release; minpos all -yyyy # yyyy determined by testing

forget all;     # erase all macros
macro sinu:     # this does one cycle of snake-like motion
move 6 to minpos, 4 to 0, 6 to maxpos;
move 5 to minpos, 3 to 0, 5 to maxpos;
move 4 to minpos, 2 to 0, 4 to maxpos;
move 3 to minpos, 1 to 0, 3 to maxpos;
move 2 to minpos, 6 to maxpos, 4 to 0;
move 1 to minpos, 5 to maxpos, 3 to 0
move 6 to 0     , 4 to maxpos, 2 to 0
move 5 to 0     , 3 to maxpos, 1 to 0
end;
```

Figure 1. Sample Code

Student deliverables for this segment of the course provided a framework for evaluation. Each group had to submit a Gantt chart that identified activities and persons responsible for each subtask in each phase of the project. Milestones included a preliminary sketch of the robot’s planned geometry and a description of the strategy planned, as well as informal oral progress reports to the instructor. Each group submitted a final written report, and gave a final oral
presentation to the rest of the class. During the last week of class, each group placed their robot into a competition to see whose robot would perform best. Figures 2 and 3 show two of the robots built by students. Of the six robots submitted, all but one successfully completed the task.

4. Student Response

An end-of-term survey conducted with students in the authors section revealed that working in teams was most often identified as the best feature of the course. The survey also showed that the students really enjoyed the final project. In fact, a number of them suggested assigning a more complex project and having it span more weeks of the term. The day of the competition provided the most rewarding evidence of the student response to the project. A number of students brought cameras to immortalize their design experience, and a spirit of friendly competition was pervasive as each group took their turn racing against the clock. Two groups that initially had problems with their robots were able to quickly identify the source of their problems, and modify the code so that their robots could compete.

5. Next Steps

Because the native programming language for the Robix kits does not allow for the easy incorporation of sensor feedback, the author is considering adopting the use of a general-purpose microcontroller to launch more challenging applications of mechatronics. She is planning to introduce the Basic Stamp II microcontroller4 to students in all sections with a simple hands-on design activity. In the longer term, she plans to investigate the use of the Stamp II to control the robots, so that the students can incorporate sensors easily, and be challenged to write more sophisticated code.

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Bibliography

2 Tinto, V., Leaving College, University of Chicago Press, Chicago, 1993
3 www.robix.com
4 The Basic Stamp 2 is made by Parallax, Inc. (www.parallaxinc.com)

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