EXPLORE ENGINEERING: Rose-Hulman's Outreach to Middle and High School Students

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Introduction

Rose-Hulman Institute of Technology (RHIT) places a high priority on reaching out to the local community. This is part of the formula for its success. Such outreach fosters service opportunities so students can discover engineering, mathematics, and science careers are about more than calculations, theories and books. Service is a fundamental aspect of being a professional and thus fundamental to our students' education. Pedagogically, learning in the affective and social domains is enhanced by such activities, helping improve cognitive learning. Although our emphasis on outreach is a top-down initiative, newcomers to the RHIT community have always been surprised by how unselfishly the staff, students and faculty rally to be a part of community outreach.

Terre Haute, Indiana, the home city of Rose-Hulman, is also a regional center for most of the Wabash River valley in west-central Indiana and east-central Illinois. Much of RHIT's outreach is to Wabash Valley residents. RHIT's EXPLORE ENGINEERING is a science and engineering program for Wabash Valley middle and high school students. This program is offered every other Tuesday night during the academic year for 1-1/2 hours. Though the program was free for a number of years, a nominal fee of $10 per family is now charged to join for the entire year. Over its nearly 10 year life, hundreds of middle and high school students have explored the exciting world of engineering and science thanks to their participation in EXPLORE ENGINEERING. The program has grown in popularity and stature during the past four years, thanks to the support of the Lilly Endowment Inc. and Indiana Space Grant Consortium. Prior to the recent funding, however, the program was still successful, though operating on little to no budget, other than the commitment of Rose-Hulman External Affairs' staff to organize and moderate the meetings every other week, publish a newsletter, maintain membership information and lead the faculty/staff mentoring team administering the program.

Educational Benefits

Hands-On Learning Models: The students work in teams to complete hands-on projects to learn elementary engineering and science principles. Examples include mousetrap-powered cars, where elements of force, aerodynamics and simplicity of design were crucial to developing a successful project; construction of hot air balloons, where the students' efforts must consider heat transfer, aeronautics and teamwork; and constructing model bridges, where students learned project planning, cost effectiveness and computer techniques to build sturdy bridges.

Learning That Science and Engineering Are Fun Career Fields: EXPLORE ENGINEERING program addresses national studies showing that teenagers lose interest in engineering, science and mathematics during middle school years. Students turn out in large numbers every year for the Edible Engineering Contest (constructing vehicles from simple food products), K'Nex® Building

Projects (miniature roller coaster) and model rockets program. High school-aged Explorers also participate in the National Engineers Week's RHIT Student Visitation Day program, a job-shadowing opportunity showcasing professional engineers and scientists.

Breaking Down Barriers: Students of all ages, ethnic and economic backgrounds, and academic skill levels come together twice each month to meet and exchange ideas on how to solve an engineering or science problem. They also learn that there are students in other areas of the community that are interested in becoming engineers, scientists or mathematicians.

Inside The Numbers: EXPLORE ENGINEERING Covers All Ages

To market the program and provide program visibility, information about EXPLORE ENGINEERING is distributed to counselors, math and science teachers and principals at Wabash Valley middle schools and high schools. Media coverage about the program is made available to the public through The Terre Haute Tribune-Star (daily newspaper, 44,000 circulation), The Brazil Times (daily newspaper, 6,800 circulation), The Clinton Clintonian (daily newspaper, 4,200 circulation), The Park County Sentinel (weekly newspaper, 800 circulation); WTHI-TV (Terre Haute's CBS affiliate); WTWO-TV (Terre Haute's NBC affiliate); and WSDM-FM/AM (Terre Haute's news talk radio station).

Students are also attracted to the program through recommendations by other Explorers or their parents. A total of 132 students from 22 area schools and home-school educational situations were enrolled in EXPLORE ENGINEERING during the 2001-2002 school year, with an average of 75 students actively involved in the bi-weekly programs on the Rose-Hulman campus. One student came all the way from the Louisville, Kentucky, area, 2-1/2 hours from Terre Haute, to attend programs.

A demographic breakdown of the Explore Engineering roster reveals:

- 109 (82.7%) were middle school students
  - 49 in the sixth grade, 29 in the seventh grade, and 31 students in the eighth grade
- 23 (17.3%) were high school students
  - 11 freshman, 5 sophomores, 5 juniors and 2 seniors
- 105 were male students, with 27 female students
  - a high attendance rate by female students as compared to male students resulted in about 40% female student participation in the regular activities
- Eight counties were represented
  - Vigo, Putnam, Sullivan, Vermillion, Parke, Greene, Clay, and Louisville, Kentucky
- Eight students were home-schooled

Explore Engineering Leadership

A four-member executive committee that included members of Rose-Hulman Institute of Technology's faculty and staff supervised the EXPLORE ENGINEERING program in 2001-02. These co-directors were:

RHIT's Associate Director of Communications: This member of the college's External Affairs Office staff serves as the primarily contact person for interested students and parents. He also

plans most of the educational programs, purchases supplies and publishes a bi-weekly newsletter that describes upcoming programs.

Chair of Electrical and Computer Engineering Department: This faculty member assists in many of the design projects and helps provide financial assistance through the Indiana Space Grant Consortium.

Associate Professor of Civil Engineering: This faculty member coordinates the popular hot air balloon project and the yearly multi-part civil engineering design education program.

Visiting Professor of Electrical and Computer Engineering: This faculty member provided valuable assistance to programs involving electrical engineering and computer engineering.

EXPLORE ENGINEERING also involves planning and facilitation of the actual activities by students and student organizations. In 2001-02, these included two mechanical engineering students who assisted with all programs as the EXPLORE ENGINEERING student assistants; two Physics and Optical Engineering Professors; a Chemistry Professor; the Cecil T. Lobo American Society of Civil Engineers Student Chapter; Phi Gamma Alpha fraternity; the American Society of Mechanical Engineers Student Chapter; Alpha Chi Sigma Chemical Honor Society; American Institute of Chemical Engineers; Circle K and Alpha Phi Omega Service Fraternities; and Institute of Electrical and Electronic Engineers.

Descriptions Of EXPLORE ENGINEERING Programs

The annual planning of EXPLORING ENGINEERING occurs in the summer before academic year startup. With the exception of the most popular programs, most activities return to Exploring Engineering every other year so that students can plan at least a two-year program involvement without seeing a lot of the duplicate activities. The 2001-02 schedule is typical of each year's activities. Starting in September 2001, EXPLORE ENGINEERING educational programs were conducted twice monthly through April 2002. These programs were:

Sept. 25 - Edible Engineering Contest: Student teams used edible objects (Oreo cookies, pretzels, Cheese Whiz and peanut butter) to build a movable object. This is a great program to start the year, showing the students that science and engineering are fun, and that they will have fun by participating in the program. The competition also attracts considerable media attention, further spreading important messages about engineering education and the program.

October 9 and 23, November 6 and 27 - Scientifically Speaking: EXPLORE ENGINEERING lives up to its name as students get a chance to explore different types of science and engineering fields. These programs included:

- *Slimey Time In Chemistry*: Students found out the chemistry properties of slime, Silly Putty and other chemical components.
- *Fun With Physics*: Several hands-on projects got students a chance to examine applications for light meters, three-dimension projects and fiber optics.
- *Bridge Modeling*: Explorers used West Point Bridge Designer software to design bridges in preparation for the national competition organized by the American Society of Civil Engineers and U.S. Military Academy.

- *Signal Generation*: Students built electronic circuits, created speakers and studied sound waves in the electrical engineering laboratories.

December 11 - K'Nex® Projects: Students used more than 12,000 K'Nex® building Parts to create a 6½-foot long model roller coaster, The Screaming Serpent; a ferris wheel; and a carousel - creating a miniature amusement park that was put on public display in Rose-Hulman's Student Union building for three days.

January 8 – K'Nex® Bridge Competition: The Cecil T. Lobo ASCE Student Chapter organized a K'Nex® bridge design and construction competition. Each team of Explorers was provided a specific collection of bridge building parts and assigned the task of constructing a bridge for the least "cost" to support 5 pounds while spanning 22 inches and providing clearance for passage of a 2 inch x 4 inch cross section "barge" under the bridge. Each part was assigned a different cost so the total cost could be determined at the end of the competition to be a consideration in selecting prize winners.

January 15 - Mousetrap-Powered Vehicles: Teams came up with an assortment of ideas when asked to design a vehicle that could utilize the power of a mousetrap to travel 15 feet. A car kit came with performance tips, wood for a frame, brass tubing for axles, compact discs for wheels and, of course, a mousetrap.

January 29 - Paper Airplane Flying: A model B-2 Stealth Bomber, a King Fisher Racer and a conventional glider were among the aeronautical objects that soared across the Rose-Hulman campus during this project. Explorers tested their creations on a large competition field, scoring points by landing on targets scattered throughout the field.

February 12 - Engineering Career Information Night: To celebrate National Engineers Week, this special program gave students and parents a chance to learn about different forms of engineering. Faculty made short educational presentations or on careers in civil engineering, chemical engineering, electrical engineering, computer engineering, computer science and mechanical engineering. Parents also received advice on how best to prepare their children for college during an information session with a member of Rose-Hulman's Admissions Office staff.

March 5 - Fancy Vehicle Night: Explorers once again got another chance to experience the thrill of creating their own magnetic racers or miniature solar car racers.

March 19 - Model Rockets: Students experienced aerospace engineering and flight by designing and constructing their own solid-fuel Estes® model rockets. Rockets were launched on April 23.

April 2, 16 and 23 - Hot Air Balloons: Using different colored sheets of crepe paper, Explorer teams created colorful, 6 foot tall hot air balloons that were launched into the air on April 23. This has become a favorite annual activity with the students and parents.

Additional Educational Activities During 2001-2002

Besides the bi-weekly educational programs, the EXPLORE ENGINEERING organized the following activities to involve youths in lifelong learning opportunities:

- Botball Robotics Competition: For the past two years, a group of enterprising EXPLORE ENGINEERING members designed, constructed and programmed miniature robots for the Indiana Regional Botball Robotics Competition[1], conducted at Rose-Hulman. Over the course of six weeks, youths learned the basics of computer programming, electronics, robotics, mechanical engineering and teamwork to design a robot that scored points by picking up and placing ping pong balls around a large competition field - against an opposing robot. The EXPLORE ENGINEERING team finished fifth (out of 15 teams) in the regional competition.
- JETS' (Junior Engineering Technical Society) TEAMS Competition: A team of eight high school EXPLORE ENGINEERING students tested their problem-solving skills against other area students in the 2002 TEAMS academic competition, conducted by the Junior Engineering Technical Society[2]. The EXPLORE ENGINEERING team posted the fifth highest score in the Wabash Valley regional, the second highest score in the state (in its enrollment division) and the eighth highest score in the nation (in its enrollment division).
- National Engineers Week Presentation, 'Millionaire' winner and engineer Kevin Olmstead: EXPLORE ENGINEERING members and their parents attended an on-campus presentation on engineering by professional environmental engineer Kevin Olmstead, who won the largest grand prize in game show history ($2 million) on ABC's Who Wants to be a Millionaire?® television show. Besides giving insight on the show, Olmstead discussed why more people need to consider careers in engineering and science. The title of his talk was "Who Wants to be an Engineer?"
- Recyclable Engineering Contest: Two teams of Explorers competed alongside Rose-Hulman students in the college's annual contest, which challenged teams to develop a movable object from an assortment of recyclable materials. The contest entries were judged by Rose-Hulman faculty for engineering skill, craftsmanship, use of materials and appearance.

Types Of Materials Purchased And Used

Funding from the Lilly Endowment Inc. and Indiana Space Grant Consortium was used to purchase the following educational supplies and projects:

- K'Nex® Screaming Serpent Roller Coaster ($93)
- Model Rocket Construction Kits and Solid Fuel Cells ($275)
- Power of Flight Paper Airplane Construction Guide ($42)
- Hot Air Balloon Construction Supplies ($50)
- Mousetrap Car Construction Kits ($603)

Sponsorship also paid the registration fees of the EXPLORE ENGINEERING team for the Junior Engineering and Technical Society's TEAMS competition ($135) and helped cover the postage expenses of the EXPLORE ENGINEERING newsletter, published bi-weekly, incurred by Rose-Hulman's External Affairs Office ($500).

Program Assessment: High Marks From Explorers & Parents

At the end of each year, the EXPLORE ENGINEERING staff surveys students and parents about the educational program.

Student Feedback: When asked to give an overall assessment of the EXPLORE ENGINEERING program in 2001-2002, three out of every five students surveyed gave the program "good" reports, with the remaining two viewing the program as "excellent." There were no unsatisfactory reports. The most popular programs were Slimey Time Chemistry, Edible Engineering, Paper Airplanes, K'Nex® building projects and mousetrap-powered cars. To assist with planning for 2002-2003, the students requested more projects in robotics, egg drops, and K'Nex® building projects. Students also expressed frustration in the amount of time available to complete projects, normally 90 minutes (7-8:30 p.m.). Overall, student opinions included the following statements:

- "We got to engineer lots of different things. It was better than school."
- "It is fun and interesting. You meet a lot of people."
- "It was very fun!"
- "It's cool!"
- "Come and join the fun"

Parent Feedback: Three out of five parents surveyed assessed EXPLORE ENGINEERING as "outstanding," with the remaining two viewing the program as "good." There was not an overwhelming favorite or least popular program (one vote for 10 different programs). The hands-on experiences were viewed as the best aspect of the program. Parents found EXPLORE ENGINEERING newsletter to be very informative (all respondents) and felt that it arrived as households in time to prepare for upcoming events. Overall, parent opinions included the following statements:

- "Best organized program we've ever participated in over the past seven years in Terre Haute."
- "Very well organized and extremely stimulating. My child was encouraged to participate and it was OK if she couldn't work on a project."
- "It exposes students to various aspects of engineering, team building and socialization. Students make friends from other schools."
- "My son enjoyed it a lot."

Program Leader Reflection: The program is a highly satisfying outreach to the community. Each leader can recall numerous examples of unsolicited parent feedback thanking RHIT and EXPLORE ENGINEERING's leaders for continuing the program. Although stepping into the program as a co-advisor involves climbing a learning curve to get into the flow of bi-weekly meetings, program leaders quickly gain confidence in the Explorers, RHIT student volunteers, and their own ability to make last-minute adjustments, when necessary, to assure a productive learning experience. There is also great satisfaction in seeing current and former Explorers succeeding regionally and nationally in science, engineering, and mathematics opportunities. Seeing our "graduates" pursuing careers in engineering is particularly satisfying. Students from the program have continued into engineering in college and are attending schools such as Dartmouth, University of Nevada Las Vegas, Cornell, Purdue, and of course Rose-Hulman.

Summary and Conclusions

EXPLORE ENGINEERING has taken great strides during the past three years, increasing in student participation (from a membership of 54 in 1998 to 132 in 2001), demographics (more middle school-aged students) and diversity (more female and minority students). Also, funding from the

Lilly Endowment, Inc. and the Indiana Space Grant provided the financial resources to improve the quality of educational programs - from simple "hobby shop"-type projects using spare parts from Rose-Hulman department laboratories to challenging projects, like mousetrap-powered cars, hot air balloons and K'Nex® building projects. EXPLORE ENGINEERING also gave Wabash Valley students a chance to participate in the Indiana Regional Botball Robotics Competition and the Junior Engineering and Technical Society's TEAMS academic competition. These students showcased their skills by earning top marks in each contest (finishing 10th nationally in the 2001 National Botball Robotics Championships.) EXPLORE ENGINEERING members and past members also made up 40 percent of the students participating on their high school team's in the 2002 Wabash Valley Regional JETS TEAMS academic competition. More than 50 students with EXPLORE ENGINEERING ties participated in the 2002 National Engineers Week's Student Visitation Day - taking an important step toward becoming college students. The student and parent surveys from the past three years reveals that the EXPLORE ENGINEERING program has successfully achieved its goals of attracting and retaining area teenagers in engineering and science fields, while showing that these areas are fun and exciting.

Despite the recent growth that may in part be due to additional funding, the pre-funding version of EXPLORE ENGINEERING was similarly successful with smaller numbers of students and can provide a good model for similar startup programs elsewhere. To get started at RHIT merely required a number of committed faculty and staff who were willing to schedule activities sponsored by departments and student clubs, and a limited budget for supplies and a regular newsletter to keep members informed. Interested faculty or staff at other schools are encouraged to contact any of the authors about the program to receive insights about starting a similar outreach initiative in their region.

Bibliography

[1]Botball (2003) "Botball Educational Robotics Program" KISS Institute for Practical Robotics, www.botball.org
[2]JETS (2003) "Junior Engineering Technical Society" www.jets.org

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