OUTREACH AND RECRUITMENT TO ATTRACT STUDENTS TO CHEMICAL ENGINEERING: FERMENTING STUDENTS' INTEREST IN ENGINEERING

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Abstract

The techniques used to encourage young people to pursue careers in engineering are presented in this paper. The first two programs were developed by Rowan University faculty at other universities. The third program is being developed for a summer enhancement experience. The first program described was part of the Exploring Career Options in Engineering and Science (ECOES) program developed by Stevens Institute of Technology in which the brewing process was employed to encourage high school students to consider engineering and science. A National Science Foundation sponsored Young Scholars program at the University of Tulsa is the second program presented which features hands-on engineering experiments and design activities. The third program is aimed at attracting women into engineering through funding by the EIF Foundation.

Introduction

Rowan University in Glassboro, NJ is building a new College of Engineering made possible by an endowment of $100 million from industrialists Henry and Betty Rowan. The mission of this new College is to provide programs that are effectively responsive to regional aspirations and address the needs and changing characteristics of the leading-edge engineers of the future. To be successful Rowan University must recruit high quality faculty and students. Faculty recruitment has taken place through networking opportunities at national and regional conferences and through advertisements in national publications. Student recruitment has been typical of a private school with mailings to prospective students, high school visits, university open house programs and individualized visits. Rowan University has also been recruiting bright young minds into engineering through summer and mentoring programs.

The focus of this paper is to present two programs developed by us at previous institutions and briefly summarize a program that will run this summer. The first program described was part of the Exploring Career Options in Engineering and Science (ECOES) program developed by Stevens Institute of Technology in which the brewing process was employed to encourage high school students to consider engineering and science. A National Science Foundation sponsored Young Scholars program at the University of Tulsa and an EIF Foundation funded program to attract women into engineering.

FERMENTING STUDENTS INTEREST

The brewing process is used to introduce students to engineering fundamentals related to material balances and stoichiometry, fluid flow, heat and mass transfer, and biochemical reactions. Through this project, several educational objectives are met: to develop creative and critical thinking, to introduce design principles, to provide hands on experience, to develop teamwork and communication skills, and to stimulate enthusiasm for engineering.

Exploring Career Options in Engineering and Science (ECOES) is a program developed by Stevens Institute of Technology to encourage high school students to consider college majors in technical fields. The two-week exploration and research program provides exposure to diverse fields of engineering and science and affords students the experience of living on a college campus. After completing the ECOES program, a student has a comprehensive view of the technological disciplines and is able to make more informed decisions about his or her future.

The program was originally open only to high school girls, but beginning in 1993, all qualified high school students have been encouraged to apply. The technical focal point of the program is a research project that is chosen by the student, according to his or her interest in a particular science or engineering discipline. In addition to the intensive research projects, the students also explore other engineering and science disciplines through dynamic hands-on laboratories. Students sharpen their leadership skills through interactive seminars and workshops where they interact with engineering students and professionals who share their experiences. By visiting local industries, students gain an insider's view of what scientists and engineers do on a daily basis.

The brewing process is an exciting industrial biochemical process that requires application of chemical engineering principles. The materials and supplies are inexpensive and readily available at local stores, and the fermentation is performed using *Saccharomyces cerevisiae*, a yeast that is easy to grow without special expertise with microbial systems. This fermentation process was used as the focal point of the two-week Chemical Engineering research project in the ECOES program in 1990. In designing the project, we set out to meet the following objectives:

- Foster creative thinking
- Develop critical thinking
- Introduce engineering, scientific, and design principles
- Provide hands-on experience
- Develop communications and teamwork skills
- Stimulate enthusiasm for Engineering

The Brewing Process

There are three major steps involved in the brewing process: mashing, boiling, and fermentation.

Malted barley is fed to a mash tun where it is mixed with warm water and incubated for approximately 20 minutes to 2 hours. During this time, some enzymes break down starches from the barley into fermentable sugars, and other enzymes break down proteins in the barley to form amino acids. Sugars, proteins, amino acids, and vitamins are extracted from the barley to form a nutritionally complete wort. The solid barley is then separated from the liquid solution, which is then fed to a kettle and boiled with hops for about 15 - 30 minutes. Hops impart the characteristic bitter flavor to beer and have a bactericidal effect. Later they are removed by filtration from the liquid, which is then chilled and fed to the fermenter. After several days of fermentation, the product is beer.

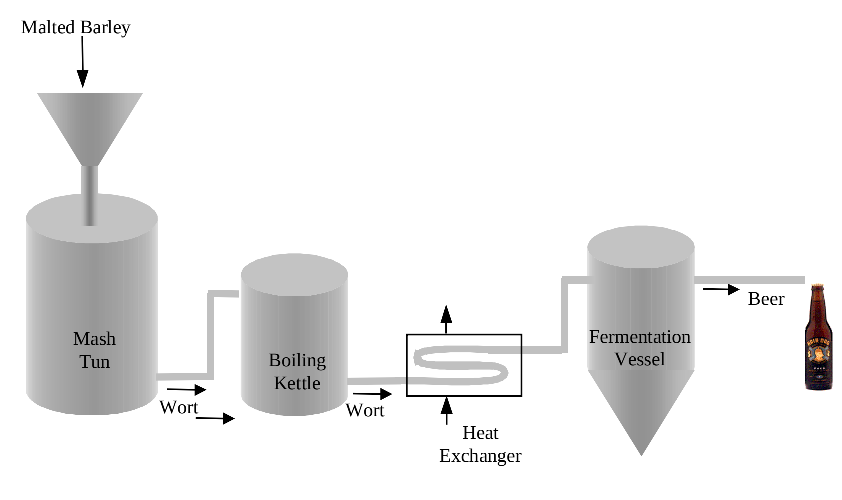

Figure 1: Schematic representation of the brewing process showing the major process steps

The project structure

The project is divided into three phases: design and building, implementation, and evaluation. The design and building phase of the project focuses mainly on the mashing and chilling equipment. Students then implement their process and monitor the fermentation. Finally the teams present their designs and results to the other teams, and then set out to do a comparative evaluation of the designs.

Design of the Equipment

Working in teams, students design and build the equipment for the mashing, boiling, and chilling process steps, working within a budget of $50. They may use or adapt items commonly available at department or hardware stores, but they may not use equipment specifically made for homebrewing.

There are several considerations for the design of the mashing equipment: how to maintain the desired temperature range for enzyme activity for the duration of the mashing process; how to remove the grist (spent barley grains) from the malt wort after mashing; and how to leach out the remaining sugars from the grist. Maintaining the temperature may be accomplished by manual on-off temperature control, or by using insulation. The grist may be removed by using a strainer, a pot with a "false bottom" such as a spaghetti pot, or by containing the grist in a mesh or cloth sack.

For the boiling and chilling steps, students must consider how to prevent the hops from clogging the system when draining the kettle (this is an issue if tubing is used in a gravity flow system). Other considerations involve cooling the wort before the fermentation. Yeast cannot be added until the temperature of the liquid is sufficiently low (below about 25^{o}C). As the wort cools, it becomes susceptible to contamination. Thus it is desirable to cool the wort rapidly and minimize exposure to the atmosphere. Ideally, the wort is cooled by flow through tubing as it drains from the boiling kettle to the fermentation vessel; this minimizes the exposure to the atmosphere. The tubing may be submerged in a bucket of cool water, and the tubing must be long enough to achieve the desired temperature. Cooling may be further enhanced by flowing cool water through the bucket.

Implementation of the Brewing Process

The culmination of the project is the implementation of the brewing process when students produce beer from malted barley using the process equipment that they design and built themselves. They monitor the fermentation as it proceeds to produce ethanol and carbon dioxide from sugar, and collect data that reveals the progression of the reaction.

Evaluation of the Process Design

After the teams have implemented their process and product, they prepare written reports and present their results orally to the other teams. Each team must describe its process design and discuss how specific design considerations were addressed. They evaluate the strengths and weaknesses of their design, and suggest possible modifications and improvements to the process and equipment. The teams then have an open discussion in which they compare and evaluate the designs of the other teams. The teams follow up with a written summary of these process evaluations and comparisons.

Project Summary

As the teams of students work through the various phases of this project, several educational objectives are met. Students think creatively to make an original design for their brewing process, and they use critical thinking to compare and evaluate their designs. They are introduced to basic engineering design concepts and engineering principles when they design the mashing, boiling, and chilling equipment. Students gain hands-on experience in building their own equipment, implementing the process, and monitoring the fermentation. Communications skills are emphasized with the final oral reports, written reports and the discussion of designs afterwards.

AN INTRODUCTION TO ENGINEERING FOR EARLY HIGH SCHOOL STUDENTS

Through the NSF Young Scholars Program Robert Hesketh has implemented the outreach vision presented in the ASEE's of *Engineering Education for a Changing World*. In this highly acclaimed program he has promoted engineering and motivated numerous high school students to pursue careers in engineering. A major goal of this program is to increase awareness of engineering as a career potential for Native American, minority, and female students. Over 80% of the program's participants were from this underrepresented population in engineering.

The goal of the Young Scholars program is to introduce students entering 9th and 10th grades to the field of engineering. The primary component of this project is a 4 week summer session in which the scholars interacted with departmental faculty, undergraduate students, and representatives from local industry. The hands-on activities that were developed include engineering laboratory experiments, computer workshops, and a design project. The unique engineering experiments stimulated the scholars interest in the field of engineering by relating each experiment to a process that is familiar to the student: a coffee machine. In the computer workshops the Young Scholars worked with a state-of-the-art and user friendly computer aided design package. Each of the students designed, constructed and marketed a model solar-powered car for their design project. Other activities include industrial site visits, an engineer-for-a-day program, special career exploration workshops, and 4 academic year follow-up sessions.

Engineering Laboratory Experiments

The engineering experiments have been designed to stimulate the students interest in the fields of science and engineering by relating each experiment to a process that is familiar to most students; the coffee machine. The coffee machine is a very effective tool to introduce students to the field of engineering and has been used by The University of Tulsa as a recruiting tool for the last two years. We related all of the engineering laboratory experiments to the coffee machine, depicted in Figure 2.

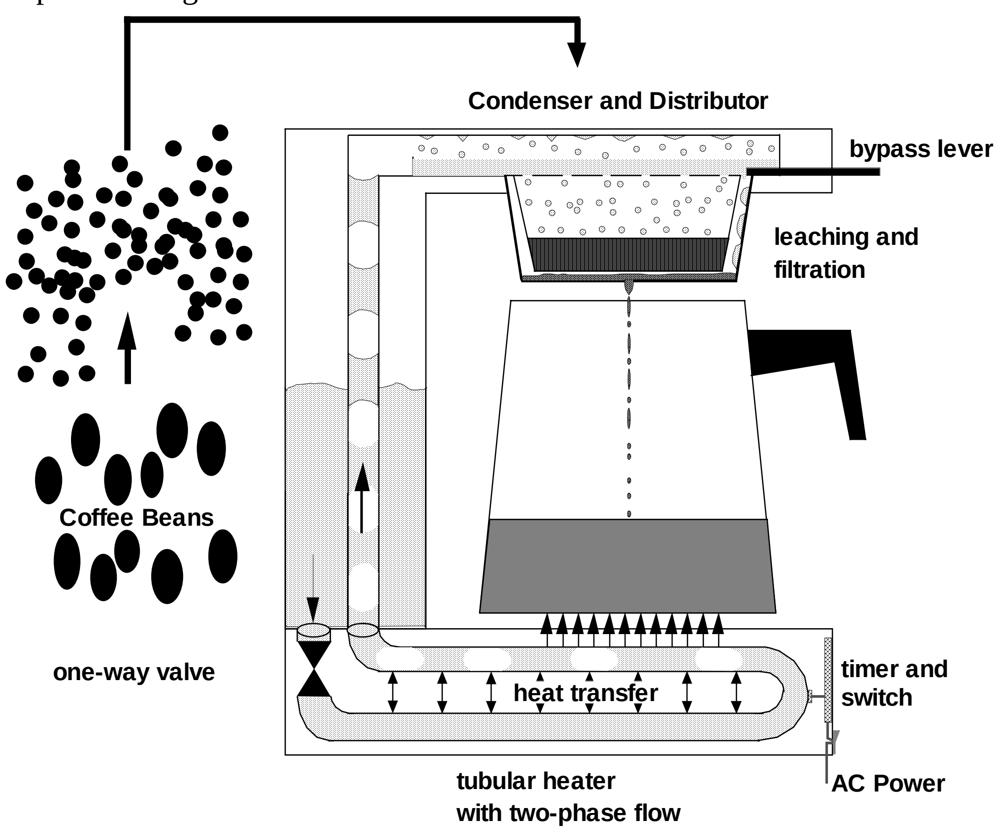

Figure 2: Schematic of Coffee Machine

The engineering laboratory experiments were designed to

- demonstrate the role of laboratory experiments in the engineering decision-making process.
- show the interrelationship of engineering and science required for the design and fabrication of a single product.
- give stimulating and challenging experiments that relate the laboratory experiments to a consumer product with which most students are familiar.

The Young Scholars conducted eight three hour engineering laboratory and three 1 hour laboratory experiments. The engineering laboratory experiments were conducted throughout the 4 week period. Students were divided into groups of 4-5. All of the engineering laboratories were run simultaneously so that each group could work on an individual experiment. Each session consisted of an introduction to the principles of the experiment followed by an explanation of the safety procedures. For each experiment, a group leader was chosen and the students were assigned specific tasks involving data collection and analysis. The scholars were requested to obtain specific information and then encouraged to attempt additional work of their own design. Most of the experiments required the students to make a plot of their data, which was done on the computer. Some of the laboratories required "sophisticated calculations" and the teaching assistant prepared a spreadsheet for these calculations.

The engineering laboratories and major equipment are detailed below for each experiment in the table below.

Table 1
Engineering Laboratory Experiments

Principle	Experimental Goals	Engineering Equipment	Laboratory
Particle Size Analysis	Establish the relationship of grinding time to the size of coffee grounds produced.	Video Image Analysis System. Coffee grinders, & stopwatch	Chemical Engineering Unit Operations Laboratory I
Extraction of Coffee	Determine the effect of water temperature, particle size, and filter type on the strength of coffee produced.	UV spectrophotometer, electronic Balance, grinder, stopwatch, coffee machines, coffee, and filter paper.	Chemical Engineering Unit Operations Laboratory I
Heat Transfer	Examine the effect of water temperature and flowrate on the rate of heat transfer.	Plate & Frame, and tubular heat exchangers	Engineering Science Laboratory
Fluid Flow	Determine the effect of tube length, tube diameter, and liquid height on tank drainage time.	tanks, tubes, and stopwatch.	Chemical Engineering Unit Operations Laboratory II
Timer construction	Construct a timing device for a light source and a music maker.	Electrical circuit components: transistor, potentiometer, resistors, LED, capacitors, piezoelectric disk and circuit board.	Electrical Engineering Laboratory

Robotics	Examine the possibilities of using a robot with a coffee machine.	computer controlled mechanical arm	Mechanical Engineering Robotics Laboratory
Fracture of Materials	Examine and compare the strength of glass, metal and plastics.	Mechanical Testing Equipment	Strength of Materials Laboratory
Computer Aided Process Control	Investigate liquid level control using a computer.	Tanks, valve, actuator, pressure transducer and computer	Chemical Engineering Unit Operations Laboratory II

Table 2 Science Experiments

Principle	**Experimental Goals**	**Engineering Equipment**	**Laboratory**
Pore Size and Structure of a coffee bean.	Determine what a coffee bean looks like under high magnification before grinding, after grinder, and after leaching.	Scanning Electron Microscope Optical Microscope	Geoscience Microscopy Laboratory
Polymer	Mold plastic objects	Molds, polymer	Chemistry Laboratory
Fun with Chemistry	Thermodynamics of Liquid Nitrogen	Liquid Nitrogen, Objects	Chemistry Laboratory

The most popular laboratory experiment was the Fun with Chemistry. Dr. Bob Howard, Chairman of the Chemistry Department illustrated some basic principles of chemistry using a very entertaining format. In addition, the Scanning Electron Microscope was several students favorite. One student commented, "All through my biology book SEM pictures are everywhere, now I've seen one in person." They were impressed with the sophistication of the equipment.

The highest rated engineering laboratory experiment by the students was the timer construction experiment. In this experiment each student constructed a timer and measured the frequency of the flashing LED. A piezoelectric disk was added to the circle and the vibrations caused an audible sound. By increasing the frequency of the oscillations, the pitch could be increased. The students enjoyed playing music with their new electronic instrument. The advantage of this experiment was that each student could work at their own pace on their own circuit board. Other popular experiments were the robotics and the fracture of materials experiments. In all of these experiments, the TA's received high marks.

Computer Laboratories

The Computer laboratories were based on a simple commercial computer aided design package called Visio Technical. This simple MSWindows based CAD is similar to AutoCAD in form and function, but is easier to use. Previous evaluations of the YSP held at The University of Tulsa indicated that the students felt computer activities such as programming, word processing, and spreadsheets, were boring and similar to computer instruction they had in school. The best liked of the previous programs activities were drawing packages. To build and improve on these comments from past YSP's the computer activities for this year were based entirely on the Visio Technical package. The students were very responsive to the computer activities and seemed to enjoy graphically oriented work as an immediate result from a command from the mouse or keyboard.

Nine lab activities were performed. Each activity was held in one of three Personal Computer laboratories, so that each student could use their own computer. The activities lasted two hours each. Two teaching assistants were placed in each lab to assist the Young Scholars. The computer activities included:

- An introductory session featuring a "guided tour" of a PC. The cover was removed from a PC and the working components explored. The viewing of a PBS video on the history of computers was also featured.
- Five tutorial labs on the various features of Visio Technical, including topics like creation of lines, circles, text, zooming, blocks, printing, and so forth.
- Two sessions in which the students did a standard 3-view drawing of a three-dimensional object: a coffee maker.
- Two sessions in which the students drew a picture of their solar car project.

The computer sessions involving Visio Technical were very well received by the students. The students were able to use the CAD package to draw pictures of their solar cars and were able to use CAD to help them in the design process. Two questions were asked in the exit survey concerning the computer sessions; what did the students like the most and what did they like the least about the computer sessions.

What the respondents liked the most about the computer sessions was that they learned a software package that is not "covered in school computer classes" and they got to "use something engineers use." Our ideas on students enjoying graphics on the computer was confirmed by comments such as, "liked being able to see the end product of the work" and "being able to easily modify designs and see results right away" and the "package was fun and easy to use." In addition, the computer sessions were tied to the solar car project and the students liked, "designing my car and experimenting with the software" and "drawing the solar car project."

What the students liked the least about the computer sessions was mainly directed at the tutorials. Some of the students felt that the "tutorial lessons were slow and boring" or that there were "too many tutorials." This was countered by other students who felt that "some of the tutorials were difficult and hard to understand." One student responded by saying, "I just don't like computers." Many of the students responded to the question of what they liked least with the word *Nothing!*

Engineering Design Project

The design project for the Young Scholar's Program consisted of designing, building, and testing of scale-model solar powered cars. Each young scholar designed, built, and tested his or her own car. The young scholars were allowed to keep their cars - one of our follow-up activities this fall will involve these cars.

The research project got underway on the second day of the program. The subject of "engineering design" was introduced to the students with a brief lecture, and then, by way of example, a brief project was undertaken. This three hour project consisted of the design, construction, and testing of "flying machines". Each young scholar designed and built his or her own device out of paper, scotch tape, paper clips, and crayons. The idea was to design a craft that would, when launched by hand, (1) fly the farthest, (2) land closest to a target, (3) look the "coolest". The first two objectives were separate contests, the third objective was judged by the undergraduate teaching assistants (TA's).

This brief exercise had its intended effects: (1) It generated excitement for the much larger and more complex solar car project and (2) It ably introduced the critical concept of design "tradeoffs". This latter concept was accomplished when the students realized how different the winners of the three categories were: The winner of the distance contest looked like a "rock", the winner of the accuracy contest looked like a conventional paper airplane, and the winner of the appearance contest looked really "radical" (unfortunately, it didn't fly too well). The students learned that it is a real challenge to design and build something that can excel at multiple requirements.

This was a perfect introduction to the solar car project. As with the "flying craft" contest, there were multiple objectives: (1) to build the fastest car, (2) to build the car that would climb the steepest hill, (3) to build the "best designed" car. This third category, again to be subjectively judged by the TA's, included such design aspects as appearance, safety, "passenger" comfort, options, and so forth.

The young scholars were informed at the outset that they would each receive four solar cells (1 inch by 2.5 inches), a small electric motor, and two small dolls to serve as passengers in their car. They were also given unlimited freedom to design and build their cars, provided that they used only the above materials, plus whatever they needed from a large stockpile of general materials of construction, including 1/4 inch foam core, assorted balsa wood, steel and brass tubing and wire, wooden wheels of various sizes, rubber bands, adhesives, paints, clear plastic sheet, etc.

As with most novice designers, the young scholars were anxious to begin construction right from the start. However, they were instructed that the best designer is the one who puts his or her ideas down on paper, refines them, and then efficiently builds what has been designed. Thus, the first three sessions were devoted to placing the design on paper. When the young scholars had developed several feasible concepts, the TA's and faculty helped them to refine the ideas, in some cases combining aspects of different concepts. Then, the young scholars produced scale drawings (by hand or computer) of their favorite concept.

Finally (from the young scholars perspective!) it was time to begin the actual construction. The young scholars were instructed in the safe and proper use of adhesives, soldering irons (for use in attaching wire leads from the solar cells to the motor), and, most importantly, the razor knives used to cut foam core and balsa wood. The construction sessions were closely supervised by faculty and TA's. Despite these precautions, two young scholars suffered minor cuts with the razor knives.

Many of the young scholars experienced great difficulty translating their design from paper to "reality". This is a lesson all designers must learn, and the earlier the better! Despite these difficulties, and the attendant last-minute radical design changes, most of the young scholars managed to produce reasonably well-designed, roadworthy vehicles. The young scholars were encouraged to test their designs as early as possible, so that there would be time for modifications. Testing of drivetrains was accomplished using batteries. Once solar cells had been incorporated, testing was done either under a high intensity photographic light, or outdoors. About half the young scholars managed to test their cars prior to the two days of competition held at the end of the camp. The construction process mirrored the paper design phase in that many of the young scholars tended to be preoccupied with the external appearance of their cars. Thus, many of the young scholars had great difficulty mounting their wheels to their vehicle, and also in getting power from the motor to the wheels. Eventually, about two-thirds of the vehicles ran in some fashion under their own power.

Because of the need for a bright sunny day for the competition two dates were scheduled for the solar car competition. The first day was partly cloudy, and as a result the cars did not perform at their peak. This day was devoted to the "fastest car" competition held on an 18 foot sidewalk course. The young scholars were allowed to make as many "runs" as they wanted, and only their fastest time counted. The second day (the last day of the program) was bright and sunny, and the cars ran quite well. A second "fastest car" competition car was held, as well as the "hill climb" competition. For the hill climb competition, the maximum grade that the cars could climb before stalling out was measured. By the second day, more of the young scholars had managed to get their cars running, making for a lively competition.

After the competition had finished, the young scholars took their creations to the nearby student center, where the cars were placed on display for the design competition judging. Each young scholar had prepared a one page "advertisement" describing the advantages of their vehicle, listing the vehicle's (and the young scholar's) name, etc. These advertisements were displayed alongside each car. The judges for the design competition were the TA's. Each TA received a score sheet with a set of criteria on which to evaluate the cars. These criteria included overall appearance, safety (of the doll passengers), innovation, and technical features (such as multi-speed drivetrains, etc.). The judges also voted for a special category, sort of an "against all odds" category for some of the young scholars who, despite the best of intentions, did not fare too well in the other phases of the competition.

The "tradeoff" aspect of engineering design, introduced in the earlier "flying craft" competition, was reinforced in the solar car project. Three different cars won the three contests: fastest car, best hill climber, and best design. This time the design winner, however, did manage to complete both the fastest car race and the hill climb. The overall winning car placed first in the fastest car race, second in the hill climb, and third in the design competition - quite a display of overall excellence!

The solar car project, in the opinion of the faculty, was an overwhelming success. It captivated the imagination of the young scholars, who participated with great enthusiasm. For example, many of the young scholars worked on their cars at night in their dorm rooms. In addition to whetting the appetites of the young scholars for a possible technological career, we believe that important lessons were learned. These include the fundamental concept of the tradeoff (i.e., the fastest car may not be the best hill climber, or the best looking). Many of the young scholars admitted that they had never built anything of their own design. They learned the lesson that translating an idea from one's mind, to paper, to reality is easier said than done! The scholars learned the importance of detail. For example, if your wheels are not aligned, your car will not run, or else it will not run in a straight line! If your motor is not aligned properly, your drive belt will not stay on. Finally, the young scholars learned a great many individual technical details. For example, they learned the difference between wiring their four solar cells in series or in parallel, in terms of the performance of their cars. Also, many of the young scholars learned about gear ratios for the first time, discovering that a high gear would run their car, but only if they first gave it a push! Lower gears were usually needed to get the cars to start from a dead stop.

The young scholar's evaluations of the solar car research project were almost uniformly enthusiastic. In response to the best phrase that describes the solar car project 77% chose "A real challenge - and a great learning experience." Many of the young scholars commented on how much they learned about the technical aspects of the project, such as going from a drawing to a real object and working with solar cells and electric motors. The young scholars also appear to have learned some important life lessons from the project, as evidenced by their comments about budgeting their time, planning, and staying focused.

Careers Exploration Activities

Career Workshops

Nine one-hour sessions were led by engineers from the community to discuss their backgrounds and careers. These three women and six men included engineers from the fields of civil, mechanical, chemical, petroleum, safety, instrumentation, and environmental engineering. Backgrounds ranged from a new graduate with a B.S. to a recent Ph.D. graduate to engineers who have worked their way into top management positions with their companies. Like many of the young scholars, several speakers had been raised in small towns where a college education was out of the norm. Still others were from homes where college had been an expected extension of their education. Several of the speakers had known from a young age that they wanted to be engineers, while others had experimented with several other careers before becoming an engineer.

The format for each session was determined by the visiting engineer. Most began by talking about their background and what motivated them to become engineers. They all brought visual aids to show what they do in their current careers. Many brought slides or videos of projects they had worked on. The instrumentation engineer brought a computer simulator and control valve to demonstrate how such a control system might work. The safety engineer presented safe and unsafe work environments then demonstrated the use of a variety of meters including a noise meter. A chemical engineer who designs flares demonstrated several simple experiments on combustion and pressure drop. The drilling engineer brought manipulatives to explain the void space in a reservoir and how drills can be damaged by shifts in the center of rotation.

Overall the students seemed to respond well to the variety of speakers with particular interest in the demonstrations. Typical student comments on these sessions include:

> I learned what they do in a day.
> I liked learning more about careers and different occupations.

They showed me that women can be engineers also and do just as good of work as men can.
They told us about their jobs in language we could understand.
I liked how they put the school "theory" into real life situations on the job.
They taught me how hard, rewarding and fun engineering can be. They definitely focused my attention in the general direction of engineering.

Ethics in Engineering

Two sessions were devoted to exploring issues of ethics under the guidance of the dean of the College of Engineering and Applied Science, Lewis Duncan. These sessions began with a discussion of ethics codes within schools as well as in engineering. That was followed by playing a game distributed by Martin Marietta Corp. entitled "Gray Matters" in which the group divided into teams of 4 students and as a group had to decide on a course of action for a variety of situations. In some cases, the dynamics of a group could sway the decision from the original "good instincts" to being an "unethical" decision This game was fun and beneficial because it awarded points for the various answers ranging from -10 to + 10. This demonstrated that some answers weren't really bad but they weren't really good either. This game also included a discussion of each option which was read to the students then discussed as interest indicated.

During the second session, the experimental technique was discussed and demonstrated through magic and "pseudo-science." It was emphasized that ethics requires absolute truth in presenting all (not just part) of the data and that "sleight of hand" is unacceptable. The session was fun and entertaining, but Dean Duncan adeptly focused this on good and ethical science practices.

Engineer-For-A-Day

For one day each year the students went to work with an engineer from the community. The engineers were from companies ranging from small-local businesses (such as Callidus and Residual Technologies, Inc.) to large companies (such as Ford Glass and Sinclair) and also included the US Corps of Engineers. Students went in pairs with an engineer who was matched with the student's interest. The students went to work with the engineer and did whatever the engineer was doing for that day. Some students were in offices a large portion of the day, but all were able to go out at least a part of the day to see plants, assist in field tests, trouble shoot equipment which was working improperly, or other hands-on types of activities. The students then reported on their experiences in a 5-10 minute presentation. Their reports indicated that they had learned a lot about the companies and what engineers at those companies did. Some of the written comments on the final evaluations include:

It was fun because we were shown a lot about how a large-company office operates.
They helped me decide somewhat on what kind of engineer I'd consider being.
I had no idea engineering was this fun. I had expected to sit in an office all day.

Industrial Site Visits

The Young Scholars visited six industrial sites: John Zink Co., Ford Motor Co. - Tulsa Glass Plant, Blue Bell Creameries, Inc., Allied Signal Automotive Catalyst Co., Atochem North America, Inc., and FlightSafety International. The most popular site visit was to FlightSafety. At FlightSafety each of the students were able to fly an airplane simulator. In addition, eight engineers acted as tour guides gave presentations. Links between what the Young Scholars were leaning at the campus program and what engineers were using in industry were demonstrated. For example, the students were able to see the use of a CAD program in the design of all the mechanical and electrical components of a simulator.

FlightSafety was the most rewarding industrial site visit. Students commented in the evaluation that, "I found FlightSafety the most rewarding because I am strongly interested in that field, and I also learned a lot from their experienced staff," "we got to experience their job," "it showed us that engineering doesn't have to be boring," "I learned how all the different engineering fields mix," "fun and interesting," "they explained everything without huge words," Blue Bell creamery also received high marks because of the free ice cream. One student responded that "all of them were rewarding" and that "safety, what the engineers do, and quality," were stressed in all the tours. Based on our experience, the best site visits had students participate in either a hands-on activity or an interactive discussion with one of the engineers.

Project Assessment

We feel our Young Scholars programs were very successful. The Young Scholars were able to practice engineering design through the hands-on activities in the Residential program which was rated by the Young Scholars as the most beneficial. The next highest rated program was the engineer-for-a-day program. The major value of this program was seeing what engineers do during a working day. Also the communication between the engineer and the Young Scholar showed that engineers were *real people*. Increasing the numbers of minority and females in engineering is a fundamental concern for the well being of society. This program encouraged many highly skilled young people to consider engineering as an exciting and realistic career choice.

ATTRACTING WOMEN INTO ENGINEERING PROGRAM AT ROWAN UNIVERSITY

The thrust of this proposed project is to introduce the broad field of engineering to outstanding young middle school female students, especially those who might not otherwise be exposed to engineering as a career option. Students in the 7th and the 8th grades will be our targets. This target audience is selected as this age is a critical juncture in the lives of young girls. The 1990 AAUW poll, Shortchanging Girls, Shortchanging America, documents a loss of self-confidence in girls that is twice that for boys as they move from childhood to adolescence. In their middle school years, girls show a drop in math and science confidence and achievement. In one classic study, the girls' decline in confidence preceded their lowered achievement.

This proposal focuses on a two-week on-campus session at Rowan University wherein students will interact with departmental faculty, undergraduate engineering students and representatives from local industry. Research has also shown that girls are more attracted to, and become more engaged in cooperative learning situations, where students take a team approach. Hence, the workshop will place particular emphasis on collaborative learning. Programs will specifically focus on hands-on engineering laboratory experiments, field trips, workshops on engineering ethics, professionalism, gender sensitivity and computer training sessions. This project will strive to make engineering come alive for young girls as a career, while helping them reinforce the educational fundamentals they require in high school to pursue an engineering career. The program will also serve as a model that other schools will be able to adopt readily in a cost effective manner.

Table 3: Outline of 1999 Activities

Computer Skills	**Seminars**
Engineering Drawing	History of Women in Science and Engineering
Slide Presentations (PowerPoint)	Scholarship for Women in Science and Engineering
WebPages	Careers in Engineering for Women
Engineering Modules	**Workshops**
Truss Bridges	Sexual Harassment
Building Sand Castles	Gender Sensitivity
Water Treatment	Professionalism in the Workplace
Chemical Processing	Engineering Ethics
Electrical Circuits	Robotics
Field Trips	**Team Competitions**
Cogeneration Plant Trip	Tower Building Competition
Sony Music Company	Engineering Design Competition
NJ American Water Treatment Company	

Summary

As the teams of students work through the various phases of this project, several educational objectives are met. Students think creatively to make an original design for their brewing process, and they use critical thinking to compare and evaluate their designs. They are introduced to basic engineering design concepts and engineering principles when they design the mashing, boiling, and chilling equipment. Students gain hands-on experience in building their own equipment, implementing the process, and monitoring the fermentation. Communications skills are emphasized with the final oral reports, written reports and the discussion of designs afterwards.

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Biographical Information

Robert Hesketh is Associate Professor of Chemical Engineering at Rowan University. He received his B.S. in 1982 from the University of Illinois and his Ph.D. from the University of Delaware in 1987. After his Ph.D. he conducted research at the University of Cambridge, England. Prior to joining the faculty at Rowan in 1996 he was a faculty member of the University of Tulsa. Robert's research is in the chemistry of gaseous pollutant formation and destruction related to combustion processes. Nitrogen compounds are of particular environmental concern because they are the principal source of NO_X in exhaust gases from many combustion devices. This research is focused on first deriving reaction pathways for combustion of nitrogen contained in fuel and second to use these pathways to reduce NO_X production. Robert employs cooperative learning techniques in his classes. His teaching experience ranges from graduate level courses to 9th grade students in an Engineering Summer Camp funded by the NSF. Robert's dedication to teaching has been rewarded by receiving several educational awards including the 1999 Ray W. Fahien Award, 1998 Dow Outstanding New Faculty Award, the 1999 and 1998 Joseph J. Martin Award, and four teaching awards.

Stephanie Farrell is Associate Professor of Chemical Engineering at Rowan University. She received her B.S. in 1986 from the University of Pennsylvania, her MS in 1992 from Stevens Institute of Technology, and her Ph.D. in 1996 from New Jersey Institute of Technology. After receiving her Bachelor's degree, she worked on the design of a needleless injector to be used by the World Health Organization in a worldwide measles eradication project. She also spent six months working at British Gas in London before returning to graduate school. Prior to joining Rowan in September, 1998, she was a faculty member in Chemical Engineering at Louisiana Tech University. Stephanie's laboratory development experience began at Stevens Institute of Technology, where she instructed the ECOES summer program for high school students, sponsored by NSF. She is currently focusing efforts on developing laboratory experiments in heat transfer, process control, and biochemical and biomedical engineering at Rowan. Stephanie won the ASEE Outstanding Campus Representative Award in 1998, and she will serve as Newsletter editor of the Mid-Atlantic Section of ASEE beginning in June, 1999.

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James A. Newell received a B. S. in Chemical and Biomedical Engineering from Carnegie-Mellon University in 1988, his M.S. in Chemical Engineering from Penn State in 1990, and his Ph.D. in Chemical Engineering from Clemson University in 1994. His dissertation focused on the conversion of PBO to carbon fiber, and he received the American Carbon Society's Mrozowski award for best student paper presentation in 1993. After completing his doctorate, he stayed on at Clemson for one year as a Visiting Assistant Professor before accepting a tenure-track position at the University of North Dakota in 1995. This is his first semester as an Associate Professor at Rowan. Dr. Newell has been published in Chemical Engineering Education, Carbon, and The Journal of Applied Polymer Science and has coauthored a textbook chapter on the spinning of carbon fiber precursors. His work has been presented at several international conferences in Spain and the United States. In 1997, he was named as the Dow Outstanding New Faculty Member by the North Midwest Section of The American Society for Engineering Education (ASEE). His current research activities include examinations of structure-property relationships in high-performance fibers, statistical modeling of compressive and tensile failure using maximum-likelihood theory, and development of enhanced fiber-resin and carbon-carbon composites. Dr. Newell is a member of the American Carbon Society, The American Institute of Chemical Engineers, and ASEE, where he serves as a director for the Chemical Engineering Division.