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An Engineering Linkage To K 12 Teachers

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Abstract
Engineering faculty at Iowa State University have worked collaboratively with teacher education faculty since 1996 to offer an undergraduate course entitled Toying with Technology to elementary and secondary education majors1, 2. The development of this technology literacy course provided students with an appreciation for the technological innovations that surround them. Studies have shown that students form many of their overall career and educational attitudes as early as elementary school. Elementary (and even secondary) schoolteachers who have an appreciation for technology will likely convey that appreciation to their students. This will, in turn, broaden the horizons of these students regarding the opportunities they may have regarding careers in scientific and engineering disciplines. Engineering faculty believe the Toying with Technology course is a component of the long-term recruitment of K-12 students, particularly minorities and women, into technology-based fields3, 4, 5.

This course is designed to explain the principles behind many of the technological innovations in wide use today via a collection of hands-on laboratory experiences based upon simple systems constructed out of LEGOs and controlled by small computers. These laboratory experiences are designed to lead students, literally by their hands-on experimentation, through the use of technology in support of many everyday activities. The lab experiences are simple enough to isolate and illuminate the underlying basic principles and yet complex enough to represent real-world examples. Students typically design and construct simple models of real-world systems, including an elevator and its controller, a garage door and its opener, a computer-controlled car, and a house security system. A significant portion of this course is the many field experiences involving K-12 students being facilitated in mobile robotics exercises by the pre-service teachers. The literature in recent years shows numerous papers on mobile robotics1, 2, 6-8, many using LEGOs. There also are many references to engineering outreach efforts3-5, 8-12.

During the summer of 2000 a graduate course incorporating these mobile robotics and scanning electron microscope exercises was offered to in-service teachers and teacher education graduate students. Several of the in-service teachers who took this course are now partnered with the current undergraduate students to provide an on-going relationship among the practicing teacher, the pre-service teachers, the K-12 students, and the engineering faculty. In effect, the practicing teacher's classroom becomes the laboratory for the Toying With Technology course.

Disciplines
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Comments
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An Engineering Linkage to K-12 Teachers

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Introduction

Engineering faculty at Iowa State University have worked collaboratively with teacher education faculty since 1996 to offer an undergraduate course entitled Toying with Technology to elementary and secondary education majors[1, 2]. The development of this technology literacy course provided students with an appreciation for the technological innovations that surround them. Studies have shown that students form many of their overall career and educational attitudes as early as elementary school. Elementary (and even secondary) schoolteachers who have an appreciation for technology will likely convey that appreciation to their students. This will, in turn, broaden the horizons of these students regarding the opportunities they may have regarding careers in scientific and engineering disciplines. Engineering faculty believe the Toying with Technology course is a component of the long-term recruitment of K-12 students, particularly minorities and women, into technology-based fields[3, 4, 5].

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The Undergraduate Course

This course began in 1996 as a technology literacy course using LEGOs and microprocessors to simulate real-world devices such as elevators, garage-door openers, and remote controllers. At first cheaply made miniboards and "hand-wired" interfaces were used. When the LEGO Mindstorms kits became available, the reliability and availability of the equipment dramatically improved. The course has evolved to one which features not only the motorized, programmable devices built with the Mindstorms kits and used with grades 3 and up, but also the "Simple Machines" kits that are useful for younger children. These kits include levers and pulleys, wheels and axles, and bridges and towers. Engineering problem solving for all ages is taught in this undergraduate class.

A recent Department of Education Grant in Iowa State University's College of Education allows for expanded funding and partnerships with K-12 school districts. Two school districts are now full partners in this program and the undergraduate students in the Toying With Technology course, as part of their instruction, participate in field experiences in K-12 classrooms in these districts. The same equipment used in ISU's teaching laboratory was purchased and donated to these K-12 schools. The in-service teachers who are involved have participated in workshops and/or a graduate-level course, which is now being offered. In effect the actual K-12 classrooms are the laboratories for this engineering/education course and in-service teachers are assisting in the pre-service teachers' professional development. A second grant with the National Science Foundation provides funding to work with all of the Area Education Agencies in Iowa to insure that the program reaches the maximum audience.

The course begins by having students construct a two-motor car with the Mindstorms kit. Students are given pictorial directions and some simple programming code written in "Not Quite C" language. The first program, for example, instructs the car to move forward for 5 seconds, pause for a second, and move backward for 5 seconds. The students are shown how to compile and download the program to their robotic device (in this case, the car), and then execute the program on their cars. Next students are asked to change the code to have the car move forward some specified distance. It should be noted that the given program specifies time, but not distance or speed. The students are left to discover the relation among the three variables. This exercise is the beginning of most field experiences for grade 3 and up.

The students quickly progress to using bumper and light sensors, traversing mazes and following (or avoiding) dark lines, and many other projects that become increasingly less directed and more creative and open-ended. Two examples of the more creative exercises are the "egg drop" and the "tightrope walker" projects. In the egg drop project the students are instructed to construct any LEGO device that will transport a raw egg from the tabletop to the floor without breaking. Although results have been very positive, it is recommended that plastic drop cloths be used for testing and demonstration runs. The tightrope is an orange rope with black tape markings every two feet. The students are challenged to construct a device that will traverse the rope that has been hung across the

classroom, counting black tape markings along the way, dropping a "bomb" on a target below the seventh mark, and returning to the beginning of the rope. Other challenging projects, too numerous to list, are being used in this class. All of them have a similar basis in creative problem solving applied to a physical device that is computer-controlled. The students in this course are required to write lesson plans for K-12 classes, journal their activities in the class, participate in the filed experiences with K-12 students and teachers, and, design and build robotic devices that meet the challenges laid before them.

Constructivism

The partnership among the Engineering College, the Education College, in-service teachers, and pre-service teachers has proved beneficial for all involved. One benefit that was unexpected was the incorporation of the "Constructivist Method" of teaching into engineering classrooms. Since the class content in Toying with Technology is based upon many engineering concepts, it could easily be taught in a very traditional behaviorist manner. However, the class is taught in a highly constructivist atmosphere. Constructivist classrooms encourage the students to think and develop their own perceptions of the world[13]. By having students move through class activities at their own pace and even create their own version of a project or concept, the students actually construct their own meaning.

At a personal level, the student is actively engaged in constructing meaning by bringing in prior knowledge and development on new situations[14, 15]. In the social level, construction of meaning occurs when students negotiate their understanding by actively engaging in classroom discussion and exchanging ideas with others[16]. The constructivist model of learning is based upon the students becoming meaning-makers rather than the traditional empty vessels that are waiting to be filled, and the teachers become facilitators in the co-construction of knowledge[17]. The majority of school instruction is often times centered on the content and not that of the students[18].

"A constructivist teacher creates a context for learning in which students can become engaged in the process of their own discoveries. They are guided through problems, adventures, and challenges that are rooted in real life situations, that interest them, and that have self-satisfying outcomes. They are aware of their own strengths and weaknesses and they work towards meaningful goals. Teachers facilitate their growth, as do peers and other members of the community[19]."

For many engineering educators the science of teaching is not a research area. It is interesting to see how many of the historically employed methods in engineering education, when done well, are incorporated in this method. Much of this method has been routinely employed in engineering classes, especially those that include a laboratory component. It is the invoking of students' prior knowledge and allowing them to construct meaning for their new knowledge that alter the common teaching methods of most engineering educators. To invoke students' prior knowledge the professor inquires at the beginning of a new topic to see what the students' perceptions are about this topic. If there are misconceptions or outright errors in their thoughts about the topic, they are

left to discover the new paradigm and construct their own meaning as they learn the material. It is believed that if the student changes the misconceptions themselves, they have truly incorporated the new knowledge, but if we "tell them" what is right it won't penetrate their formerly held perceptions.

After completing a topic the students are asked to reflect on what they've learned. This may be a class or small-group discussion, a written document such as a journal or a project report, or performing a summarizing project demonstration. The senior design project in engineering can be seen as this culminating step as applied to the four-year engineering curriculum.

The Graduate Course

After gaining experience with the undergraduate class and interacting with in-service teachers, a need for a graduate-level course was observed that the in-service teachers could take to become familiar with this technology. In the summer of 2000 this course was offered for the first time. Taught in a workshop format, it attracted 14 students, nine of who came from one of the partnered schools. In addition to the mobile robotics described above in the undergraduate course, additional training on the use of a scanning electron microscope (SEM) across the world-wide-web was incorporated[20]. This technology allows the use of an expensive microscope, not available in K-12 schools, to be brought into any internet-connected K-12 class. The graduate students have access, and contribute, to a growing library of samples and lesson plans for use in classrooms for all ages.

Teachers from the partner schools have continued their involvement with the Toying With Technology program by developing an ongoing relationship with the students enrolled in the undergraduate course. Students assist in facilitating the robotics exercises in the K-12 classrooms of the in-service teachers, adding some great practical experience to the pre-service teachers education similar to an engineering co-op or internship.

The graduate students not only constructed mobile robots, they also built a real world sensor for the mobile robots. This is an example of hands-on learning that is not performed in many teacher-preparation programs. The graduate students used tools such as soldering irons, hobby knives, wire cutters and adhesive to build a light sensor. Since none of the graduate students had previously used tools such as a soldering iron, learning how to use these different tools will allow them, depending on the skill level of the students in their classroom, to implement instruction of constructing the sensor in their classroom environment or to construct the sensors themselves.

After constructing their sensors, the graduate students used them to detect ambient light that was emitted by a robot called "IT-bot" during a game of tag. This Tag game was taken from the Autonomous LEGO Robotics course at Case Western and can be seen at Dr. Richard Drushel's web page www.eecs.cwru/courses/lego375. As the light sensor came closer to the emitted light, the number representing the intensity that the LEGO RCX detected increased, which allowed the students to program their mobile robots

accordingly. Once in a classroom environment the graduate students can simulate real world applications such as outdoor lights turning on when the sun goes down, turning down the intensity of car lights when an oncoming car is approaching, and the testing of smoke alarms with a flashlight. After introducing this sensor project in the graduate course, it has been used in the undergraduate course with equal success.

Conclusion

The undergraduate and graduate Toying With Technology courses continue with great success. Both courses are oversubscribed and the list of K-12 partners, and would-be partners, grows at an astounding rate. The web site for our program, always under continual construction, is at http://class.ee.iastate.edu/twt.

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Jenny Golder is an undergraduate student in Computer Engineering at Iowa State University. She has been working with Toying with Technology since September of 1999. She has been researching the ability to create sensors for the RCX microcontroller. She has received numerous scholarships including: ISU Engineering Scholarship, Melinger Scholarship, and Baenzinger B Memorial.