

FUTURE SCIENTISTS AND ENGINEERS OF AMERICA A MODEL K-12 PROGRAM

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***Abstract** - Hands-on project activity and especially projects that relate science, mathematics, engineering, and technology (SMET) to the real world, is severely lacking in most K-12 schools. The fun and excitement of projects relating to SMET are generally short-term enrichment rather than a continuous informal activity all year. Businesses, community organizations and parents are either not involved at all or have very brief involvement in career days, job shadowing, etc. Very few contribute anything to excite and motivate children in SMET and to help teachers relate academic subjects to the real world of community and work. There is a critical need for a national informal SMET program which is rich in hands-on activities, draws on local volunteers and establishes long term partnerships between businesses, community, parents and schools. The need becomes even more critical due to the huge under representation of women and minorities in SMET since they will become the major percentage of the workforce in the near future.*

INTRODUCTION

Future Scientists and Engineers of America (FSEA) is a national non-profit organization that provides the structure, project material, documentation and workshop training necessary to establish after-school technology clubs in K-12 schools. The FSEA program focuses on technology and can easily and readily be implemented in every school. FSEA gives students an opportunity to experience real engineering and science with a practical, hands-on method that uses projects that challenge student teams to creatively solve problems. FSEA team members experience the same process an engineer or scientist experiences, i.e., given an objective, using techniques of innovation, design, creativity, trial and error, how well can that objective be met?

FSEA shares similarities with other well-known programs such as Scouts and Future Farmers of America. FSEA is provided by and for the entire community. Participants include students, parents, schools, businesses, technical and civic organizations, universities and colleges as well as PTA/PTO organizations. FSEA is structured to involve working scientists, engineers, retirees, college

students, teachers and parents. The goal is to provide hands-on opportunities for enjoyment, motivation and development for every interested student. Each FSEA club consists of a sponsor, mentors, a teacher and a parent coordinator, who are recruited from the local community by people interested in setting up an FSEA club.

FSEA requires that females make up at least half of participants and that participating students represent the demographics of their school by gender, ethnicity, socio-economic status, and academic status. FSEA integrates equity principles into its model, and recruitment strategies to ensure that equity is accomplished.

Goals

There are four major goals for this model K-12 program.

1. To provide for these needs with a program that has the potential for being available in every public and private school in America.
2. To make a systemic change both in participation and in assumption of responsibility in teaching SMET. It is imperative to get local business and community to participate since they are the beneficiaries of the effort.
3. Introduce excitement and fun in learning SMET and parity for girls in numbers and participation.
4. Finally, the goal is to use informal science so it will be a major supporter of formal SMET education in filling the SMET pipeline for colleges, universities and the future technical workforce.

THE NEED

Businesses, colleges and universities in southern California are all experiencing the severe shortage of technically trained personnel in science, computer science, and engineering. The effect is so critical that some businesses curtail their growth and tend to focus their efforts on immediate fixes, such as importing foreign workers or

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paying exorbitant salaries for luring employees from other companies.

According to the National Science Teachers Association, the Third International Mathematics and Science Study Repeat TIMSS-R validates the results of the 1995 TIMSS study "that after 4th grade, students in the United States fall behind their international peers as they pass through the school system."¹

These are current needs and issues, but even more critical is the shortage of technology focused students in the K-12 pipeline. Children need to be motivated by hands-on project experience, by having access to technical companies in the area and to research activities at the colleges and universities. Starting in elementary school children are being turned off by the lack of opportunity to experience the fun of science and technology. Technology is changing so rapidly that children and teachers are unaware of university research and workforce needs. The need is growing exponentially and it will take an integrated effort of the entire community to meet the 21st century needs. In California, and many other states, this challenge can only be met by including a much higher proportion of groups currently under represented in technology: specifically women and minorities.

The National Science Board² (1983) Commission on Precollege Mathematics, Science and Technology emphasized two key elements in educating Americans for the 21st century. The first is that science education must be modified to include a substantial technological component and the second is that "science and technological literacy" should be established as one of the primary goals for all students. These recommendations marked a shift from considering technology as vocational education to recognizing technology education as necessary for all students, K-12, as citizens in a technological society.

Since the recommendation of the National Science Board, science and technology appear together in virtually all new curricular documents. Close examination, however, reveals that science knowledge and processes are clear, but technology is vague or lacks curricular direction. Definitions, concepts, processes, and students' outcomes are absent.

The Need for Emphasizing Technology Education

There is a problem of scientific and technological illiteracy in the United States with a majority of the population, documented in national surveys by Jonathan Miller. The National Science Commission states that the general public should have both science and technology knowledge and facility with problem solving strategies so they can cope adequately with their personal lives, their work and their role as decision makers in our technological society.

The U.S. Labor Department, concerned about changes in the world of work examined the changes and implications for learning. The Secretary's Commission on

Achieving Necessary Skills (SCANS) produced a two part report³ defining competencies, and a foundation of skills and personal qualities needed for employment, focusing on "responsible employees comfortable with technology and complex systems, skilled as members of teams, and with a passion for continuous learning."

Another often-stated need is the recruitment and training of enough competent scientists and engineers to maintain the leadership necessary for the nation's economic well being. Students need to be interested and involved in science and engineering in their early school years in order to make decisions about technology related careers. The U.S. labor force is changing and through the year 2001 is expected to be comprised of 69.4 percent of minorities and females. Minorities and females are not choosing to follow science, engineering and technology paths and receive little encouragement from home or school.

Economic reasons are often cited.⁴ Atkin (1990) advocates that greater emphasis be placed on technology in schools, rather than science, if the purpose is to maintain and improve the American standard of living and global competitiveness. Economic competitiveness, he writes, is about serving human needs.

FSEA: LEARNING ABOUT TECHNOLOGY EDUCATION IN AN INFORMAL SETTING

FSEA provides an opportunity for teachers, parents, and the community to understand the importance of technology education and the preparation their children are receiving for a range of career opportunities.

An FSEA project begins with a problem to be solved in a real context. Students explore alternative solutions to the problem before designing and building a prototype. The opportunity to integrate mathematics and science in an informal setting enables them to select and test the proposed solution to the problem. Experimenting with the developing prototype engages them in math and science concepts and explanations. A review of technology and engineering projects reveal that FSEA is unique in offering students a program that is developmental from grades 4-12 and a system of achievement, with certificates that can be filed in their personal assessment profile, as endorsed by the SCANS Report of the U.S. Department of Labor.

Needs Met by FSEA

- Students see the need for mathematics and science through the hands-on projects and are motivated to learn.
- Students and teachers have contact with industry, especially as it relates to science, engineering, and technology. FSEA brings industry into the classroom.
- FSEA clubs have a high female and minority representation in elementary schools and the

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opportunity to continue through middle and high school. Girls also express surprise at their own abilities in these areas.

- FSEA offers industry an opportunity to impact elementary, middle and high schools in a structured program with hands-on projects.
- Hands-on learning is provided in the areas of science and technology, which meets the needs of educators by providing models.
- FSEA is the only national structured program which provides elementary through high school advancement in science and technology, paralleling job lines in industry from Technician to Engineering Specialists or Senior Scientists.

THE MODEL

FSEA Clubs

FSEA clubs consist of 25 students in elementary, middle or high school. Elementary school clubs start in the 4th grade. The clubs can be a single grade or span several grades since FSEA is an advancement program spanning grades 4-12. A school may have several clubs in order to accommodate as many interested students as possible. Participation in FSEA is voluntary and special effort is made to encourage female and minority students to take advantage of this exceptional opportunity.

Sponsors

Each club is sponsored by a local organization. Typical sponsors include small and large businesses, technical societies, civic organizations and parent-teacher organizations. FSEA provides a unique opportunity for an organization to become effectively involved and share responsibility in the local education process.

Sponsor responsibilities include:

- Provide the funding. (\$60 per year per student, \$1500 for 25 students)
- Provide or help recruit mentors
- Add the company or organization identity to the club
- Promote FSEA in other schools and businesses until it is available in every K-12 school

Hands-On Projects

FSEA projects are designed to stimulate the process of technical inquiry and by doing so stimulate interest in mathematics, science and technology. FSEA projects have many unique characteristics including:

- Hands-on, not just demonstration
- Creativity and problem solving
- Grade levels 4-12
- Designed for teams of 2-4

- Performance criteria, including cost trade-offs
- Many areas of science, mathematics and engineering
- Complete package provided including project material, write-ups, videos, certificates, and awards.

Schools

All FSEA club meetings take place at the school.

School responsibilities include:

- Adopt FSEA as a sanctioned after-school activity and publicize it with other school activities.
- Provide a teacher to participate in the club.
- Provide a meeting place.
- Provide a place to store project material.
- Recruit a parent coordinator.
- Help to recruit student FSEA members.
- Assist in recruiting mentors and sponsors.

Mentors

A team of volunteers – two mentors, one teacher and a parent coordinator, conduct each FSEA club. The mentors can be employed or retired engineers, scientists, technicians or people with other technical backgrounds, as well as college students working in these areas. For elementary school projects a technical background is desired, but not required. Parents should be encouraged to volunteer as mentors.

Mentor responsibilities include:

- Present the project goals and objectives at the weekly one-hour FSEA club meeting.
- Answer questions and suggest possible research sources. FSEA provides most background material.
- Provide direction and assistance as required.
- Relate projects to personal work experience when possible.
- Describe sponsoring organization's activities and products.
- Evaluate teams' performance and select winners.

Teachers

Each FSEA club must have a teacher who is present and participates in each FSEA meeting. The training obtained by the teacher(s) in FSEA sessions can provide for more hands-on activities in the regular classes.

Teacher responsibilities are:

- Select a place to meet.
- Secure parent approval slips. (See Student Application forms)
- Collect the \$5 membership fee. (Scholarships are provided if necessary to waive fees)
- Maintain discipline

EVALUATION SUMMARY

In conjunction with a National Science Foundation grant, Science Learning Incorporated, Sli, completed an evaluation of the Future Scientists and Engineers of America program. This evaluation study was designed to determine the effectiveness of FSEA clubs in creating positive changes in participants. Participants in this study included teachers, industry sponsors/mentors, and students. Data were collected over a six-month period in 1997 using a methodology, which combined written questionnaires and semi-structured interviews.

Teachers

The majority of teachers and principals felt that a student's participation in FSEA positively impacted his or her knowledge of and attitudes toward science, mathematics and technology. Results indicated stronger agreement among teachers that FSEA had improved student attitudes toward science than for improving student knowledge about science. Teachers reported that FSEA participants had become more empowered, confident problem-solvers as a result of FSEA participation. Some teachers specifically noticed this change among girls.

Nearly all of the teachers and principals felt that FSEA would positively impact technical education if implemented throughout the school district, positively impacting more students' scientific knowledge and skills, as well as, increasing their interest in and enthusiasm for science. These views should be encouraging to FSEA to further expand the program.

The mentors were considered critical in improving student understandings of work and career. Mentors' direct discussion of their work and career were useful to students, as was their ability to model positive qualities such as cooperation, teamwork and problem-solving tenacity. In addition, FSEA activities were seen as enabling students to more fully appreciate science and engineering careers.

Almost half of those surveyed described that, in addition to FSEA, their schools collaborate with local industry through their science curriculum or science-based extracurricular activities. This collaboration consisted mostly of invited guest speakers, school field trips to businesses, school-based competitions facilitated by professional engineers, material donations and advice given by experts.

Industry Sponsors and Mentors

Industry sponsors and mentors regarded students' participation in FSEA as an opportunity to expose students to careers, duties and the working world of scientists and engineers, as well as, an opportunity for them to develop the youth of the nation and potential employees.

Industry sponsors and mentors felt that students learned important work-related skills or information such as teamwork skills, problem-solving and planning skills, and thinking, analytical and communication skills.

Sponsors felt that the FSEA collaboration with schools allowed them to contribute back to the community; motivate and/or inspire students to pursue science careers; help teachers in their teaching of practical skills; and help others understand the importance of what they do as a company. Furthermore, it was felt that such collaboration would ultimately provide a better future workforce; build better community relations and better image for the company; and improved company morale and personal satisfaction among employees.

Sponsors and mentors felt positive about their experiences with FSEA and believed that they had gained an increased appreciation for the nature of student learning and students' interests, and the roles and duties of the teachers. However, they did not feel particularly empowered to influence K-12 education in general, but sensed a greater level of impact on their local schools through their participation in FSEA.

Industry sponsors and mentors almost entirely agreed that business had a responsibility toward educating students which included fostering and investing in the future scientists and engineers of the American workforce and to promote education and/or support education generally.

Students

Students thought that they learned from their participation in FSEA in terms of increased and improved knowledge of science, increased and improved cooperative learning skills, improved teamwork skills, and improved thinking and design skills.

The things students liked about FSEA related to opportunities to learn new things, the fun nature of the program, opportunities to make things, working in teams and the positive relationships they develop with teachers and mentors. Overall student attitudes toward FSEA were very positive changes in students' understanding and attitudes toward math, science and FSEA were small, but positive. All students developed a greater appreciation of teamwork as a result of their participation in FSEA. Elementary school students gained increased appreciation for what engineers do and for why science and engineering are important.

Many students also claimed that they felt somehow different or special compared to other students because of their participation in FSEA. Students considered it to have been a privilege to be selected to participate in FSEA and thought that they learned more things than other students due to their FSEA participation.

Overwhelmingly, students were of the view that engineers build, design and improve things. Other themes relating to students' views on what engineers do related to improving life, solving problems, making things work/or

repairing things and inventing new things. The majority of students considered science and technology to be important because it improves life and/or helps people.

Teachers and principals perceived FSEA to have empowered students by motivating them to pursue careers in science and engineering, as well as helping them to better understand science and engineering careers. Many teachers believed that students gained insights into the duties, responsibilities and attributes of scientists and engineers and that the students see the relevance of FSEA activities to real-world engineering problems. Industry sponsors and mentors believed students benefited through their exposure to the careers, duties and the working world of scientists and engineers. Students, particularly those in high school clubs, felt that FSEA had inspired them to pursue science and engineering-based careers.

In conclusion Future Scientists and Engineers of America is a program that makes a difference. FSEA can inspire, motivate, and excite students to pursue engineering and technology careers. FSEA can and does form significant partnerships between education and business helping to bridge the gap between learning and earning.

REFERENCES

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