Toying With Technology in Elementary Education

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Abstract - Sponsored by a Miller Faculty Fellowship at Iowa State University, a new course was developed and offered for the first time in the fall semester of 1997. The course is called "Toying With Technology" and is designed to explain the principles behind many of the technological innovations in wide use today. It does this 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 initial offering of this course was to elementary education majors. As the course proceeded, it became clear that material appropriate for such majors was also appropriate for the students they would ultimately be teaching. Consequently, emphasis was placed on material appropriate for elementary-level students and a particular approach to teaching such material. This paper describes the development and first offering of the course, highlights some of the lab exercises used, and describes future expansion plans for our technology literacy project.

Statement of Purpose

This project represents the development of a technology literacy course aimed at students in non-technical fields who want an appreciation for the technological innovations that surround them. These lab experiences are simple enough to isolate and illuminate the underlying basic principles and yet complex enough to represent real-world examples. We are living in a world of electronic and electromechanical gadgetry, much of which is a complete mystery to the average, non-technical person. Garage door openers, TV remote controllers, microwave ovens, automobile cruise controllers, and cellular phones are but a few such items in wide use today. As complex as these gadgets seem on the surface, much of the mystery behind their functionality can be explained in simple terms well within the grasp of the average, non-technical person.

Our intent is to introduce such students to recent advances in electronic technology in a gentle, non-threatening manner. We have developed a collection of hands-on laboratory experiences based upon simple systems constructed out of LEGOs and controlled by small microcomputers. These laboratory experiences are designed to lead students, via hands-on experimentation, through the use of technology in support of many everyday activities. Students typically design and construct (out of LEGOs) 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. This course has no prerequisites and is closed to science and engineering students. In fact, the inaugural offering was made to elementary education majors only, but in the next year the course will expand to include secondary education majors as well. Other non-technical majors will be added in future years.

Project Description

The course was developed in four phases.

Phase One: Course design and prototyping of laboratory experiences.

During the Summer of 1996 the course itself was designed with special emphasis on the supporting laboratory experiences. Particular instructional items were identified and closely-related laboratory experiences developed to support each item. The basic instructional approach of hands-on laboratory experiences to provide students with an introduction to important principles underlying technological developments guided these efforts. These laboratory experiences typically involve students in the design, construction, and testing of simple models of real-world systems. Model construction is generally of LEGOs with a small (credit-card size) microcomputer system used as a controlling mechanism for the model. Various sensing devices, switches, etc., allow the model to interact with its environment as appropriate. A simple programming notation, suitable for each laboratory model, is introduced to the students in the course.

An important part of the course development effort was the design of the laboratory experiences. We did this with the help of student interns participating in Iowa State University's Program for Women in Science and Engineering. These students had just completed their junior year in
Phase Two: Laboratory development.

During the academic year 1996-7, we acquired equipment and materials to be used in support of the laboratory experiences. In the course, students generally work in teams of two supported by a laboratory station. Each laboratory station includes a personal computer, a special LEGO kit, a small microcomputer, batteries, and various electronic sensors, switches, etc. Since the first offering of the course had 34 students enrolled, 17 laboratory stations were needed. An existing personal computer laboratory is available to support this course. The lab items were acquired and each laboratory station was properly configured by a team of undergraduate students who were led by the third author and assigned to this project. The student team constructed each lab station and formally tested each laboratory experience for length, feasibility, etc. Again, adjustments were made as appropriate to finalize the laboratory and each laboratory experience.

Phase Three: Experimental course.

The course, Toying with Technology, was taught during Fall Semester of 1997 as a three-credit course utilizing two 2-hour sessions. Each session was a laboratory involving the completion of a prescribed experiment. The course was taught at an introductory level and targeted students from elementary education. The students at first were asked to build models where a good deal of guidance in the construction was given, although we are convinced that these students, even with their non-technical backgrounds, have little difficulty with the technical aspects of this course. However, every effort was made to assure a comfortable pace in the course and to assure that students achieve at an appropriate and satisfying level.

Phase Four: Assessment.

What we hoped to demonstrate with this project is that students with non-technical backgrounds can gain a solid appreciation for many of the technological innovations widely used in today's world. We believe an effective approach in providing students with such an appreciation is the use of hands-on laboratory experiences in which students model real-world systems. We carefully assessed our efforts throughout the duration of the course. One form of immediate feedback, of course, was the extent to which students successfully completed the laboratory experiences. We were pleased to note the willingness to complete the exercises as well as the students' abilities to do so. However, we also used post-course questionnaires to generate additional student feedback on the course and laboratory experiences. The students were unanimous in their opinion that the hands-on nature of the course allowed them to overcome their fears of technology and, specifically, programming in order to be successful.

Although this course is intended for non-science and non-engineering majors in general, in its initial offering the students were essentially all elementary education majors. Consequently, we included in the course many topics specially targeting such students. For example, we required each student team to produce a two-week unit lesson plan on what they would teach their future students. These lesson plans turned out to be far better in technology areas than they were in K-12 lesson
design pedagogy. We have since learned that the students in the course, due to being in various stages of their educational careers, had not all had courses covering lesson plans.

Another important aspect of this course and one measure of its success is related to the practical experience the students gained in acting as teachers when we were visited by, or went out to visit with, K-12 students. More than a half-dozen such experiences occurred during this course. Our elementary education students served as teachers for elementary-age children and guided them through some of the same lessons they themselves had recently experienced. Many of our elementary education majors remarked about how much they realized they had learned in the course when they began to instruct the younger students. For many of them this was their first practical teaching experience. All assessment results will be used to influence subsequent offerings of the course.

Significance

Many students have a desire to know more about the world around them. Just as music appreciation, art appreciation and computer appreciation courses have existed in college curricula over the years, we believe there will be significant interest in the course we have begun to offer. Studies have shown that students form many of their overall career and educational attitudes as early as elementary school. Elementary (and even secondary) school teachers 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.

We believe what we do in this course can also be directly applied to the recruitment of students, particularly women and minorities. These two groups have historically been underrepresented in scientific and engineering disciplines, partly because of attitudes developed in high school or even earlier. Computer-controlled LEGO models provide a highly motivational and non-threatening introduction to science and engineering that can effectively be used to broaden the interests of these important groups. We have had success in introducing computer-controlled LEGO models to both these groups in limited settings. We have developed a road show that we take to Iowa Schools to introduce some of the ideas we include in this course. This road show consists of a self-contained presentation in which students participate in the design and construction of simple computer-controlled models. We believe such a presentation will be very effective at stimulating student interest in science and engineering.

Biographies

Lawrence J. Genalo is an award winning teacher (most recently the 1995 ISU Foundation's Career Achievement in Teaching and the 1996 Regents' Faculty Excellence Award) in Materials Science and Engineering. He has been the lead teacher for the first programming course for engineers for many years. Dr. Genalo has developed Authorware and web-based multimedia lessons and tutorials on programming that have been used extensively at ISU as well as nationally. He has worked with the Program for Women in Science and Engineering (PWSE) on its Summer Intern Program since its inception. He developed, taught, and sought funds for graduate women to teach design and computer experience courses for the high school interns. He has served as a mentor for high school interns in projects that have resulted in four high school and two undergraduate students becoming peer-reviewed, published authors of papers that have been presented at the American Society for Engineering Education Annual Conference and the Iowa Academy of Science.

Through his involvement with the Synthesis Coalition, Dr. Genalo has become a national leader in projects on courseware development and delivery and, more recently, in the application of computers to the operation of physical systems. In the fall semester of 1995, Dr. Genalo's ENGR 160H class was enriched by a three-week mobile robotics workshop. Dr. Wright served as a collaborator and co-teacher for this workshop. Student responses were overwhelmingly positive towards this experience.

Charles T. Wright has been in the Department of Electrical and Computer Engineering at Iowa State University since 1984. Prior to that he taught computer science at Iowa State (1968-75, 1979-84) and at Moravian College (1976-79) in Bethlehem, Pennsylvania. He is currently involved in the development and teaching of courses in computer architecture, embedded computer systems, and digital systems design. Dr. Wright's primary emphasis throughout his academic career has been undergraduate instruction. He has been particularly active in the development of instructional computing laboratories and in course development. He has written four successful NSF instructional equipment proposals, 20 successful industrial equipment proposals, and has played a leadership role in the development of five computing laboratories used in support of computer
engineering and computer science courses. His course development activities have included the development of undergraduate courses in computer literacy, computer hardware fundamentals, microprocessors, computer architecture, computer interfacing, digital systems design, programming languages, and software engineering. Dr. Wright has authored an undergraduate textbook and also a set of course notes for IBM's technical education program. Dr. Wright is recognized as an excellent undergraduate instructor and has received several teaching awards throughout his career.

Kara B. Wright is a graduate student at Iowa State University who received a B.S. degree in Mathematics in May, 1997. Ms. Wright is involved in the design, building, and implementation of Mobile Robots at Iowa State. She has supervised PWSE interns for the past two summers including ten interns during the Summer of 1996. She was also involved on a National Student Advisory Committee for the NSF Synthesis Coalition. Before her position as a research assistant for the Electrical and Computer Engineering Department, Ms. Wright worked as an Assistant Engineer with the Iowa State University Computation Center.