Leveraging Resources: Shortening contact time without negatively impacting efficacy

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Abstract: Nationally, the population of female undergraduate engineering students has fluctuated between 17.2% and 19.8% for the past decade (Engineering Workforce Commission, 2006). These low numbers will continue because even though the academic gender gap is decreasing in advanced high school mathematics and science courses, girls are less likely to report an interest in pursuing a career in engineering or other physics-based-science fields (National Science Foundation, 2008). To increase girls' interests in pursuing a career in engineering, research advocates outreach activities for female middle and high school students (i.e. Lee & Smith, 2008; Secola et al, 2001). These outreach activities include visits to middle and high schools, inviting students for one, or multi-day campus visits, and on-campus programs that introduce young women to the various engineering fields.

The Academy at Rutgers for Girls in Engineering & Technology (TARGET) is designed to increase awareness in middle and high school girls about the career opportunities available in engineering. The objectives of TARGET are to familiarize girls with different engineering disciplines and negate negative stereotypes concerning their ability to do well in math and science. TARGET was first launched in 1997 and ran as a two-week summer program for 20 middle school girls. Over the course of 12 years, TARGET has evolved to offer six, one-week summer sessions for 144 middle and high school girls and academic year sessions. Program evaluation indicates that the one-week sessions are as effective at meeting program goals as the two-week sessions. Girls consistently reported an increased interest in engineering and greater confidence in accomplishing engineering tasks.

In times of economic hardship, leveraging resources is essential, but it is especially important to maintain the integrity of pre-college programming. TARGET offers a model that leverages resources by shortening contact time without sacrificing efficacy. In our presentation, we will discuss the evolution of our program and share results from pre- and post-test surveys from the past 10 years that evidence the consistent positive impact TARGET has had on the lives of over 300 middle and high school girls (25% Caucasian, 30% Asian, 25% African American, and 20% Latina).

A. Introduction

The technological revolution has brought with it a high demand for scientific and mathematical literacy that is global in scope. Domestically, the number of technology based jobs, such as engineering, far exceeds the number of qualified applicants. In order to compete effectively in the global economy, our nation's universities must attract and retain qualified STEM majors, regardless of their gender, ethnicity, race, or financial needs. The number of women enrolling in colleges and universities are at all-time highs and women constitute over half of the undergraduate population. Matching the shortage of qualified engineering applicants with the rise of female undergraduate enrollment should meet at a

crossroads that filters students into engineering undergraduate programs and ultimately, into the workforce. Unfortunately, this is not the case.

Rutgers, The State University of New Jersey, is one of the nation's major public institutions of higher education. Approximately 50,000 students enroll at one of the campuses in Northern, Central, or Southern New Jersey. As is the trend nationwide, more women (51%) are enrolled at the University than men (49%). While this is the case University-wide, the gender gap at the School of Engineering (SOE) remains widely parted. As of fall 2007, the SOE enrolled approximately 2700 undergraduate students. Women have represented anywhere from 15-to-21 percent of the population for the past 10 years. Currently, women represent 17% of the undergraduate population. Furthermore, approximately 22% of the undergraduate degrees are awarded to women. Our numbers are consistent with national statistics (National Science Foundation, 2008).

With a goal set to increase the number of women pursuing engineering degrees, many program administrators developed, and continue to develop, pre-college outreach and recruitment programs. Research (i.e. Hanna, 2000 & 2002; Lee & Smith, 2008; Secola, Smiley, Anderson-Rowland, Castro & Tomaszewski, 2001) has shown that outreach to female middle and high school students is successful in the recruitment of women in engineering. These outreach activities include visits to middle and high schools, inviting students for one, or multi-day campus visits, and summer programs that introduce young women to the various engineering fields.

In an effort to introduce girls to engineering at an early age and to recruit young women in our engineering program, the School of Engineering administers The Academy at Rutgers for Girls in Engineering and Technology (TARGET)[1]. The objectives of TARGET are threefold: (1) to familiarize girls with different engineering disciplines, (2) to negate negative stereotypes about their ability to do well in math and science, and (3) recruit women into our undergraduate engineering program. TARGET was first launched in 1997 and ran as a two-week summer program for 20 middle school girls. Over the course of 12 years, TARGET has evolved to offer six, one-week summer sessions for 144 middle and high school girls and academic year sessions.

In times of economic hardship, leveraging resources is essential, but it is especially important to maintain the integrity of pre-college programming. In the design and redesign of TARGET, we aimed to continuously offer models that leveraged resources by shortening contact time without sacrificing efficacy. The following sections describe the evolution of our program, the assessment of TARGET, and a discussion of the future of our program.

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B. TARGET: Yesterday & Today

In all the iterations of TARGET, several basic elements remained the same. TARGET was originated and remains as commuter program for pre-college girls. Each year, we maintain a similar recruitment and application process, train the undergraduate and graduate students who facilitate workshops, and design workshops with a focus on engineering inquiry and problem solving.

Each year, we begin recruiting for the program in early January by sending electronic and paper mailings to all superintendants, principals, and directors of guidance, mathematics, and science. Additionally, we generate a running contact list of teachers who write letters of recommendation for applicants each year. Those teachers receive personal invitations to widely distribute applications to their students. All students are eligible to apply to the program. The application consists of providing general information (i.e. name, address, school, grade), writing a short essay describing why they would like to attend TARGET, and submitting two letters of recommendation (at least one needs to be from a math or science teacher). We do not ask for transcripts or test scores and specifically ask teachers to encourage all students to apply so that we recruit students who may not be interested in or know about engineering. Each year, we administered a pre- and post-survey that assessed program impact on increasing awareness of engineering and academic confidence. We also tracked application and enrollment to Rutgers. Section C describes program assessment in greater detail. The following subsections describe the programmatic evolution of TARGET.

We design each session of TARGET so that returning participants have a unique experience each summer. In other words, a student from TARGET I in 2007, can enroll in TARGET II in 2008 and experience a new set of workshops. However, there is no pre-requisite knowledge needed to enroll in TARGET. In other words, a first-time participant can enroll at anytime into any session. Female undergraduate and graduate engineering students are hired to serve as Team Leaders for TARGET. They engage in an extensive, one-week training program that includes first-aid and CPR training, campus safety, conflict resolution techniques, and workshop facilitation management skills. Each of the Team Leaders personally experiences the workshops by working through the modules prior to the students' arrival. They develop lesson plans and outline weekly schedules.

Our portfolio of hands-on workshops evolved overtime, as staff received professional development at relevant conferences and worked with faculty and graduate students to develop fun workshops. Workshops are designed to be interdisciplinary so that participants understand the multifaceted efforts required to solve engineering problems. For example, a biologist uses high-powered microscopes designed by biomedical engineers. One of our biomedical engineering faculty members whose research is in microscopy runs a workshop that requires participants to collect samples, investigate samples under a microscope, identify how the microscope can be better, research current technology, brainstorm on how engineers build on the current technology, make engineering drawings of a better microscope, and keep a journal about their experience.

Each one of TARGET's program activities is hands-on that lend themselves well for the fostering of innovation. On the first day of the program, participants are introduced to the engineering design process: (1) identify the problem; (2) research the problem; (3) brainstorm solutions; (4) select the best solution; (5) make a scale drawing of the solution; (6) build a prototype; (7) test prototype; and (8) redesign as necessary. This eight-step process fosters innovation by allowing students to freely investigate a problem and then create a solution. We aim to make these "problems" relevant to the participants' lives so that they use their genuine interest as fuel that energizes their investigation and creation. For example, the Room Alarm workshop presents a problem that is relevant to most teenagers' lives: How do you protect your room? In this workshop, participants investigate simple circuitry and ultimately design an alarm that can be rigged to any doorway. In the spirit of engineering, we then revise the goal of workshop to secure a journal so that an alarm sounds when someone is trying to read their personal journals. In this iteration, we give the participants more freedom to explore various solutions and build on their previous knowledge.

By presenting the engineering design process as a framework for problem solving, TARGET cultivates a safe environment for participants to utilize their creativity when solving problems. The environment is safe because the engineering design process allows for "failures" and encourages groups to continuously improve their solutions until they reach the "best" solution. Most importantly, TARGET participants are constantly encouraged to let their imagination run wild!

B1. Yesterday

In its inaugural summer (1997), TARGET ran as a two-week commuter session that hosted twenty 7^{th} and 8^{th} grade girls. In the second, third, and fourth summers, we received greater number of applications, but did not want to limit enrollment. Therefore, we offered two, two-week sessions for 7^{th} and 8^{th} graders with twenty girls in each session. As the success of the program continued, a third session to accommodate an additional twenty girls was established in 2000. Each year, we had past participants expressing an interest in returning for more programming. Due to an overwhelming response and the desire of the participants to continue in engineering exploration, IWISE (Introduction of Women In Science and Engineering) was developed in 2001, which hosted 9^{th} and 10^{th} grade girls to participate in advanced hands-on projects. In 2002, IWISE was renamed TARGET II in order to maintain consistency among the programs.

In early TARGET history, we offered a variety of programming that included hands-on workshops, guest speakers, department tours, lectures, and field trips. Based on feedback from student evaluations, we removed department tours and lectures because of a lack of interest. Due to increase in transportation costs, field trips were removed in later iterations of TARGET. A core group of undergraduate students are hired and trained to be Team Leaders. They are responsible for facilitating a majority of the workshops and serving as mentors throughout the program.

In 2008, we were once again faced with an overwhelming request for continued exploration from the participants. We also recognized that we were losing touch with our participants because they would end TARGET activity at 10th grade. Consequently, we completely re-designed into its current state, which is described in the following subsection.

B2. Today

Beginning with summer 2008, TARGET moved from hosting two-week sessions for approximately 40 girls to facilitating one-week sessions for approximately 100 girls. In 2008, we hosted five, one-week sessions (TARGET I – V) for girls in 6th – 10th grade. In 2009, we held six, one-week sessions (TARGET I – VI) for girls in 6th to 11th grade. Each week welcomed a new grade. The program started at 9:00AM and ended at 5:00PM. However, we offered parents early drop-off and late pick-up to match commuter hours. During the course of the week the students were introduced to the engineering disciplines by participating in groups on several engineering design challenges.

A typical day for the students consisted of being dropped off in the morning by their parent(s). They were escorted by the undergraduate counselors to a classroom on campus where they begin hands on activities which introduce them to the various engineering disciplines in a fun and innovative manner. The students received lunch and two snacks during the course of the day. Some of the workshops were designed by faculty members that volunteered their time and efforts in supporting the objective of the program. Those programs included building a water gun using PVC pipes, cement, hoses, and water bottles to experimenting with slime by discussing the various chemical processes in everyday products such as dish detergent, shampoo, oils, etc.

Summer 2009 was unique in that we offered our program to 11th graders. These students had a different experience than the TARGET I-V participants because they were able to work with a graduate student for the entire week of their program on one project. At the conclusion of the program, student groups had the opportunity to present their projects to engineering faculty and parents. The students had the option to select from three projects, which included one electrical, one computer, and one biomedical engineering project. For example, one of the electrical engineering projects allowed students to learn about the theory of state machines from the field of Digital Logical Design by designing and simulating a simple controller of an elevator in a three story building. They used protoboards with IC's, resistors, LED's, switches, etc in order to design and functional controller. The project teams were facilitated by knowledgeable graduate students.

Because of a generous grant from the Motorola Foundation, we are currently offering a Saturday Academy (academic year programming) for the girls who participated in our summer TARGET program. We continue the TARGET model that we use in the summer by giving the students an engineering problem to solve while working in a group setting. The Academy is facilitated by our TARGET summer staff and volunteers from our female undergraduate population.

C. TARGET Evaluation

C1. Participants

Pre-college girls are invited to enroll in TARGET. We advertise the program throughout the state of New Jersey, but have had participants from outside of the state, and country, who have relatives in the area. In 1997 and 1998, we had an average attendance of 25 sixth and seventh grade girls. As the years continued, the program continued to increase attendance and age. In 2009, we hosted 123 girls in grades 6 through 11. Annually, each participant completes a pre- and post-survey that evaluates the program and assesses student's knowledge of engineering, as well as academic confidence.

C2. Data Collection & Analysis

Primarily, assessment of the TARGET program is quantitative and qualitative through a pre- and post-surveys that asks participants to rate their interest in engineering and academic confidence levels, as well as to provide a definition of engineering. Also, we track TARGET participants' applications for undergraduate admission to Rutgers. This past year, we collected preliminary qualitative data by inviting past participants to become "friends" with TARGET on Facebook and asked them to reflect on their TARGET experience by writing on the TARGET wall. In this paper, we will present results from pre- and post-survey from the past several years, as well as report the number of past participants who have applied to Rutgers School of Engineering.

C3. Findings: Pre- and Post-Survey

The same pre- and post-survey was administered from 1997 – 2008. In 2009, similar surveys were administered with additional questions about school climate. The pre- and post-surveys were administered to each student on the first and last day of the program, respectively. Participants completed basic information on academic coursework, parental academic achievement and occupations, grade, and email address. The surveys contained one open-ended question asking participants to define "engineering" and several questions about academic confidence. The responses to academic confidence questions were based on a Likert-type scale of 1-10 with 1 being Not at all Confident and 10 being Completely Confident.

Using principles of Grounded Theory (Strauss & Corbin, 1998) to inductively code for emergent themes, responses on pre- and post-survey were analyzed. Each year, participants' definitions of engineering were consistently more sophisticated on post-surveys. Specifically, responses on pre-surveys focused primarily on traditional fields of engineering (i.e. civil engineering) and structural work (i.e. building bridges). On post-surveys, responses were more sophisticated, as a greater number of themes emerged. These descriptions of engineering included younger disciplines of engineering, such as, biomedical, computer, and bioenvironmental. Also, participants identified cutting-edge research in nanotechnology, solar energy, and pharmaceuticals.

In reporting academic confidence, we continued to see an increase in reported levels on post-surveys with respect to engineering majors. Participants were asked: Assuming that you were interested and motivated to do your best, how confident are you that you could *successfully* complete each of these college majors? The average pre- and post-survey

response rates on select majors from select years are reported in Table 1, where columns 1-8 represent the following academic majors.

1. Mechanical Engineering
2. Materials Engineering
3. Chemical Engineering
4. Electrical Engineering
5. Biomedical Engineering

Table 1: Average Pre- and Post-Survey Response Rates

	1		2		3		4		5	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
2000	5.4	6.6	4.6	6.7	5.5	6.4	5.5	6.3	5.6	6.9
2002	5.6	6.6	4.6	6.5	5.7	6.3	5.7	6.3	5.5	6.1
2006	5.2	6.4	5.2	5.8	5.9	6.8	5.7	6.4	5.7	5.8
2008	4.6	5.2	4.4	5.8	5.2	6.4	4.9	6.1	5.2	6.0

While the change in reported confidence levels was not greatly significant, there was positive movement and consistency over the years. Survey results continued to indicate that TARGET program meets objectives to (1) familiarizing girls with different engineering disciplines and (2) negate negative stereotypes concerning their ability to do well in math and science (through measure of academic confidence). Sophistication of engineering definitions on post-surveys evidenced an increase in familiarization of different engineering disciplines. Furthermore, participants reported increased confidence in completing engineering majors.

D. Discussion

From 1997 – 2007, TARGET participants attended a two-week session that ran Monday to Friday from 9:00AM – 4:00PM (with one hour lunch break). In sum, participants received 54 hours of programming. In 2008 and 2009, TARGET participants attended a one-week session that ran Monday to Friday from 9:00AM – 5:00PM (with one hour lunch break). In total, participants received 35 hours of programming. Despite the drop in contact hours, results from pre- and post-surveys continue report that TARGET met program objectives to increase awareness of engineering and negate negative stereotypes concerning girls' ability to do well in math and science by showing an increase in academic confidence levels.

In shortening contact time, we were able to maintain the integrity of the program. Also, we are able to reach a greater number of students by hosting one-week sessions. Through grant awards, we are able to hold academic year programming. Another measure of success is that we continue to see a high return rate of approximately 40% second-time enrollment. In the near future, we hope to use new technology (i.e. Facebook) to track all past participants' selection of college and major.

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