INTRODUCING DESIGN TO FRESHMEN AND SOPHOMORES AT WESTERN KENTUCKY UNIVERSITY

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Abstract

The role of design in an engineering curriculum is a key issue to the success of the program and graduates. In the Electrical Engineering program at Western Kentucky University, two new courses have been developed for the first and second years of the program which are focused on teaching design through robotics. In the first course, students must build a robotic "bug." During this design experience, the students solder components, learn to read a simple circuit diagram, and program a BASIC Stamp chip. In the second design course, students must build a simple robot which is programmable logic controller driven. Through this experience, the students learn to deal with cost constraints, basic robot construction, and programming. The results of these courses, student feedback, and suggested improvements are included in this paper.

Introduction

The Department of Engineering at Western Kentucky University (WKU) has been given the rare opportunity to develop an entirely new engineering program. Western's challenge is to create a unique undergraduate curriculum focused on the needs of current and future industrial partners. WKU has a foundation of over 30 years of engineering technology education. The existing technology programs are being phased out and new programs in electrical, mechanical and civil engineering have been developed. These programs are joint programs with the University of Louisville and the University of Kentucky. The first graduates are anticipated spring 2004. The Mission of the WKU's Department of Engineering revolves around our vision of Project Based Learning. The central focus of this vision is that the faculty engage students in activities to support development of a clear understanding of engineering practice. The roles of students - as learners, as observers, as assistants, and as practitioners - should be supported by both the external project activities of the faculty as well as the implementation of the curriculum such that the practice of engineering is clearly demonstrated.[1]

In the 1990's, a move towards a project-based learning model was developed and is generally supported in the American engineering education undergraduate community.[2,3] A primary focus of WKU's engineering programs is to provide a project-based experience at all levels of the curriculum. WKU's goal is to provide students with relevant project experiences inside and outside the classroom. Throughout the electrical engineering (EE) program, hands-on experiences have been incorporated into the curriculum by the addition of several lab classes, design classes, and project classes. In addition, students are encouraged to be involved in industry

related projects outside of the classroom. These programs have been established to produce engineering graduates to meet the need of regional industries in south central Kentucky.

Role of Design Courses

In the EE program, a design course is included in each year of the 4-year curriculum. The role of these courses is to bring together material from various courses and form an integrated curriculum. The design course sequence is composed of four one semester design courses: EE Design I, EE Design II, EE Design III, and EE Design IV. In addition, the design experience culminates with a senior capstone design experience. The first two design courses have been taught in the new curriculum. EE Design III will first be taught in Spring 2003 and EE Design IV will be taught in Fall 2003.

In the first design course, students are introduced to the design process, problem-solving techniques, teaming skills, and oral and written communications. Students are also introduced to basic fabrication and soldering techniques. The goal of this course is to introduce the field of electrical engineering to first semester freshmen. All incoming freshmen must enroll in this course along with a university required freshmen seminar course taught by EE faculty.

In EE Design II, students further explore the engineering design process through cost constraints and teamwork. The students also discuss ethics and professionalism and explore measurement techniques. The students in this course have completed the digital logic course and are enrolled in the first circuits and networks course. They will at least be enrolled in the third calculus course.

The topics in EE Design III will include: application of numerical methods, statistics, economics, production techniques, ethics, and print circuit board techniques. The material in the fourth design course will cover design methodology and decision making. Also, students will design their individual senior projects during forth course.

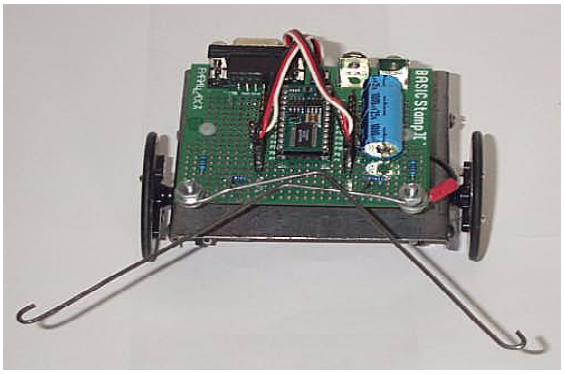

Figure. 1 EE Design I Project.

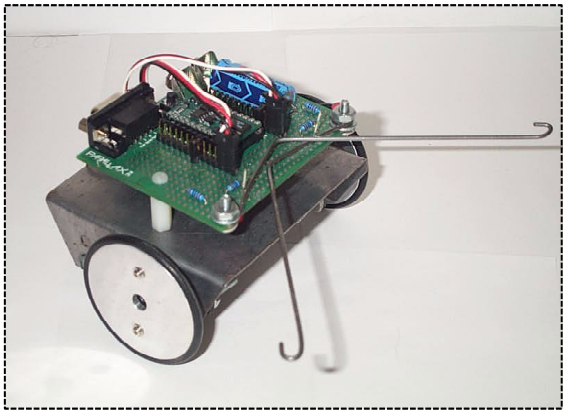

Figure 2: EE Design I Project

EE Design I Project

The EE Design I course has several team assignments throughout the semester, including a redesign of an existing product for improvements and the robot "bug" project. The students also presented a mini-conference on the environmental impacts of engineering decisions where each student wrote and presented a technical paper.

The robot project was designed so that the students would learn teamwork skills, soldering techniques, basic circuit construction, and elementary programming skills. The students were placed in teams of two and given kits from which to construct their robots. The kits included the components listed in Table 1. The students were also provided instructions on the construction of the robot and a simple Basic program. The students were expected to build and program their

TABLE I
Part List for EE Design I Robot

Part	Number

Bug Chassis	1
Modified Servomotors	2
Plastic Wheels	2
Standoffs	2
9 Volt Battery	1
Basic Stamp Mounting Screws	2
Bolts and nuts (whiskers)	2
Bolts and nuts (servo mounting)	8
Caster and 2 nuts	1
Whiskers	2
10 kΩ resistors	4
2 ft of 18 gauge wire (red)	1
2 ft of 18 gauge wire (black)	1
½ inch studs	2
washers	4
18 gauge ring terminals	2
Basic Stamp Processor	1
Basic Stamp circuit board	1

robot. Students were encouraged to enhance the design of their robot and program. Students are required to fabricate the robots body. Figures 1 and 2 show pictures of a robot built for the first EE design course. The students are required to program their robots to complete an autonomous task. Examples of autonomous robot tasks include: wall following, obstacle avoidance or completing geometric shapes.

The students were very enthusiastic about the "bug" robot. They were surveyed at the end of the project and expressed that overall this was a very positive experience. When asked what they liked about this project, their comments included: "It gave a real taste of what electrical engineering is", "It was real cool and it actually got us involved making something electronic", "I liked the fact that we got to build something and then see it work." When the students were asked what they disliked about the project, most answered they disliked nothing but some students indicated more instructions would have been helpful. Several non-traditional students felt the project was too easy. The students were also asked how they would change this project. Besides clearer instructions, the students mentioned more time and more freedom to be creative with the final design and program.

The faculty feel that the "bug" robot should be permanently incorporated into the first EE design course. The project forms a foundation for the students in skills such as circuit construction and elementary programming. Also, the students were introduced to reading a schematic. This project provided a hands-on opportunity for the students to learn about the field of electrical engineering. The "bug" project was their first experience working with electronics and processors. This type of opportunity is invaluable for retention purposes and for aiding students who are unsure about the major.

In the future, the instruction manual will be improved and more time will be spent on soldering and wiring. Also, the servo-motors and Basic Stamp programming will be examined further.

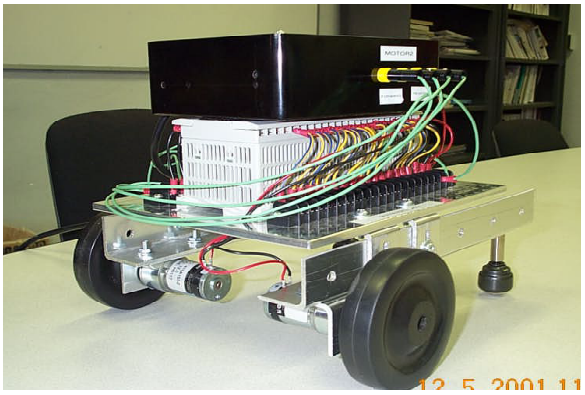

Figure 3: EE Design II Project.

EE Design II Project

Programmable logic controllers (PLC) are introduced in the second EE design course. This PLC and most others use a language called relay ladder logic programming. The students learn to program in ladder logic and spend several weeks completing small PLC assignments. The students are also assigned a PLC robot project in which they must build a robot controlled by an Allen Bradley Micrologix 1000.

Figure 4: Typical Path of Robot

The PLC robot was required to travel six feet, make a one-foot cube, and return to the starting position as shown in Figure 4. The educational goal of this project was to make the experience more than designing and programming a robot. Therefore, "dollar" values were assigned to each part and the students were given a maximum allowable "dollar" amount to spend. The students were given a purchase order list shown in Table 2.

TABLE II
Part List for EE Design II Robot

Part	Price

L Bracket 6” long	$3.00
L Bracket 8” long	$5.00
L Bracket 12” long	$7.00
L Bracket 14” long	$9.00
U Bracket	$1.00
¼ x 20 Nut, Bolt, and	$1.00
Washer	$6.00
Motor Mounting Bracket	$35.00
Motor	$10.00
Wheel	$6.00
Front Wheel Mounting	$100.00
Bracket	$2.00
PLC (power supply included)	$8.00
Front Wheel Axle	$2.00
Casters (Washers and nuts provided)	$1.00

The students had to design their robot from the parts listed and keep within their budget. They had to use good economic judgement to maximize their design. Once the students decided on their design, they had to “order” their parts from the staff engineer. In their project planning, they had to account for possible ordering delays. When the students received their materials, they had to build their robot, and program the PLC to achieve the desired results. Figure 5 shows a design of one PLC robot.

A survey was conducted at the end of this project. The students enjoyed the freedom of being able to design their robot. Some students felt that the project was too easy or that they had too much time to complete the project. Most students commented that they would have enjoyed adding more difficulty to the project and a greater variety of materials to choose from.

This project was a good creative exercise for the students. In the future, another phase will be added to the project where the students must add sensors to be able to detect a wall. Also, more PLC projects will be assigned before the PLC robot project so that the students are more familiar with ladder logic. In the future, time will be spent on formal project management skills. Students will learn about various project management tools and project planning.

Figure 5: EE Design II Project.

Conclusion

The "bug" robot and the PLC robot are valuable experiences in the Electrical Engineering program at Western Kentucky University. Through these projects, students are able to develop hands-on skills that will aid in other courses and to use knowledge from previous courses. Also, these projects and their respective design courses form important bases for the third design course, fourth design course, and ultimately the senior capstone project. These projects support a project-based, integrated curriculum.

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