2006-2365: SUMMER INTRODUCTION TO ENGINEERING FOR HIGH SCHOOL STUDENTS

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The Introduction to Engineering (ITE) program is a one-week, summer residential outreach program for academically motivated high school students offered by the University of Virginia (UVa). The main objective of this program is to offer students with academic potential a broad overview of the engineering profession and a taste of college life. This paper examines UVa's ITE program, beginning with a review of its origins, goals and objectives. The participant selection process, the program's structure, and the efforts made to make the experience both unique and comprehensive, are all also discussed. The paper then examines the program's efficacy by analyzing surveys and comments received from program participants. In addition, the paper shows how the ITE program has served as an effective recruiting tool for UVa's School of Engineering and Applied Science, that could be emulated by other engineering programs. Finally, the paper presents a critique of the ITE program that includes its demonstrated benefits as well as recommendations on how to make it even more effective in the future.

UVa Introduction to Engineering: An Overview

Studies have long shown the importance of introducing students to the exciting potential of engineering at an early age, especially those groups that continue to be underrepresented in engineering (women, African Americans, Hispanics and Native Americans).[1, 2] A student's eventual recruitment to an academic track or career in engineering is largely dependent on the student having developed positive associations with the field during or prior to high-school. [3] This can be difficult since opportunities to experience the exciting aspects of applied engineering through interactive design projects are not always included in middle and high-school curriculum in the United States.[4]

The Introduction to Engineering program (ITE) at the University of Virginia (UVa) gives pre-college students the chance to carry out engaging hands-on engineering projects that show them the creative potential inherent to engineering. By linking engineering with real-life applications, and contextual learning, the ITE program helps make participants' perceptions about engineering more realistic. UVa's ITE is not alone in this endeavor, there are numerous summer engineering programs for middle and high school students at universities across the nation. These include programs at the University of Notre Dame,[5] the University of Alabama,[6] the University of Maryland,[7] Santa Clara University,[8] the Milwaukee School of Engineering,[9] and Virginia Polytechnic University,[10] to name a few. The programs at these schools range in cost, focus, targeted demographic and duration. When other summer engineering programs for pre-college students include interactive activities, such as the program at New Mexico State University,[11] they are not necessarily combined with the range of components implemented by ITE.

The emphasis of UVa's ITE, in contrast to some other similar programs, is to reach out to the top tier of Virginia high-school rising juniors and seniors. The program puts them in a supportive environment with their high-achieving peers in order to introduce them to engineering through a hands-on approach. The program reinforces the value of intellectual achievement balanced with social interaction. This approach follows the recommendations of engineering educators for designing engaging approaches to engineering curriculum.[12] The program uses a set of core introductory engineering classes; seminars on topics such as the college admissions and the financial aid application processes; lectures by faculty and graduate students on their research and engineering career options; and an interactive team-based design competition to give a comprehensive introduction to engineering and college life. During the program, ITE participants experience many aspects of university life in a supervised atmosphere which is intended to show that both the application process and transition to college are feasible. The program also provides extra-curricular social activities such as bowling, to help moderate the challenging academic nature of the coursework. Overall, ITE aims to provide high-achieving high-school students with exposure to engineering prior to their college matriculation in order to increase interest in the field of engineering; help students interested in engineering select advantageous high school coursework; and recruit and retain possible incoming engineering students. The program's success can be measured through various means including post-program evaluations and college application and attendance rates.

The ITE program was established in 1987 as the Minority Introduction to Engineering (MITE) and was sponsored by the Office of Minority Programs (OMP) in UVa's School of Engineering and Applied Science. Initially, the MITE program was intended to serve as a preparation and recruitment program for first-generation college students and minority groups in engineering, defined as: women, African-Americans, Hispanics and Native Americans. In 2002, the program was renamed the Introduction to Engineering, reflecting a conscious decision to make the program more overtly inclusive of all demographic groups. The OMP continued to run the program and was officially renamed the Center for Diversity in Engineering (CDE) in 2004. In addition, in 2003, a new emphasis on hands-on engineering was introduced and material from interactive engineering teaching kits was incorporated into the ITE program. This included the adoption of a context-based approach in the classes and design activity, which provides insight into several engineering disciplines while emphasizing the influence and merit engineering has on the real world.

ITE Participant Selection

The ITE program is open to rising juniors and seniors from across Virginia and when there are applicants from out-of state, they are also considered. The program has space for about 20-25 participants. Every year, information about ITE is sent to every high-school guidance counselor, science and math teacher in Virginia. The high-school guidance counselors play a key role in recommending participants for the program. Many of these counselors are already familiar with this program and have students in mind to recommend for the program. Applicants are selected based on the following competitive criteria: their scholastic performance with an emphasis on engineering related courses such as mathematics and the sciences; their standardized test scores such as the PSAT, SAT and other achievement tests; prior exposure to pre-engineering classes or activities; their expressed interest and motivation in a short essay; telephone interviews; and recommendations from high-school teachers and guidance counselors.

The CDE receives on average between 40 and 50 applications for the ITE program every year. Although the specific standards for admission vary year to year based on the qualifications of that year's applicants, there are some general trends. Competitive applicants have a "B" average or higher; have taken Algebra, Algebra with Trigonometry, and preferably also Pre-Calculus;

have taken Chemistry and if possible Physics; and have a score of ranging from 500-800 on the on the PSAT and SAT tests. In addition they should have demonstrated some interest in engineering either through an engineering related class or extra-curricular activities, and have given a clear vision of how participation in the program will help them achieve long-term goals in their essay. Applicants are not expected to already have extensive knowledge of engineering, but rather to express motivation to explore applied science and engineering. The essay gives the applicants an opportunity to personalize their application, and it is especially taken into consideration if the applicant's grades and test scores are border-line.

In the past, there have been some difficulties encountered during the during the participant selection process. For example, some applicants have not taken the PSAT or SAT, and some, especially those who apply as rising juniors, do not have the necessary math skills. In these cases, the applicant's GPA, enthusiasm as expressed in the essay and phone interview are critical. Summer scheduling also frequently presents a problem as many of these students apply to ITE, also apply to other summer programs, such as music and athletic camps as well as academic-based programs. Some of the students who are accepted are not able to attend, because the schedules of these activities overlap. Financial hardship, however, does not present a barrier to participation in the program. Students are required to pay a fee to attend the program, but scholarships are available to ensure that qualified students can attend even if their families cannot cover the expenses. Figures 1a and 1b show some of the 2005 ITE participants.

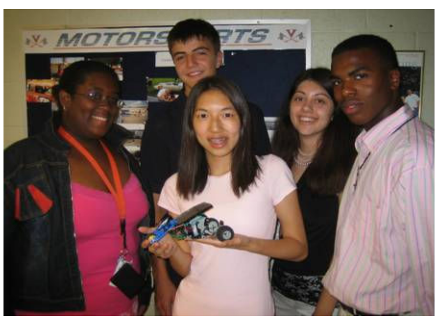
Figure 1a: 2005 ITE participants.


Figure 1b: 2005 ITE participants.

ITE Components and Activities

The week-long ITE program typically runs from Sunday to Saturday during the month of July. At the beginning of the week, ITE participants are given a schedule of activities which includes their core classes as well as designated study times and social activities. The ITE program strives to make the participants' experiences both unique and comprehensive. The program schedule purposefully includes exposure to all of the fields of engineering available at UVa. The schedule for the 2005 ITE program, which is representative of the schedule in recent years is shown in Table 1 (below). As is evident from the sample 2005 schedule, the program focuses on better acquainting the participants with engineering as a whole and the core disciplines that form the building blocks undergraduate engineering. On the first day, the participants take a tour of the campus and attend a reception and orientation. The rest of the week emulates college life, with block-scheduled classes. The daily program activities include design workshops, calculus workshops, chemistry workshops, CAD workshops, tours of engineering departments and laboratories, special presentations and social events. The core classes concentrate on intensive interactive projects, and many of the other activities also center on team building.

Table 1: 2005 ITE Schedule: July 10 – July 16

Sunday, 10	Monday, 11	Tuesday, 12	Wednesday, 13	Thursday, 14	Friday, 15	Saturday, 16
	Breakfast 7:30 - 8:30					
	Pictures 8:30-8:40	Free	Electrical Eng'g Art Lichtenberger Steve Wilson 8:30-10:00	Material Science Richard Gangloff 8:30-10:00, D-221	Civil Engineering Brian Smith THN D, 8:30-9:10	Final Activities Clean-Up 8:30-12:00
	Chemical Eng'g Robert Davis CHE 005 9:15-9:55	Computer Science James Cohoon 9:00 -10:00			Systems Eng'g Kenneth Crowther 9:15-10:00	
	Calculus E-304, 10:00-11:00	Calculus E-304, 10:00-11:00	Calculus E-304, 10:00-11:00	Calculus E-304, 10:00-11:00	Calculus E-304, 10:00-11:00	
	Chemistry MEC 205 11:00-12:00	Chemistry Chem 314 11:00-12:00	Chemistry Chem 314 11:00-12:00	Chemistry Chem 314 11:00-12:00	Chemistry MEC 205 11:00-12:00	
	Lunch 12:00 - 1:00 pm					
Arrival and Registration 2:00-4:00	CAD Larry Richards Mech 215,1:00-2:00	CAD Larry Richards Mech 215,1:00-2:00	CAD Larry Richards Mech 215,1:00-2:00	CAD Larry Richards Mech 215,1:00-2:00	CAD Larry Richards Mech 215,1:00-2:00	Departure
	Solar Car Module Mech 215, 2:00-3:00	Solar Car Module Mech 215, 2:00-3:00	Solar Car Module Mech 215, 2:00-3:00	Solar Car Module Mech 215, 2:00-3:00	Solar Car Module Mech 215, 2:00-3:00	
Reception 3:00-5:00	Systems Eng'g Leigh Baumgart 3:00-4:00	Mechanical Eng'g Jeff Crandell 3:10-4:10	Solar Car Mech 215 3:10-4:10	BME Kitter Bishop MR5 3:00-5:00	Solar Car Final Competition Mech 215 3:00 - 5:00	
	Talks with the Deans @ 4:10	Admission talk Peabody Hall 4:15-5:00	Engineering Careers Frances Hershey 4:10-5:00			
Dinner 5:00-6:00					Dinner and Awards Rodman Room 5:00-6:30	
Orientation 6:00-7:00	Bowling 6:20-8:00	Solar Car Computer Lab Mech 215 6:00-8:00	Planet Fun 6:20-8:00	Solar Car Mech 215 6:30-8:15	Free Activity	
	Study 8:30-11:00	Swimming at AFC 8:00-9:15	Study 8:30-11:00	Study 8:30-11:00		
		Study 9:30-11:00				

Although the participants in ITE are generally high-achieving rising juniors and seniors from Virginia, they arrive with a range of preparation in math and science, even when they have taken the same courses. In order to accommodate the variation in math and science preparation, the ITE instructors design a curriculum that is challenging yet feasible for participants with different levels of grounding. The professors and teaching assistants that serve as instructors for the ITE classes are drawn from the various relevant disciplines at UVa and all have extensive experience teaching during the academic year.

The calculus workshop is based around a hands-on topic that can be completed in the week span of the program, assuming no prior knowledge of calculus. In 2005, the instructor used the example of running a banana split stand in order to teach calculus-based optimization. The students were tasked with coming up with a plan to maximize the profits of the commercial enterprise. In order to determine this, the instructor taught the participants all the skills they would need. First the workshop reviewed basic algebra. Then the participants were taught the power rule for taking derivatives. Following that they learned how to complete the square and graph parabolas, how to write cost, price, revenue and profit functions and finally how to take the derivative of a quadratic equation and analyze its increases and decreases. On the last day, they worked out the optimum price for the banana splits and made sample products in class. Since the participants are not expected to have any background in calculus, the project is designed to be interesting and stimulating while also reasonable.

The chemistry workshop includes both lectures and team based hands-on laboratory components. The lectures focus on the contributions chemistry makes to society, and its applications to fields such as medicine and health-care and the environment. Since chemistry's role in society is not usually included in introductory chemistry classes in high school, the material is new to most participants. The practical experience in the laboratory has the participants work fundamental qualitative chemical techniques. Some of the projects have included thin layer chromatology and separation of substances. Some of the participants have previously conducted chemical laboratory experiments similar to those used by ITE, but that has not detracted from their experience. In most cases these participants are excited to do the project again, and if they complete the project more quickly than anticipated they are given another one. Also, since the ITE has the students work in teams, those participants who might have done the activity prior have a different perspective to lend to group discussions.

For over a decade, a workshop focusing on introducing Computer Aided Design (CAD) has been part of this program. The students learn "SilverScreen," a three-dimensional modeling package. The fundamental capabilities of the software are covered in three class periods. Following that, the students have access to the computer classroom in the evenings to practice and develop their skills. The final CAD assignment is integrated with the car design and competition activity and requires each team to document their model cars. These are modeled as a three-dimensional assembly which must show each component. The level of sophistication achieved by some of the ITE participants is exceptional and they have routinely reported that this activity is both fun and challenging. Figure 2 shows a 2005 ITE participant testing a motor, and Figure 3 shows a CAD model created by one of the teams in 2005.

Since 2000, there have been two different types of team-based interactive design activities, including first a mousetrap car competition and then a solar car competition. In 2000, ITE introduced as a pilot project a hands-on engineering project for teams of participants to work together to build and race mousetrap cars. Participants worked in teams to design their prototype car and then build and test it. They also made three dimensional CAD models of their final design. The competition involved the speed of the cars, and their ability to stay on a straight path The entire process for the car competition required sustained effort and was met with motivation and enthusiasm on the part of the participants. Based on the success of this pilot run, the ITE coordinators decided to continue this activity in the following years.

Figure 2: 2005 participant testing a motor.

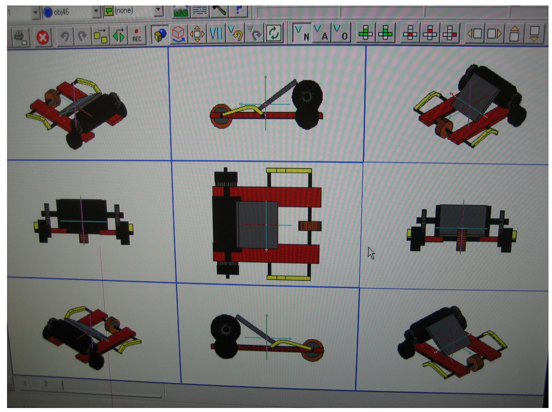

Figure 3: A Computer Aided Design Model from 2005.

In 2003, the car competition transitioned into building and racing model solar cars. The solar car competition is based on an engineering teaching kit developed for use in middle schools. In order to implement it during ITE, the kit was adapted to fit the requirements of the high-school participants. This was not a difficult process since the task of designing and building a solar powered car is thought-provoking and challenging to a range of students, from second graders all the way to fourth year mechanical engineering students.[13] Students were put into teams to design, assemble, test, and compete with solar cars. They had to test motors and solar cells and rank them based on performance measures, and then use their analysis of these components to build a car that could pull a cart loaded with weights. However the main functional components of the car (solar cells, motors and tires) had to be purchased; and the students had to operate within a budget. The costs were structured so that the teams could not buy the best of everything. Thus they had to make trade-offs and compromises. During the competition, held on the last day of the program the car that pulled the most weight won. The participants were purposefully given minimal direction and maximum freedom in designing their cars. The aim was to foster imagination and collaboration to solve the problems encountered in designing and building the cars.

Since the solar car project was introduced, ITE participants have developed some extremely intricate models with elaborate gear systems. In 2005, there were two teams that had solar cars that pulled over 20 pounds. Prior to that, the limit from any group using the kit, including college students at UVa was 14 pounds. The solar car project is a realistic engineering design challenge because it is complex enough to challenge the students, and allows each team to create a unique design. In addition to the faculty member directing the challenge, several undergraduate engineering students were available as resources for the teams. The undergraduates served as role models as well as guides, and the ITE students learned much from them about what it means to be an engineering student. Figure 4 shows a solar car from 2005 pulling the loaded cart, and Figure 5 shows the 2005 winning solar car that pulled 24 pounds.

Figure 4: 2005 solar car pulling the loaded cart.

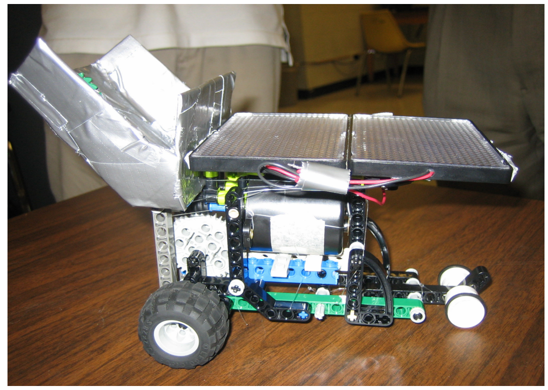

Figure 5: 2005 (24 lb pulling) winning solar car.

In addition to assisting with the solar or mousetrap car competitions, the undergraduate counselors attend classes and participate in social activities with the ITE participants. The counselors' presence and guidance during classes and the group design projects is an important motivation and source of support for participants. Every year, most of the counselors are former MITE or ITE graduates who are now students at the University of Virginia. This provides continuity to the program, and a ready source of role models for the high school students.

The schedule also includes social activities every day and tours of the engineering facilities at UVa throughout the week. These two components are integral to the overall functioning of the ITE program. The social activities provide opportunities for the participants to bond in a non-academic environment. The tours of the engineering laboratories and presentations by engineering professors give participants an informal introduction to engineering study and shows them what UVa can offer in the various disciplines.

Results: Analyzing the ITE Program

<u>Demographics:</u>

The MITE/ITE program was initially implemented as a mechanism for introducing underrepresented groups in engineering (women, African Americans, Hispanics, and Native Americans) to the engineering field while in high school, and ultimately recruiting them into engineering. Yet, the admissions process for ITE has always been competitive, with early applications favored and space in the program limited to high-school students who have demonstrated academic excellence. Since its inception, these groups have traditionally made up a significant portion of the program's participants. Table 2 summarizes the demographic makeup of participants in the MITE/ITE program, broken down by year, gender, and minority status.

Since the change in emphasis in 2002, there has been a decline in the proportion of these minority groups, though they still make up more a significant percentage of the participants. These underrepresented populations make up only about 12% of engineering baccalaureate degrees awarded nationwide.[1] Considering that, the ITE program's percentage of minority students is still well above the national average for undergraduate engineering programs. Over the years, the percentage of female participants in ITE has remained relatively steady, ranging between 53% and 64% (see Table 2). Compared to the national average for engineering students, this is also noteworthy, since women continue to be quite underrepresented in engineering undergraduate programs. The high proportion of women participants every year, is in part due to the fact that female candidates tend to submit complete applications earlier than do their male counterparts. In addition to learning about the engineering disciplines, it is important for the participants to be able to visualize themselves as engineers. In order to provide effective role-models for these underrepresented groups, the ITE administrators make a conscious effort to recruit female and minority undergraduate counselors, instructors and faculty presenters. Based on the demographic makeup of the participants, the ITE program has demonstrated success in reaching out to underrepresented populations in engineering and encouraging them to consider engineering.

Table 2: 1998-2005 MITE/ITE Demographic Chart

Year	Total	Female	% Female	Minority	% Minority*
1998	35	19	**54%**	n/a	**n/a**
1999	27	16	**59%**	n/a	**n/a**
2000	29	16	**55%**	25	**86%**
2001	22	12	**55%**	19	**86%**
2002	28	18	**64%**	20	**71%**
2003	27	17	**63%**	19	**63%**
2004	24	13	**54%**	13	**54%**
2005	34	18	**53%**	21	**38%**

Evaluations:

Recent survey data from the post-program evaluations is used to assess the ITE program's success in meeting its other stated goals. Each year, the participants complete written evaluations at the end of the program to assess their response to specific aspects of the program. In some years the evaluation surveys have had more qualitative, or open ended responses, whereas in others the focus was more on quantitatively rating an activity or workshop on a numerical scale.

Multi-Year Evaluation Comparison:

Though the surveys have differed from year to year, certain information has been consistently requested and the quantitative portion of the evaluations is presented in Table 3a and Table 3b (below). Starting in 2001, the following three questions were systematically included in the post-program evaluations:

1. What did you expect from the program? Did the program fulfill those expectations?
2. What did you learn from the program?
3. Would you recommend this program to your friends and family?

These questions all elicited a variety of personalized answers, but because they each contained a "Yes or No" component, it was possible to tabulate the results. Table 3a shows the percentage of respondents who answered "Yes" to the questions. The results indicate that the vast majority of the participants' expectations were met, all of the participants stated that they learned something and between 91% and 100% would recommend the program to others (Table 3a).

Each year in the post-program evaluations, the participants rated activities on a five point Likert scale, with a rating of 1 representing "poor" or "below average" and 5 representing "excellent" or "above average." In most cases, space was also given for participants to explain their ratings in an open-ended format. The activities that were most consistently evaluated from year to year, and therefore generated the greatest statistical relevance were the core components: the Calculus workshop, the Chemistry workshop, the Computer Aided Drawing workshop, as well as the two different car building competitions. Table 3b shows the average ratings (in bold) for the questions that were consistently included in the evaluations from 1999-2000, with the standard deviation (below in parentheses), in order to compare the ratings from year to year. It should be noted that the 2003 ITE evaluations were unavailable and could not be included in Table 3b.

Table 3a: 2001-2005 ITE Evaluation Results to "Yes / No" questions

Category:	**2001 % Yes**	**2002 % Yes**	**2004 % Yes**	**2005 % Yes**
Participants who stated that their expectations were fulfilled:	95%	81%	100%	94%
Participants who stated that they learned something from the program:	100%	100%	100%	100%
Participants who stated that they would recommend the program to friends and family/others.:	91%	93%	100%	100%

Table 3b: 1999-2005 ITE Evaluation Results to Likert rated questions

Question: (Rated on a scale from 1-5 where 1= poor/below average and 5=above average)	**1999 Average** (Standard Deviation)	**2000 Average** (Standard Deviation)	**2001 Average** (Standard Deviation)	**2002 Average** (Standard Deviation)	**2004 Average** (Standard Deviation)	**2005 Average** (Standard Deviation)
How would you rate the Calculus workshop overall?	**4.04** (0.82)	**4.12** (0.86)	**3.19** (1.25)	**3.07** (1.14)	**4.08** (1.18)	**3.45** (1.20)
How would you rate the Chemistry workshop overall?	**4.01** (0.82)	**4.29** (0.77)	**2.38** (1.28)	**2.52** (1.40)	**4.17** (0.83)	**4.14** (0.78)
How would you rate the CAD workshop overall?	**4.54** (0.72)	**4.82** (0.39)	**4.82** (0.39)	**4.48** (0.70)	**4.04** (0.91)	**4.02** (0.83)
How would you rate the mousetrap car competition?	n/a	**3.76** (0.97)	**4.15** (1.10)	**4.15** (1.10)	n/a	n/a
How would you rate the solar car competition?	n/a	n/a	n/a	n/a	**4.38** (0.71)	**4.35** (0.81)
Yearly program average:*	**4.13** (0.81)	**4.17** (0.67)	**3.52** (1.07)	**3.50** (1.05)	**4.17** (0.86)	**4.15** (0.84)

*The yearly program averages are based on the averages of all Likert rated questions, some of which are not included in the table.

As can be seen from Table 3b, the yearly program average was always above 3.50 points, ranging from 3.56 to 4.25 points, which demonstrates a high overall level of participant satisfaction. The participants had a very positive overall reaction to the core components of the program and rated nearly every category or question at 3.50 points or higher out of 5.00 possible points. Although the core requirements systematically received high ratings, some years were higher than others. The lower ratings in 2001 and 2002 for the Calculus and Chemistry workshops were related to the transitioning of new instructors for those classes, who tried to teach material that was too difficult. These two courses must be carefully constructed to present material at an appropriate level, which presents a challenge to faculty and teaching assistants used to teaching undergraduates. The CDE worked with the new instructors to develop means by which they could present interesting material that was at a satisfactory level for the ITE participants. In the case of the Chemistry workshop, the solution was to divide the class into two components and have an instructor with experience teaching high school administer the laboratory portion. For the Calculus workshop, the material was revised and the approach changed so that the class was structured around a single project that did not require prior knowledge of Calculus to complete. These alterations substantially improved the workshops as evidenced by the subsequent increase in ratings in 2004 and 2005.

The mousetrap car competition was introduced in order to add an interactive design component to the program. In the first experimental year, the activity received its lowest rating, of 3.76 points with a standard deviation of 0.97 points (see Table 3b), though still well above 3.50. Some of the comments on the evaluations regarding the mousetrap car building and competition mentioned time constraints and not having all of the materials from the start, hampered their progress. They suggested that more time be given to work on it. However, the comments also emphasized that most of the participants enjoyed the project, calling it "fun," and "challenging," applauding the team aspect and the need for imagination and ingenuity. In 2001 and 2002, the ratings for the car competition improved to 4.15, largely because the organization improved based on comments and feedback, the instructors made materials available from the start and more time was allotted to the participants to work on the project. When the solar car was adopted in place of the mousetrap car in 2003, it received even higher ratings than had the mousetrap car competition, indicating that the new project represented a worthy challenge for program participants.

1999 Evaluation Results:
The 1999 post-program evaluation included a number of additional questions that were not routinely used in subsequent years. The average ratings from the evaluations of these questions including "How would you rate the program overall?" and "How would you rate the Biomedical tour?" are shown in Table 4 (below). As the table shows, the average rating for the program was quite high at 4.54 points, as were the ratings for the ITE co-coordinators, counselors and the social activities. This indicates a high overall satisfaction rate with the program. The Biomedical tour, and the Solar/Legend Car tour were well rated at 3.91 points and 3.52 points, respectively. Though these activities were continued in subsequent years, they were not included the evaluation.

Table 4: 1999 ITE Evaluation Results to Additional Likert rated questions

Question: (Rated on a scale from 1-5 where 1= poor/below average and 5=above average)	Average Rating	Standard Deviation
How would you rate the program overall?	4.54	0.58
How would you rate the Biomedical tour?	3.91	1.21
How would you rate the Mechanics workshop overall?	3.25	1.13
How would you rate the Solar/Legend Car tour?	3.52	0.95
How would you rate the ITE co-coordinators and/or staff?	4.48	0.67
How would you rate the ITE counselors?	4.70	0.63
How would you rate the social activities?	4.41	0.64

2000 Evaluation Results:
In 2000, the ITE program included a physics course which received an average rating of 3.29 points with a 0.59 point standard deviation. Some of the comments on the evaluation related to the physics course included: "This class was the hardest because it was a lot of new information

and not enough time to learn it," "The course was extremely challenging for a person who has never been introduced to physics prior to the program," "There was too much homework on the first day," and "There was a lot of good information but it was taught too fast." These comments indicate that this class was quite challenging for most participants because it was predicated on their having learned certain basics of physics and calculus that not all had already been taught. The physics course has not been taught since 2000, leaving more time in the schedule for the other activities.

2001-2002 Evaluation Results:
Although the 2001 and 2002 evaluations were shorter and did not contain any quantitative questions not included in Tables 3a and 3b, the qualitative portions of the evaluations from those years contained other valuable information. For example, the 2001 and 2002 participants were asked "What were your most memorable experiences?" The responses frequently referred to bonding with other participants, the mousetrap car competition and the social activities. Table 6 (below) displays responses for this question from 2001, which had a total of 22 evaluations returned, and from 2002, which had a total of 27 evaluations returned. As expected, the participants stated that a very meaningful part of the program is their interaction with their peers. Some of the participants explicitly stated that they valued the opportunity to get to know other students, from similar and different backgrounds who all shared their enthusiasm for science, learning and discovery. The mousetrap car competition was also a popular response, which shows that it effectively engaged participants in a creative and challenging experience. The range of other responses all fall within the stated goals and objectives of the ITE program, and are a positive indication that the program is meeting these goals.

Table 5: 2001-2002 Responses to "What were your most memorable experiences?"

Experiences Response Categories:	Number of Respondents: 2001	Number of Respondents: 2002
Working and bonding with other participants.	13	15
The mousetrap car competition.	7	6
The social activities.	3	9
The CAD class.	0	1
The Calculus class.	2	0
The Chemistry professor.	0	1
Getting to know the counselors.	2	0
Getting to know the professors.	2	1
Getting an introduction to college life.	0	5
The tours of the engineering facilities.	1	5
Mechanical Engineering and Materials Science.	0	1

2004 Evaluation Results:
The 2004 evaluation included some questions that were not present in the earlier evaluations. According to the evaluations, the 2004 participants generally enjoyed the social activities, rating them on average at 4.29 points, with a 0.75 standard deviation. In addition, the 2004 participants were asked to numerically evaluate the food and housing provided by the program. The average rating for the food was 4.21 points with a standard deviation of 1.14 points, and 3.75 points with a standard deviation of 0.90 points for the dormitories. Although this shows room for improvement, especially in the dormitory facilities, it is above satisfactory. Factors that could

have contributed to a lower score for the dormitories are that not all high-school students are accustomed to living away from home with roommates and also the vagueness of the question. This was a common concern related to the evaluations, that the relative lack of written instructions could have led some participants to base their ratings more on personal preference than the overall merit of the activity or component. In order to clarify this issue in the future, there will be additional written and verbal instructions to the participants to evaluate the component's academic merit and success in elucidating a new aspect of the field of engineering.

In 2004, the participants were also asked what their most memorable experiences were and what they learned from the program. The responses from the 24 evaluations returned are shown in Table 6a and Table 6b, below. Similar to the 2001 and 2002 responses, in 2004 the participants stated that working and bonding with their peers was a memorable part of the program, along with the solar car competition, the social activities and a range of other program components. In response to the question of what they learned, 22 of the 24 respondents explicitly affirmed that the program taught them about the different fields of engineering. Other responses included learning about engineering careers, about specific engineering classes, general understanding of engineering, about UVa, about teamwork etc (see Table 6b). All of these responses point to the program's efficacy in introducing high school students to engineering, college life and UVa.

Table 6a: 2004 Responses to "What were your most memorable experiences?"

Memorable Experiences Response Categories:	**Number of Respondents:**
Working and bonding with other participants.	14
The solar car competition.	10
The social activities.	5
Experiencing working as a team or in a group.	3
The Calculus class.	3
Learning about the different types of engineering.	2
The tours of the engineering facilities.	2
Getting to conduct experiments in the Chemistry laboratory.	2
Listening to the presentations.	1
Getting to know the counselors.	1
Getting to know the professors.	1
Seeing and getting to know UVa.	1
Getting some career counseling.	1
Getting an introduction to college life.	1
The meals.	1

Table 6b: 2004 Responses to "What did you learn from the program?"

Things Participants Learned Response Categories:	**Number of Respondents:**
About different fields of engineering.	22
About what type of careers are available.	4
About engineering classes: CAD, Calculus, Chemistry.	5
Changed my understanding of engineering.	3
How engineering is related to society and the real-world.	3
About UVa in general.	2
Locations of the engineering buildings at UVa.	1
About UVa's admissions process.	1
How to work better in a team.	1

Problem solving skills.	1
To be myself.	1

Focus on ITE 2005

All of the quantitative and qualitative data from the 2005 post-program participant evaluations is presented separately here in order to discuss in greater detail how participants perceive the current structure of the program. Table 7 (below), summarizes the responses to all of the Likert rated questions and the "Yes / No" questions from 2005, including several that were new to the evaluation, and were therefore not included in Table 3b. These include "How would you rate the schedule?" and "How would you rate the individual major presentations?" among others.

Table 7: 2005 ITE Evaluation Results to Likert rated questions and "Yes / No" questions

Question: (Rated on a scale from 1-5 where 1= poor/below average and 5=above average)	**Average Rating**	**Standard Deviation**
How would you rate the schedule?	3.73	0.80
How would you rate the CAD workshop overall?	4.02	0.83
How would you rate the Calculus workshop overall?	3.45	1.20
How would you rate the Chemistry workshop overall?	4.14	0.78
How would you rate the solar car competition?	4.35	0.81
How would you rate the individual major presentations?	4.13	0.82
How would you rate the social activities?	4.33	1.17
How would you rate the staff?	4.97	0.17
How would you rate the closing reception?	4.27	0.98
How would you rate the dormitories?	4.52	0.80
How would you rate the food?	3.77	0.89
Yearly program average:	4.20	??
Were your expectations fulfilled? (Yes or No)	94%Yes	n/a
Would you recommend the program to your friends and family? (Yes or No)	100% Yes	n/a

Of the core components of the program, the Calculus workshop received the lowest rating, averaged at 3.45 points, with a significant 1.20 standard deviation. This is interesting, considering that it was the same instructor who taught the class the year before when the ratings were a half a point higher, though still with a high standard deviation. The approach used by this instructor is to apply mathematical concepts to real-life situations, so it is quite different from a textbook based method. Although this challenge was well received by some participants, for others it was frustrating to be asked to apply concepts to the real world without the assistance of a textbook. Introducing participants to a more interactive learning style is one of the aims of the program, since many college math and science courses are structured in this way. Exposure to this approach prior to matriculating into a university helps students realize that they will need to use problem-solving skills and creativity to explore increasingly complex concepts.

The program schedule also received one of the lower ratings during the 2005 evaluations with an average of 3.73 points and a standard deviation of 0.80. There were comments and suggestions from the 2005 evaluations on how to improve the program's schedule. Several of these concerned the duration of the program. Some students felt that too much was included in a single week, and that the days were too tightly scheduled. Instead, they wanted more time between activities and some down time to relax and reflect. Some students and parents suggested expanding ITE to two weeks. In addition, several students indicated that they would have liked more time to interact with professors, and more social interactions in general.

In an interesting inversion of the 2004 responses to the food and dormitories, the 2005 participants rated the dormitories three-quarters of a point higher at 4.52 and the food three-quarters of a point at 3.77, which is an almost exact switch of the 2004 evaluations. The dining halls likely got a higher rating in 2005 because there were more options to choose from than in 2004. In the open-ended response area, several participants complained about insects in the dormitories, overcrowding and mildew. Yet, as one participant also noted, it was not feasible to expect too much from a shared dormitory room. Learning to live in a small, shared space, away from one's family, is an important transition for college students, and ITE gives participants a taste of what this involves.

In the qualitative counterpart to the "Yes or No" question related to whether the ITE program fulfilled their expectations, 2005 participants were asked to state what they had expected from the program. Of the 33 survey respondents, 29 said they expected a general overview of the fields of engineering; eight said to learn about engineering at UVA; and five said to participate in a project or hands-on activity. By the end of the week, 94% of the participants felt that these expectations had been fulfilled. The participants both self-selected categories that correspond with the program's goals in stating their expectations of the program and in stating that they were largely fulfilled. This demonstrates that the program makes its objectives and organization clear before the start of the program and accomplishes its goals over the duration of the program. When asked about their most memorable experiences, 23 respondents cited social activities and interactions. This is an important measure of success to the program organizers since it is crucial to present engineering as a fun and exciting discipline that facilitates social interaction, in order to counteract stereotypes about engineering as dull and solitary work.

Some of the other questions not included in the quantitative table because of their open-ended format had to do with the application process, their individual expectations, and what activities were most enjoyable and valuable. These all grant insight into the participants' view of the program. In 2005, students were asked for the first time on the evaluations, how they learned about UVa's ITE program. Fourteen reported that they had learned of it from a teacher or guidance counselor; five from general announcements at their school; seven from the UVa website; and five from family or friends. This shows that the schools and, in particular the mail campaign to teachers and guidance counselors is a key element in publicizing ITE to Virginia students. It also indicates that informal networks and "word of mouth" help encourage interest.

There were also some comments in the open-ended portion of the 2005 evaluation indicating that less lecture and more hands-on activities would be appreciated. Achieving a successful balance of instruction, group-work and fun interaction is a difficult challenge for the ITE administrators and the suggestion to expand the program into two weeks is under consideration. Without extending the length of the program itself, it is hard to provide a meaningful introduction to the academic subjects, include a design project and also allow more unstructured time. Whenever possible, accommodations are made to allow participants to pursue outside interests during the program. For example, participants have used their free time to practice piano, or train for various sports. Participants' complete experience during the program is important, since the ITE strives to demonstrate how engineering can be an interesting and valuable part of participants' lives.

ITE as a Pathway to UVa

The impact of ITE extends far beyond the residential portion of the program. The ITE program effectively encourages the participants to explore their college options and pursue academic goals. One indication of this is the substantial proportion of ITE participants who apply to and attend UVa, for engineering or another discipline in the College of Arts and Sciences (CLAS). Since 1998, more than 55 ITE participants have attended UVa (see Table 8). From the 2005 ITE class, of the 34 participants (which also included some rising juniors), seventeen have applied for admission to UVa. Of those who applied early, six have already been accepted. All but two of these UVa applicants selected engineering. As seen from Table 8, the number of applicants to UVa CLAS and UVA SEAS varies from year to year, though, there are usually more applicants to SEAS than the college.

Table 8: 1998-2005 ITE Participants Attending or Applying to UVa

Year	Accepted into UVa: CLAS	Accepted into UVa: SEAS	Graduated from UVa: CLAS/SEAS
1998	2	1	**3**
1999	1	5	**6**
2000	1	2	**3**
2001	4	7	n/a*
2002	2	6	n/a
2003	4	7	n/a
2004	2	2	n/a

*Participants from the 2001 ITE and later would start graduating in May 2006, projecting four years of full-time coursework.

Conclusions: ITE Benefits and Future Recommendations for the Program

As seen from the evaluation section, the ITE program has consistently met and surpassed the expectations of participants which correspond with the program administrators objectives as well. In addition, the CDE has frequently received letters of thanks from participants after completing the program. The program is continually being improved based on feedback from the participants. The emphasis on engineering design, the integration of CAD, and the hands-on design and build activity have been important recent improvements. The overall program, with its cooperative components gives participants a realistic and challenging engineering experience. Based on the positive response to the solar car and other teaching kits, this area will be expanded in the future. It is expected that biomedical engineering, aerospace engineering, and submersible vehicles would be particularly relevant.[14] The goal is to expand the role of active cooperative learning in ITE to further engage participants and prepare them for future engineering coursework.

Other areas targeted for improvement include adding more free-time to the schedule, giving more specific instructions to the faculty giving presentations on how to choose material appropriate for the participants, staying open to advances in technology to keep the design project exciting, implementing more standardized evaluations from year to year, and initiating a more thorough tracking method for ITE alumni.

Since ITE participants are involved in typical engineering coursework and attend interactive lectures which include demonstrations and experiments they complete the program with a good sense of what engineering undergraduate work entails. During the faculty and graduate student lectures, the participants have a chance to ask questions about all aspects of engineering and interact with university-level role-models. Studies have shown that the types of activities used in the ITE program help student become more comfortable with engineering and technical problem solving techniques, and perhaps discover a natural talent in engineering skills.[15] Through this exposure to the daily rigors of engineering course work and applied design activities, the ITE participants are able make informed decisions about a career in engineering. Those participants who go on to apply to engineering programs do so based not on the stereotypes about engineering, but rather on their own experience and performance in challenging situations. As discussed in the evaluation section of the paper, a high proportion of the ITE participants matriculate in the UVa engineering school and graduate with degrees in engineering. The ITE program is the first of many stepping stones that helps these students achieve academic success.

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