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Bridging the Freshman Engineering Gap by Building Mobile Robots[1]

M.Z. Atashbar, D.A. Miller, F. Severance, R. Tanner, and M. Suchowski

Department of Electrical and Computer Engineering
Western Michigan University, Kalamazoo, MI 49008

Introduction:

Many freshman-engineering students have little or no idea of exactly what an engineer does. In addition, these students often lack even the most basic technical skills that will be required throughout their careers. These skills are often are taken for granted by instructors, e.g., use of hand tools and identifying basic components. These problems are compounded by the traditional approach to engineering education, which delays the introduction of "real" engineering work until at least two years into the curriculum. Students quickly lose focus amongst the large number of seemingly unrelated prerequisites. The end results are low retention rates and too many unmotivated and underachieving students, as demonstrated in electrical and computer engineering (ECE) programs across the country.

One means to address these problems is the use of an introductory freshman-engineering course that immediately exposes students to the essentials of their chosen profession. Indeed, most members of National Science Foundation (NSF) sponsored engineering Education Coalition have adopted this type of course as the beginnings of integrating design across engineering curriculums [1]. This has resulted in a wealth of information on how to effectively develop and

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implement such courses. Based on these successes, we are offering an introductory engineering course to our ECE freshmen at Western Michigan University. This course is supported by a NSF Division of Undergraduate Education grant [2]. The centerpiece of this course is construction of a walking Stiquito™ robot (see Figure 1) [3]. The goals of this course include developing construction skills, fostering confidence, improving basic instrumentation and construction skills needed for practice of ECE, growing a physical intuition for electrical and mechanical systems, clarifying career choices, making students feel in the home, forming long lasting peer support structures, developing effective team player, and improving retention rates. The course content is described and early assessment results are provided. In particular we will emphasize process education and teamwork, which is used for the pilot course to stimulate creative problem solving.

Figure 1: A basic walking Stiquito™ robot.

The ECE 123 Course:

The class is a three credit hour course for ECE freshman, consisting of short introductory lectures followed by work in the laboratory for a total meeting time of 2.5 hours, twice a week. Other engineering majors may take this course as well. The lecture is primarily driven by construction of the robot in the laboratory. The proposed course schedule is shown in Table 1. The pilot course schedule deviated from this schedule, but this table accurately shows topics covered with a few exceptions.

Since Stiquito™ robots are walking robots there is ample opportunity to address mechanical concepts such as load, structural integrity, and thermodynamics (the legs are actuated by heating

Nitinol wire). The need for energy to power the robot leads naturally to study energy resources, regulation, sizing, and control.

Table 1: The robotics course (ECE 123) schedule, Chapter numbers refer to [3].

Week	Topics	Laboratory
1	Course overview (ch. 1); how to work in teams; introduction to electricity	Demonstrations of robots from previous semesters
2	Introduction to electronics; bread boarding circuits	LAB 1: electricity basics
3	Introduction to Nitinol; phase transition diagrams; basic mechanical systems (e.g., levers)	LAB 2: Nitinol (ch. 4)
4	Stiquito™ construction	LAB 3: construction of the Stiquito™ (ch. 5)
5	Engineering skills (ch. 2); design process; overview of ECE	LAB 3: construction of the Stiquito™ (ch. 5)
6	Tools of the ECE profession; construction skills; reading schematics; ECE software tools	LAB 4: manual controller (ch. 6)
7	Use and limitations of ECE instruments	LAB 4: manual controller (ch. 6)
8	Introduction to digital logic; interfacing digital logic to the real world	LAB 4: manual controller (ch. 6)
9	Basic computer programming personal computer parallel port	LAB 5: computer-based controller (ch. 7)
10	Oscillators	LAB 5: computer-based controller (ch. 7)
11	Sensors and sensor circuitry	LAB 6: autonomous Stiquito™
12	Introduction to control systems	LAB 6: autonomous Stiquito™
13	Design: expanding the robot's capabilities	LAB 7: robot customization robot Olympics (ch. 9);
14	Design: expanding the robot's capabilities	LAB 7: robot customization; robot Olympics (ch. 9);

The control portion necessitates a discussion of feedback and digital systems. Students were introduced to the tools of the trade, e.g., oscilloscopes, digital multimeters, circuit board fabrication, applied computer programming, and simulation tools. The intent was to enable students to use as many tools as possible to enrich their physical intuition.
The course text book [3] provides detailed construction for assembly of the robot, the primary components of the basic Stiquito™ are available in the kit form. In spite of this, the kits have limitless flexibility and expandability (Figure 1). In fact, this robot and its variants have been used in research efforts studying such subjects as evolving walking strategies [4], hardware / software design [5] and robotic colonies [6]. The text contains a chapter entitled “Engineering Skills and Design Process” which provides an excellent overview of the engineering process, including creative thinking, identifying the best solution to the problem, preparing reports, plans, specifications, and scheduling, etc.

Team work was emphasized throughout the course. In order to facilitate effective team work, students were taught how to work as a teams and specific protocols were established for resolving problems within students groups. Also as in [7], homework and lab assignments are completed within the student teams. Students also maintain a laboratory notebook and the need for planning their project is stressed in order to ensure completion.

In the lecture the instructor addressed questions and introduced concepts needed for the current experiment. This has avoided the passive style of learning, which tends to inhibit learning by all but the most gifted students [7]. In contrast, the active participative style of learning was employed [8]. Providing an end goal coupled team-based learning is an example of the effective cooperative learning model [9].

Lab Details:

The goal of the pilot course offered in Fall 2001 was to fine-tune the course schedule. Students investigated basic electrical and electronics principles via simple experiments with basic components, such as resistors, LED’s, transistors and capacitors. Mechanical topics included characteristics and use of the nickel-titanium alloy Nitinol to lift a dead weight, illustrating the basic properties of this material. A lever was used to increase the range of movement to illustrate the trade-off between an increased range of motion and available force. Another experiment used a length of Nitinol attached to a leaf spring. This is the configuration that is used to actuate the robot legs. Student groups built the basic Stiquito™ robot using basic construction and model building skills. This includes how to accurately measure and cut materials and how to knot and crimp nitinol wire. The students also learn the important skill of troubleshooting their work. The resulting robot has a hard-wired tripod-walking gait. Students built a manual controller for the robot. Students then used the parallel port of a personal computer (PC) to control the robot legs. This included fabricating printed circuit boards for interface circuitry using a milling machine. The students also developed simple programming skills while working on PC program to control the robot's gait. All students groups created a working controlled Stiquito™; there was difficulty getting the parallel port printed circuit board working mainly due to lack of time. The semester ended before the autonomous Stiquito™ could be built, thought the basic building blocks were investigated. Our experience in the pilot course will be used to improve the next course offering.

Assessment Results:

The ECE 123 course elected by eighteen Honors College students was held in the Fall term of 2001. Thirty two item pre- and post-attitude questionnaire was administered to the students. Questions were rated on a 1 to 5 scale, with 1 being the poorest rating and 5 being the best. There were 18 complete pre-tests, and 16-post tests were returned. Although sample numbers are small due to the small class size, answers to questions were compared to obtain an initial appraisal of difference between answers, if any. Table 2 shows the questionnaire and the mean, number of samples, standard deviation.

From Table 2 it can be seen that continuous improvements have been observed from the pre- and post- questionnaire. Answers on 21 questions rose somewhat. There was a slight drop in ratings on the question: I prefer to work alone (corresponding to a slight rise in rating on the question: I prefer to work in groups). There was also a slight drop in ratings on the question: I have good study habits. Answers on the remaining questions were flat.

Table 2: Pre and Post Attitude Questionnaire.

Question:		Pre			Post		
		Mean	N	SD	Mean	N	SD
1	Engineers have a good life	3.63	16	.72	4.19	16	.66
2	Engineers are paid well.	4.07	15	.59	4.33	15	.62
3	An engineering degree will provide job security	3.63	16	.81	3.88	16	1.02
4	The work engineers do has a positive impact on solving world problems.	4.25	16	.58	4.25	16	.58
5	Engineering is a respectable field.	4.43	14	.51	4.43	14	.51
6	Engineering is an exact science.	3.50	16	1.10	3.56	16	1.09
7	I prefer engineering to other fields of study.	3.31	16	.87	4.00	16	.89
8	My family encourages my to study engineering.	3.57	14	.65	3.93	14	.92
9	I am confident in my writing skills.	3.19	16	1.05	3.75	16	1.00
10	I am confident in my speaking skills.	3.44	16	.89	3.81	16	.98
11	I am confident in my knowledge of math.	4.13	16	.72	4.19	16	.83
12	I am confident in my knowledge of physics.	3.56	16	1.03	3.81	16	.98
13	I am confident in my computer skills.	3.88	16	.81	4.00	16	.89
14	I have good study habits.	3.56	16	.96	3.38	16	.96
15	I prefer to work in groups.	3.31	16	1.20	3.44	16	1.03
16	I prefer to work alone.	3.25	16	1.00	3.06	16	.85
17	I have the creative thinking skills needed to survive in engineering.	3.88	16	.72	3.81	16	.54
18	I have the problem solving skills to survive in engineering.	4.00	16	.63	3.94	16	.44
19	I have the design skills to survive in engineering.	3.86	14	.86	3.79	14	.58
20	I have the construction skills to survive in engineering	3.50	16	1.10	3.63	16	.72

Table 2 continue …..

21	I have the instrumentation skills to survive in engineering.	3.19	16	.83	3.38	16	.72
22	My pre-requisite courses will help me to improve my skills.	3.80	15	.77	3.67	15	.72
23	I prefer the study of electrical engineering to other fields of study.	2.56	16	.51	2.69	16	1.08
24	I prefer the study of electrical systems to other study.	2.63	16	.50	2.63	16	1.02
25	I prefer the study of computer systems to other study.	3.19	16	.98	3.31	16	1.14
26	I feel comfortable in the WMU College of Engineering.	3.73	15	.70	3.93	15	.96
27	I am proud to be part of the engineering college.	3.87	15	.64	3.80	15	.94
28	I feel at home in the electrical engineering department.	2.93	15	.59	3.27	15	.96
29	I like my engineering professors.	3.75	16	.77	3.94	16	1.00
30	I like my electrical engineering professors.	3.44	16	.73	3.94	16	1.00
31	Engineering students will help me with my studies.	3.60	15	.63	3.73	15	1.03
32	I have friends in the electrical engineering department.	2.93	15	1.03	3.93	15	.96

A significant difference was indicated on two questions: Engineers have a good life (Mean pre test: 3.63, Mean post test: 4.19) and I have friends in the electrical engineering department (Mean pre test: 2.93, Mean post test: 3.93). It should be emphasized that these are initial assessment results and that the course is undergoing continuous improvement.

Conclusions

We have described our initial offering of an introduction to engineering course centered on building on a walking robot. This course has been established to better prepare our students for the rigors of undergraduate engineering work. Even though there has been some inevitable start-up problems, we believe that the course has had a significant impact on our first group of students. The goal of providing a meaningful and hands-on introduction to engineering appears to be realized; the precise impact will be ascertained after conclusion of the assessment process.

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Biographies:

MASSOOD ATASHBAR is an Assistant Professor in the Electrical and Computer Engineering Department. His research interests include mobile robots, sensors, and VLSI. He may be contacted at: massood.atashbar@wmich.edu.

DAMON MILLER is an Assistant Professor in the Electrical and Computer Engineering Department. His research interests include nonlinear systems, soft computing, and engineering education. He may be contacted at: damon.miller@wmich.edu.

FRANK SEVERANCE is an Associate Professor in the Electrical and Computer Engineering Department. His research interests include mobile robots, system modeling and simulation. He may be contacted at: frank.severance@wmich.edu.

RALPH TANNER is an Associate Professor in the Electrical and Computer Engineering Department. His research interests include mobile robots, walking machines, and controls. He may be contacted at: ralph.tanner@wmich.edu.

MARIA SUCHOWSKI: is the consultant for the evaluation and assessment of the course. She may be contacted at: msuchowski@hotmail.com.

Bridging The Gap. What still needs to be done so that application software isnâ€™t dependent on specific hardware. February 24th, 2011 - By: Frank Ferro.Â The recent CES felt very similar to Mobile World Congress (MWC) with all the emphasis on smart phones and pad computing. When I first started attending MWCâ€"it was called 3GSM in those days and held in Franceâ€"semiconductor companies seemed somewhat misplaced because 3GSM was considered a â€œsystemsâ€ show.Â To compete effectively, semiconductor companies â€œadded valueâ€ by building reference designs and providing the software stack. Suddenly the chip was only part of the solution because a large percentage of resources were focused on system design, which includes software and applications. Traditionally, industrial robots are expensive, fixed, and unsafe for humans to work alongside with. Cobots stick true to their collaborative name by providing a more flexible, low-cost option for manufacturers that frees-up workers to take on higher-level tasks.Â Instead of traditional reprogramming robot procedures, where an operator will have to leave the area to update the robotâ€™s configurations and procedures, AR brings a virtual interactive dashboard to the shop floor in a timely and immersive experience, potentially saving thousands in changeover costs.Â The Reality Lab is also extending this interface to mobile cobots with its automated guided vehicle named Frida. The bot leverages kinetic AR and spatial mapping to program its motion in physical spaces. Session number 1526. Bridging the Freshman Engineering Gap by Building Mobile Robots1. M.Z. Atashbar, D.A. Miller, F. Severance, R. Tanner, and M. Suchowski. Department of Electrical and Computer Engineering Western Michigan University, Kalamazoo, MI 49008. Introduction: Many freshman-engineering students have little or no idea of exactly what an engineer does. In addition, these students often lack even the most basic technical skills that will be required throughout their careers. These skills are often are taken for granted by instructors, e.g., use of hand tools and identifying basic compo Traditionally, industrial robots are expensive, fixed, and unsafe for humans to work alongside with. Cobots stick true to their collaborative name by providing a more flexible, low-cost option for manufacturers that frees-up workers to take on higher-level tasks.Â Instead of traditional reprogramming robot procedures, where an operator will have to leave the area to update the robotâ€™s configurations and procedures, AR brings a virtual interactive dashboard to the shop floor in a timely and immersive experience, potentially saving thousands in changeover costs.Â The Reality Lab is also extending this interface to mobile cobots with its automated guided vehicle named Frida. The bot leverages kinetic AR and spatial mapping to program its motion in physical spaces.