Tutorials http://www.ece.utah.edu/~cfurse/Tutorials/tutorialsUofU.htm

Several tutorials of interest to EM students are linked on this site. These include how to use Agilent's Advanced Design System (ADS)™ software for basic microstrip circuit and antenna design, Remcom's *XFDTD*™, and *MATLAB*™. Additional tutorial links from professors or vendors are welcome. Please send them to cfurse@ece.utah.edu.

Teaching Resources, Hardware and Software Links, and More

In time, this Web site will include a variety of teaching resources, and links to EM demonstration software, labs, and hardware demonstrations suitable for use in EM courses. Watch for upcoming additions!

Robots and Girls

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Despite the efforts of the education community to encourage girls to pursue math, science, and engineering careers, age-old prejudices like "girls don't have the ability or interest to do technical work" persist. Our personal experience has been that girls often tell teachers in both high school and college that they are not going to study engineering because they would rather go in to a field that "helps people." Obviously, engineering helps society in many ways, but we felt that it was important to provide an experience that would drive home the point that engineering has a human side as well as a technical side. We chose Lego Mindstorm® Robots to introduce engineering concepts to a high-school physics curriculum at an all-girls' school to see if we could interest more girls in studying engineering. Besides overcoming prejudices, other objectives were to apply physics concepts, introduce design skills, teamwork, and engineering concepts.

The project lasted about four weeks. The equipment and framework for the program was provided by the Wireless Integrated Micro Systems (WIMS) Research Center at the University of Michigan. None of the girls in the two physics sections had any experience with Legos, and only a few had building or "fixing" experience. The projects centered on the theme that WIMS devices improve people's lives and, in this case, would introduce the girls to the basic elements used in these small devices. The cochlear implant was picked as the device around which the projects were loosely based because most of the girls seemed particularly interested in biological applications, and because the cochlear implant helps individual people.

The course consisted of several sections, as follows:

1. Graduate students from the University of Michigan gave presentations about their research on cochlear implants, which provided a connection other than the teacher.

2. The girls then studied circuits using prepackaged kits by Gibson Technologies® that use solder-less boards, which gave an understanding of the basic electronics behind WIMS (Figure 1).

3. The girls experimented with motors and sensors provided in the Mindstorm kits, which, like WIMS devices, have sensors and actuators (motors).

4. The girls then built a variety of simple robots using directions from Lego that reinforced their sense of "I can" about engineering/technological activities.

5. The girls' final challenge was to build a robot that simulated at least one human movement, to tie in the overall theme that engineering is a field that helps people on a personal level (Figure 2).

6. Each team wrote a *PowerPoint* presentation that described the steps they took to build their robot, to emphasize the need for communication.

7. The capstone experience was to visit the clean rooms at the University of Michigan, where they went through several of the steps that are used to make WIMS devices, in this case, a vibration sensor. They were asked to write a short paper about what they learned at that time, an alternative evaluation activity to a test.

The girls initially were very intrigued by the cochlear implant. The researchers explained the physiology of hearing loss, as well as the engineering portions of the devices used to restore

Figure 1

Figure 2

hearing. They enjoyed the presentation, but after a week or two, they seemed to have forgotten the details of the device and their enthusiasm waned. We think this was because they did not see a cochlear implant, nor speak with someone whose hearing was restored due to a cochlear implant.

The circuit kits brought out enthusiasm that surprised the teacher. Each of ten lessons had the girls build circuits that either lit up an LED or rang a buzzer. This immediate feedback seemed to fuel their enthusiasm. Besides learning about the basics of circuits like resistors, capacitors, transistors, etc., and the basic laws of physics, like Ohm's law, they learned that these same components were packaged in a very small element called an integrated circuit or "chip." At this point, they were introduced to the idea that all WIMS devices (not to mention computers, cell phones, and other everyday devices) used chips. A chip is the brain of a device.

The girls were then given Lego Mindstorm kits, which served as a large-scale demonstration of WIMS device characteristics. After experimenting with motors and sensors, and after discussing how these elements were also used in WIMS devices, the girls built robots that simulated at least one human movement. The robots were built around the RCX "brick," which contains a simple microprocessor that takes input signals from the sensors, and then turns on motors or other actuators based upon how the RCX is programmed. Because of their lack of building skills and visualization skills, many of the girls were very frustrated at first. They had a hard time building the simple lessons provided in the Mindstorm kits. That frustration changed quickly.

By mastering simple robots, they quickly acquired the skills to build a more complicated robot of their choice. Most of the teams chose to stick to the Lego suggestions book, but after becoming comfortable with the robots, they branched out to add features not included in the directions. They programmed the movement of their robot with the simple programming language provided by Lego. The programs were downloaded from laptops to the robots via an infrared tower connected to the computer. The RCX box has an infrared sensor that picks up the information sent by the tower. This opened up the opportunity to talk about types of communications, particularly radio-frequency devices.

A couple of the groups became frustrated because they wanted to do more! They soon came to realize the limitations of the RCX processor. They asked if they could be taught *Java* or *C++* so that they could extend the capabilities of the robots. Unfortunately, the school does not teach any programming languages, and there was not enough time in the physics curriculum to teach programming languages other than simple programming, like what was used by the Mindstorm kits.

During the four weeks, the University of Michigan brought in a variety of speakers to talk about why they think engineering is an exciting field, as well as to show the girls other WIMS devices. Sometimes the language of engineering overwhelmed the girls. However, all girls ended with a strong understanding that WIMS devices, and many macroscopic engineering devices, consist of three primary components: 1) sensors, like a touch sensor, which sends a signal to a 2) microprocessor, which then makes a decision to turn on an 3) actuator, like a motor.

All teams put together a *PowerPoint* presentation, the purpose of which was to describe how they built their robot and what tasks their robot could do. They then presented their work to each other during class time. It was interesting to discover how differently the girls viewed their project, with the exception that they all picked up on the three basic components of a WIMS device. This captured the communication side of engineering activity for them.

One evening, parents were invited to see their daughters' robots in action. Even though parents were very enthusiastic about the idea of this project at the beginning of school, very few parents showed up. One parent later confided to the teacher that she was disappointed that so few parents were interested in their daughters' technical abilities. The parent said, "If this had been a sporting event, both mom and dad would have been there!"

The last portion of the project was a field trip to the University of Michigan. The highlight of the girls' trip was a visit to the "teaching" clean room. There, the girls worked through several steps in making a small vibration detector. At the end of the visit, the head of the program, Prof. Ken Wise, gave a presentation that described a wide variety of WIMS devices, all of which helped people. The girls appeared to understand this presentation after their experience with the robot, and they expressed how interesting the talk was. They were particularly impressed with the many human problems that could be eliminated – or at least helped – by WIMS devices, and that engineers did, indeed, help people!

With the exception of one team (out of a total of 11 teams), the girls were extremely enthusiastic about the experience. One girl commented that physics class was now the reason that she looked forward to school. Another described how while riding in a car with her mother, she was able to explain how air bags were triggered by vibration sensors and – we think, to her amazement – that "she knew so much engineering."

Only four students expressed an interest in engineering at the beginning of the project, and those same four students were the only ones who said, on a questionnaire, that they planned to pursue engineering after graduation. However, we feel their experience dispelled the myth that engineers are all white males, working in rooms by themselves on subjects that don't affect anyone's personal lives. The girls clearly understood that engineering is a cooperative effort, that there are many biological applications where, e.g., engineers work with medical personnel, and that the quality of life is greatly improved because of engineering.

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