# Introduction to Engineering Concepts for Middle, Junior High, and High School Teachers

James M. Conrad

## INTRODUCTION

The future of any country lies in its ability to use its resources to build a technological resource base. One of these critical resources are the youth still in secondary schools who need encouragement and practical examples to help them learn about and want to choose careers in engineering and technology. Hence, our objective is to introduce engineering and technology to Arkansas middle, junior high, and high school students with the assistance of school teachers.

A pilot teacher training workshop will take place during July of 1995. One teacher from fifteen middle, junior high, and high schools will attend the three week workshop at the University of Arkansas, Fayetteville. During the workshop the teachers will learn about engineering concepts and the role of engineers in society. Teachers will also be exposed to technology used in engineering companies which they may not see otherwise. A workbook of suggested engineering discussions and activities will be provided to the teachers who will work on several of these activities during the workshop.

This paper will describe the organization of the workshop activities and the process of how workshop materials will be developed. Instructions to access workshop activities and lab exercises is also included.

## THE NEED FOR ENGINEERING AND TECHNOLOGY EDUCATION

The future of America's global competitiveness depends upon a well-educated, technologically-literate workforce. The key to developing this workforce lies in our ability to teach our youth about the importance of science and technology in our rapidly-changing, rapidly-shrinking world. As the authors of *Science for All Americans* explain, "The terms and circumstances of human existence can be expected to change radically during the next human life span. Science, mathematics and technology will be at the center of that change–causing it, shaping it, responding to it. Therefore, they will be essential to the education of today's children for tomorrow's world [6]."

Recent studies indicate, however, that students lose interest in science courses in junior high and high school. Only 62 percent enjoy science by the time they reach the 11th grade. Only one half of students surveyed thought that science would be useful to them in the future, and less than one third thought they would pursue a career in science.

It is not surprising, therefore, that too many of our young people are unaware of the excitement and the potential of the engineering field. Enrollment in undergraduate engineering programs shrank 17 percent in the last decade [5]. In 1993, only 16 percent of engineering degrees were awarded to women, and only 7.9 percent were awarded to minorities. Of particular concern is the fact that only five percent of minority students graduate from American high schools with the traditional academic prerequisites to enroll in engineering.

Engineers will play a key role in providing the technological leadership necessary to meet the demands of the next century. Public school science teachers will be the catalysts for motivating students to pursue careers in engineering and technology. According to David Schwartz of the Society of Automotive Engineers, "It is important to get young people aware of and interested in engineering at an early age. As children get older, they feel engineering is something they're not capable of doing [5]." The teaching of engineering and technology concepts must be fun, and it must be relevant to students' everyday lives.

Recognizing that our educational system is not producing the quantity or quality of engineers, mathematicians and scientists required to ensure future economic security, the state of Arkansas has developed the Arkansas Statewide Systemic Initiative–a bold attempt to systemically change math and science education in the public schools. Our engineering and technology education workshop plans to build on this initiative. The workshop will introduce middle, junior high and high school teachers in Arkansas to the principles of engineering and technology, expose them to the latest technological advances, stress the importance of technology in math and science education and create a group of well-trained teachers who can provide similar in-service education for other teachers in their district or educational cooperative. Teachers will be selected from across the state, with particular emphasis on the Delta region.

## GOALS OF THE WORKSHOP

The engineering and technology education workshop is designed to accomplish the following goals:

1. To support the state of Arkansas in its efforts to improve education statewide through reform in mathematics, science, engineering and technology education;
2. To create a pool of technically-trained teachers throughout the state who can conduct workshops

on engineering and technology in their own school districts and educational cooperatives;
3. To develop partnerships with Arkansas public schools to increase awareness of and interest in engineering and technology;
4. To increase the technological knowledge of Arkansas students;
5. To increase the number of women and minorities who pursue degrees in engineering;
6. To reach a broad range of students–particularly those from the Delta region–who might not otherwise consider engineering as a viable career opportunity;
7. To help to improve the technological workforce of the state and region.

## ORGANIZATION OF THE WORKSHOP

A three-week workshop will be held in July 1995 for 15 middle, junior high and high school teachers. It is the ultimate goal to have individuals who will be able to assist in the development of district-wide systemic initiatives to integrate technology and engineering concepts into the science curriculum within each educational co-op in Arkansas.

Applications will be sent to every middle, junior high and high school in Arkansas. A steering committee of UA faculty and professional volunteers in Northwest Arkansas will review applications and select candidates. Selection will be based on a number of factors, including the qualifications of the applicants, the geographic location of his or her school and the level of commitment of the applicant and his or her school administration to integrating technology concepts learned in the workshop into the school's curriculum.

The workshop will be held on the University of Arkansas, Fayetteville campus, and many participants will be provided room and board in university dormitories. Each participant will be paid a $1000 stipend to compensate for the loss of part-time summer employment and will receive reimbursement for travel to and from the workshop. Graduate credit will be given for participating in workshop. University of Arkansas faculty engineering professionals will serve as faculty for the workshop and will be responsible for developing materials, demonstrations and laboratory experiments.

The workshop will include the following components:

- **Introduction to Engineering.** Participants will tour engineering facilities, meet workshop faculty and staff and participate in icebreaker activities and team-building exercises.
- **Computer Concepts.** Participants will be introduced to computer concepts and applications which include Internet, workstation windows, PC Windows and DOS.
- **Applications of Engineering Technology.** Participants will examine current consumer products and analyze the engineering skills needed to design them.
- **Stiquito Robots.** Participants will study the design of the Stiquito robot, an educational tool which employs principles from a variety of engineering disciplines. They will also participate in the assembly of the robots.
- **Role of Women and Minorities in Engineering.** Workshop faculty will discuss the career opportunities for women and minorities in the engineering profession and will address current issues which are specific to these underrepresented groups.
- **Activities Involving Engineering Disciplines.** Engineering faculty members will lead one-day or one-half-day sessions on each of the following engineering disciplines: Aeronautical, Biological and Agricultural, Biomedical, Chemical, Civil, Computer Systems, Electrical, Industrial, Materials Science, Mechanical and Nuclear.
- **Industry Visits.** Participants will tour selected Arkansas industries to gain first-hand knowledge of the types of technological jobs available in the state and to observe the latest technological advances utilized by today's manufacturers.

## WORKSHOP MATERIALS

Materials for the workshop and participants include workbooks for teachers and students which the participating teachers will use during the workshop and in their respective schools. Teacher workbooks will contain units for each engineering discipline, general information on each topic, information on each lab experiment, suggested field trips, materials checklists for experiments, suggested sources for materials and suggested speaker topics. A two-to-five minute video on each unit will also be developed. Student workbooks will contain units for each engineering discipline and other topics, a 50-minute class for each unit, six to ten 25-minute laboratory experiments and two 50-minute laboratory experiments. Teachers who attend the workshop will also be provided laboratory supplies and equipment, including Stiquito robots, for use in their classrooms.

Written materials are being developed by University of Arkansas faculty, faculty from other universities, teachers, and graduate students. Teachers from around the state have volunteered to test the materials in their classrooms this spring and offer feedback on its effectiveness.

Continual dissemination of materials and information will take place using ARKNET, the state's internal communications network and gateway to the national information superhighway. It is anticipated that ARKNET will be accessible to public school teachers by the fall of 1995. Bulletin boards (news groups) will be set up specifically for discussions on technology and engineering education.

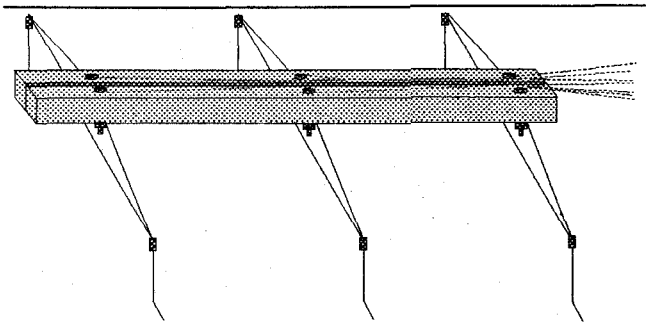

Fig. 1. The Stiquito Robot

## ROBOT APPLICATION - STIQUITO

One vehicle for introducing engineering principles to Arkansas students is Stiquito, a small, inexpensive hexapod robot, which employs concepts from a variety of engineering disciplines [4, 5]. A diagram of the Stiquito robot is shown in Figure 1.

Stiquito provides a challenging–and fun–way for young students to use technology to learn about engineering. Developed by Dr. Jonathan Mills at the Department of Computer Science of Indiana University at Bloomington, Stiquito is used worldwide for educational purposes. The device employs several concepts from electrical, mechanical and chemical engineering; its applications encompass computer systems and industrial engineering concepts as well.

The hexapod robot does not use motors for its movement. Instead, it uses nitinol wire actuators. Nitinol wire is an alloy of nickel and titanium. When current is passed through these wires, they heat and contract. When the current is interrupted, these actuators return to their original state. The speed at which these actuators can move each leg of the robot depends on the surrounding temperature. The actuators can be activated individually or in groups to give the robot different gaits.

The applications of Stiquito are limited only by one's imagination. It has proved to be a challenging tool for young students.

## CONCLUSIONS

Funding for the workshop has come from the Arkansas Department of Higher Education, the Trinity Foundation, and the University of Arkansas. Organizers are currently seeking additional funding from private and government sources to expand the workshop and allow more teachers to attend, and continue the workshop for several years.

The engineering and technology workshop described above can have a significant impact on engineering and technology education in middle, junior high and high schools across the state, help to improve the technological workforce of the state and the region and highlight the strength of technology-intensive industries that affect America's success in the global marketplace. Working with the public schools, the University of Arkansas, the Department of Higher Education and the Trinity Foundation can improve engineering and technology education for all Arkansas students.

Detail of the workshop and lab exercises can be obtained by anonymous ftp to `engr.engr.uark.edu`, subdirectory `pub/engr_ed`. The file `workshop.txt` contains detailed information on the organization of the workshop. The file `lab_list.txt` contains the current list of lab exercises, and the subdirectory the exercises are located.

Other *Frontiers in Education* papers [1, 2] contain detailed information on possible lab exercises teachers can use in the classroom.

## REFERENCES

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[3] Miller, Krystal, "Dwindling Supply of Engineers Brings Sense of Desperation to Auto Makers," *Wall Street Journal,* pp. B1, B6, June 7, 1994.

[4] Mills, Jonathan W., "Stiquito: A Small, Simple, Inexpensive Hexapod Robot. Part 1: Locomotion and Hard-wired Control," Technical Report 363a, Computer Science Department, Indiana University, Bloomington, Indiana 47405, 1992.

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[6] Rutherford, F. James and Andrew Ahlgren, *Science for all Americans,* New York: Oxford University Press, 1990.

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**James M. Conrad** is currently an Assistant Professor in the Computer Systems Engineering Department at the University of Arkansas. He can be reached at: 313 Engineering Hall, Fayetteville, AR, 72701-1201, (501) 575-6036 (email: jmc3@engr.uark.edu).