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A Sophomore's Exposure, Interest, and Aspirations in Research on Current Practices of Volatile Organic Compound Removal

Ms. Aimee Oz, Salt Lake Community College

Aimee Oz is a sophomore pursuing a degree in Chemical Engineering. Currently she attends Salt Lake Community College and will be transferring to a four-year university for fall 2016. She is reviewing current methods of volatile organic compound removal so that she can one day conduct her own research on air pollution containment. Her academic goal is to earn a Ph.D. in chemical engineering and conduct VOC research while teaching at the university level.

Dr. Nick M. Safai, Salt Lake Community College

Dr. Nick M. Safai has been an ASEE officer and member for the past 24 years. He is the Division Chair for ASEE-ID. He is the Program Chair for Graduate Studies Division.

He has been the seven-time elected as the Program Chair of the ASEE International Division for approximately the past 18 years. Nick has had a major role in development and expansion of the international division. Under his term as the International Division Program Chair the international division expanded, broadened in topics, and the number of sessions increased from a few technical sessions to over eighteen sessions in the recent years.

Nick has served in the ASEE Graduate Studies division for the past 5 years as Treasurer and Program Chair for the annual conference.

The ASEE International Division by votes, has recognized Nick's years of service through several awards over the past years. Nick has been the recipient of multiple Service awards (examples: 2010, 2006, 2004, 1996), Global Engineering Educators award (example: 2007, 2005), Best Paper award (examples: 2010, 2005, 2004, 1995) and other awards from the International Division for exceptional contribution to the international division of the American Society for Engineering Education. Examples of some Awards from other Professional Organizations: • American Society of Civil Engineers (ASCE): Engineering Educator of the Year Award 2004. • Utah Engineers Council, UEC: Engineering Educator of the Year 2005 award, in recognition of outstanding achievements in the field of engineering and for service to society. • SLC Foundation; Salt lake City, Utah: Teaching Excellence Award 2004. • American Society of Civil Engineers (ASCE): Chapter faculty Advisor recognition award 2002. • Computational Sciences and Education; recognition for outstanding contributions and for exemplary work in helping the division achieve its goals1998. • Engineering Division; recognition for outstanding contributions and for exemplary work in helping the division achieves its goals 1995. • Science and Humanities; recognition for outstanding contributions and for exemplary work in helping the fields achieve its May 1994. • Math & Physical Sciences; appreciation for academic expertise February 1994.

Academics: Nick Safai received his PhD degree in engineering from the Princeton University, Princeton, New Jersey in 1979. He also did a one year post-doctoral at Princeton University after receiving his degrees from Princeton University. His areas of interest, research topics, and some of the research studies have been; • Multi-Phase Flow through Porous Media • Wave propagation in Filamentary Composite Materials • Vertical and Horizontal Land Deformation in a De-saturating Porous Medium • Stress Concentration in Filamentary Composites with Broken Fibers • Aviation; Developments of New Crashworthiness Evaluation Strategy for Advanced General Aviation • Pattern Recognition of Biological Photomicrographs Using Coherent Optical Techniques Nick also received his four masters; in Aerospace Engineering, Civil Engineering, Operation Research, and Mechanical Engineering all from Princeton University during the years from 1973 through 1976. He received his bachelor's degree in Mechanical engineering, with minor in Mathematics from Michigan State. Nick has served and held positions in Administration (Civil, Chemical, Computer Engineering, Electrical, Environmental, Mechanical, Manufacturing, Bioengineering, Material Science), and as Faculty in the engineering department for the past twenty seven years.

Industry experience: Consulting; since 1987; Had major or partial role in: I) performing research for industry, DOE and NSF, and II) in several oil industry or government (DOE, DOD, and NSF) proposals. Performed various consulting tasks from USA for several oil companies (Jawaby Oil Service Co., WAHA Oil and Oasis Co., London, England). The responsibilities included production planning, forecasting and reservoir maintenance. This production planning and forecasting consisted of history matching and prediction based on selected drilling. The reservoir maintenance included: water/gas injection and gas lift for selected wells to optimize reservoir production plateau and prolonging well's economic life.

Terra Tek, Inc., Salt Lake City, UT, 1985-1987; Director of Reservoir Engineering; Responsible of conducting research for reservoir engineering projects, multiphase flow, well testing, in situ stress measurements, SCA, hydraulic fracturing and other assigned research programs. In addition, as a group director have been responsible for all management and administrative duties, budgeting, and marketing of the services, codes and products.

Standard oil Co. (Sohio Petroleum Company), San Francisco, California, 1983-85; Senior Reservoir Engineer; Performed various tasks related to Lisburne reservoir project; reservoir simulation (3 phase flow), budgeting, proposal review and recommendation, fund authorizations (AFE) and supporting documents, computer usage forecasting, equipment purchase/lease justification (PC, IBM-XT, Printer, etc.), selection/justification and award of contract to service companies, lease evaluation, economics, reservoir description and modeling, lift curves, pressure maintenance (gas injection analysis, micellar-flooding, and water-flooding), Special Core Analysis (SCA), PVT correlations, petrophysics and water saturation mapping.

Performed reservoir description and modeling, material balance analysis. Recovery factors for the reservoir. Administrative; coordination and organization of 2 and 6 week workplans, 1982 and 1983 annual specific objectives, monthly reports, recommendation of courses and training program for the group. Chevron Oil Company, 1979- 1983; Chevron Overseas Petroleum Inc. (COPI), San Francisco, California 1981-1983. Project Leader/Reservoir Engineer, Conducted reservoir and some production engineering work using the in-house multiphase model/simulators. Evaluation/development, budgeting and planning for international fields; Rio Zulia field – Columbia, Pennington Field – Offshore Nigeria, Valenginan, Grauliegend and Rothliegend Reservoir – Netherlands. Also represented COPI as appropriate when necessary.

Chevron Geo-Sciences Company, Houston, TX, 1979-1980 Reservoir Engineer Applications, Performed reservoir simulation studies, history matching and performance forecasting, water-flooding for additional recovery (Rangeley Field – Colorado, Windalia Field – Australia), steam-flooding performances (Kern River, Bakersfield, California), gas blowdown and injection (Eugene Island Offshore Louisiana) on domestic and foreign fields where Chevron had an interest, using Chevron's CRS3D, SIS and Steam Tube simulator programs.

Chevron Oil Field Research Co. (COFRC), La Habra 1978-1979, California. Research Engineer, Worked with Three-Phase, Three-Dimensional Black Oil Reservoir Simulator, Steam Injection Simulator, Pipeflow #2. Also performed history matching and 20-year production forecast including gas lift and desalination plants for Hanifa Reservoir, Abu Hadriya Field (ARAMCO).

Aimee Oz.

Aimee is finishing an engineering associate degree at Salt Lake Community College (SLCC) and will begin working on a bachelor's degree in chemical engineering at the University of Utah in the fall of 2016. Currently she is interning for the American Chemical Society's nanotech group at SLCC. They are working on building an ultramicroelectrode using silver nanowires. In addition to this she is participating in a community college aerospace scholars program conducted by the National Aeronautics and Space Administration (NASA) and she is the treasurer of the Society of Women Engineers at SLCC. She is a chemistry and mathematics tutor for SLCC's Learning Center.

Aimee is very interested and anxious for research and experience to help guide her broad engineering interests. Ultimately she wants to earn a doctorate degree in chemical engineering and work for NASA. To Aimee, space exploration is the nexus of science, technology, mathematics and engineering. It signifies

hope, adventure, and possibility. At heart, she wants to reduce the negative environmental impact from industrial facilities and help develop, improve, and implement new technology for this planet (and perhaps beyond).

Brandon Lewis Walker
Mr. Christopher F. Thompson, Salt Lake Community College

A Sophomore's Exposure, Interest and Aspirations in Research on Current Practices of Volatile Organic Compound Removal

Aimee Oz Chemical Engineering Student
Brandon Walker Civil Engineering Student
Salt Lake Community College, Salt Lake City, Utah

and

Dr. Nick M. Safai: Professor

(Student Poster-Paper ASEE Annual Conference)

Abstract:

The authors of this paper are presenting an example of how undergraduate students' interest in research may be linked to an interest in graduate and professional education. Based on both an example of the undergraduate author's experience and undergraduate surveys conducted at Salt Lake Community College (SLCC) this paper suggests that exposing students early-on to research of engineering and scientific topics will increase their interest in pursuing graduate degrees, future research or professional school.

Introduction:

"Undergraduate faculty-student interaction, which is often cited as the key to the involvement-integration outcomes of retention and academic achievement at the undergraduate level, appears to encourage students to enroll in graduate and professional education as well" (Hathaway et. al, 2002, p. 17). From the undergraduate author's own experience, reading peer-reviewed journal articles about current methods of Volatile Organic Compound (VOC) removal and disposal have not only made theory-based classes such as thermodynamics, differential equations, and organic chemistry relevant to ongoing research, but as a result she aspires to continue forward with undergraduate research and subsequently pursue a graduate degree. Her investigation into what experiments and models have been developed to reduce the volume of pernicious airborne pollutants, specifically VOCs, is an example of developing student interest in research early on. As a result of becoming more aware of this topic in the field of chemical engineering it has been made clear that at the graduate level the student has the opportunity to conduct research. In addition to this one example, recent surveys conducted at SLCC to undergraduate students from both SLCC and the University of Utah (U of U), by an author of this paper, have suggested that exposing students early on to present-day research topics will instill a similar inclination to continue their education beyond the undergraduate level.

Technical Discussion and Methods:

Normally, graduate-level topics are not included in an undergraduate education. For chemical engineering students topics related to atmospheric sciences are currently not offered nor explored at both the freshman and sophomore levels. Through mentorship and independently studying the topic, it was made clear to the student that the difficulty of VOC vapor removal depends on each chemical species and she began to research what other current methods were available:

Traditional VOC retrieval procedures are expensive and dependent on several variables, such as temperature, gas flow rate and pollutant concentration (Tatin et al., 2015). Conventional VOC removal requires resources and materials not only to maintain a high temperature, high pressure, and sometimes adiabatic system but when replacing and discarding spent catalysts.

After reviewing different experiments testing sustainable methods of VOC removal, perhaps a combination of silicone oil and water emulsion sprays and bio-filters could be a cost-effective technique with an overall low environmental impact. Both have separately demonstrated capable means of VOC removal. However, there has not been a system developed to combine these techniques of retrieval and removal.

Since VOCs can be hydrophilic or lipophilic methods of capture include condensation, absorption, adsorption and membrane separation. Absorption and condensation are two containment methods which use water and oil separately to contain hydrophilic and lipophilic pollutants, respectively. Still, this method requires independent spray towers and an increase in thermal energy costs (Darracq et al., 2010).

Alternatively, Tatin et al. (2015) analyzed the effectiveness of using a water/silicone oil emulsion to capture VOCs in spray towers. In this study the researchers found that the emulsion was up to 90% effective at VOC removal. By using the emulsion spray the researchers wanted to distinguish the effectiveness of using both oil and water together and whether or not this method is more practical and cost effective. Aqueous toluene, an aromatic VOC, was used as the pollutant and converted to a gas inside the spray tower. Silicone oil and tap water were used in the emulsion. Contrasting this method to thermal and catalytic oxidation methods, less resources were used in controlling the temperature of the experiment, as it was performed at temperatures ranging from 5 to 60 degrees Celsius. Traditionally, thermal and catalytic oxidation methods of VOC removal are 95-99% and 90-95% effective, respectively (Faisail et al., 2006). However, they increase fuel consumption and material expenses. Thermal oxidation requires temperature ranges of 760 to 870 degrees Celsius and catalytic oxidation temperature ranges fall between 320 to 540 degrees Celsius (Berenjian et al., 2012).

Since VOCs are biodegradable, they can be treated biologically. Bio-filtration is an extremely effective alternative to oxidation. Heterotrophic bacteria, yeast and fungi cultures can be used to eliminate VOCs. When VOC laden air is passed through a bio-filter carbon dioxide, water, and inorganic salts are the only byproducts (Berenjian et al., 2012).

A co-culture of the bacteria Pseudomonas putida and Pseudomonas fluorescence has been used successfully in a bioreactor to degrade aromatic VOCs. Shim et al. (2002) devised a bio-filter using P. putida and P. fluorescence to abase benzene, toluene, ethylbenzene and o-xylene. "The bioreactor also had a stable long-term performance, maintaining its ability for efficient BTEX degradation without requiring additional nutrients (e.g. glucose) for more than 1 year." (Shim et al., 2002, p. 1) The ph-level remained neutral, indicating that conditions were stable and acid-intermediates were not forming. An additional buffer was not required during this process (Berenjian et al., 2012). As an alternative to the use of bacteria, Ahmed and Song (2011) tested the yeast strain Candida tropicalis as a means of VOC elimination. Their results indicated that C. tropicalis is capable of removing gaseous toluene.

When it comes to pursuing research in chemical engineering the student author (Aimee Oz) wants to focus on air quality and pollution control from being encouraged to read about VOCs. After she's investigated these current experiments and models of research that have been developed to reduce the volume of VOCs, she proposed a combination of oil and water emulsion and the use of two separate bio-filters, one with yeast strain and the other with bacteria co-culture, which could offer an effective long-term and cost-efficient means of containment and removal. In addition, a sequence of containment steps could offer an effective alternative solution with backup options to ensure stead operations of plants and other facilities. If an industrial spray tower is first inundated with a silicone oil and water emulsion spray the mixture could then be separated by filtration. Both the VOC contaminated water and oil would then pass through independent bio-filters. Each filter would have its own nutrient solution bath to ensure the stability of the cultures.

As shown above, when an undergraduate chemical engineering student was introduced to ongoing VOC research, it motivated her to want to design a new experiment to further understand if there are more efficient ways to contain VOCs. Perhaps if a major-specific undergraduate research-exposure course is included early on in the freshman and sophomore years, a course where students are dedicated to exploring a research topic of interest, such as VOCs, then students may want to pursue graduate school.

Student Surveys:

To study the impact of research and student involvement in studies outside the regular course work a few surveys were performed. In addition to the experience of outside mentorship and research, a total of 163 freshman and sophomore students were surveyed during the Spring, Summer and Fall 2015 semesters at SLCC including freshman, sophomore, junior and senior level students from the U of U. The intent of the survey was to assess undergraduate interest in outside course work, research and graduate school.

Students in different engineering classes with various course topics were surveyed from the following engineering classes taught by SLCC faculty, Dr. Nick Safai, during the aforementioned semesters.

The topics of these courses were all in engineering and included:

- Two engineering forum classes each semester the survey was performed
- Both a statics and a strengths of materials class during spring, summer and fall semesters
- Civil engineering surveying class during the spring and fall semesters and a short 3-week fast track condensed surveying course from May 18th to June 5th 2015
- Mechanical engineering special topics classes during spring and fall semesters
- Marvels in civil engineering class during spring, summer and fall semesters

A presentation on what students do in graduate school and various research topics in different engineering fields was presented during the survey. A survey was conducted by method of questionnaire. Prior to the presentation each student was asked to indicate on the questionnaire if they were interested pursuing research or graduate school. After the presentation each student was asked again if they were interested in doing research or attending graduate school and if the presentation affected their decision. Again, their responses were recorded.

Tables 1 illustrate the categories of students surveyed, student types, designations for each category, and the results of and the percentages for the surveys for each of the categories. Both tables are shown in the following pages.

Type of Student Surveyed (Categories)	Total number of students surveyed	Students who want to do research or pursue graduate school after hearing the presentation (Yes)	Presentation had no effect on the student's decision	Students undecided on whether or not they want to go to graduate school	Percent interested in doing research or graduate school
SLCC (F only)	54	11	37	6	21%
SLCC (S only)	87	28	42	17	32%
SLCC only Chemical Engineering (F,S)	14	4	6	4	28%
SLCC and UoU (F,S,J,Sr)	163	64	51	48	39%

Table 1: Categories of and number of students surveyed and the results for each category
Key: (F = freshman, S = sophomore, J = junior, Sr = senior), UoU = University of Utah, SLCC = Salt Lake Community College

Tables 2 exhibits the types of students surveyed, and the designations for each category. Both tables 1 and 2 are shown above and in the following page.

#	Type of Student Surveyed	CATEGORIES
1	SLCC (F only)	Category A Students
2	SLCC (S only)	Category B Students
3	SLCC only Chemical Engineering (F,S)	Category C Students
4	SLCC and U of U (F,S,J,Sr)	Category D Students

Table 2: Student categories surveyed, and the labels for each category
Key: (F = freshman, S = sophomore, J = junior, Sr = senior), UoU = University of Utah, SLCC = Salt Lake Community College

The student author who is in her sophomore year at SLCC is studying chemical engineering and has been exposed to a the different engineering topics presented in the survey. When she came across VOCs as an area of research she became more curious about the field and found it to be interesting to her. She has made the decision to pursue a graduate level degree with the intention to pursue further research in VOCs and atmospheric science.

As has been already stated the survey questions were handed-out before each presentation and again were asked afterwards. Below are examples and types of the questions which were used in these surveys (Safai & Thomson et al.).

Example of Survey Questions

RESEARCH STUDIES and GRADUATE SCHOOL

'Inspiring College Undergraduates to Pursue Advanced Graduate Degrees Utilizing Graduate Level Research and Application.'

**NAME: _____*

**EMAIL: _____*

COURSE: _____

SURVEY QUESTION 1
On a scale from 1 to 5, 5 being 'Complete Knowledge' and 1 being 'No Knowledge,' how much do you know about Graduate School?

1 2 3 4 5

SURVEY QUESTION 2
On a scale from 1 to 5, 5 being 'Most Definitely' and 1 being 'Definitely Not,' how interested are you in attending Graduate School?

1 2 3 4 5

SURVEY QUESTION 3
On a scale from 1 to 5, 5 being 'Very Much' and 1 being 'Not At All,' how has exposure to Graduate Level Research topics increased your knowledge and interest about Graduate School?

1 2 3 4 5

SURVEY QUESTION 4
On a scale from 1 to 5, 5 being 'Complete Knowledge' and 1 being 'No Knowledge,' how much do you know about Graduate School after this presentation?

1 2 3 4 5

SURVEY QUESTION 5
On a scale from 1 to 5, 5 being 'Most Definitely' and 1 being 'Definitely Not,' how interested are you in attending Graduate School after this presentation?

1 2 3 4 5

Results:

After the students from the various categories were exposed to different research topic presentations they were again surveyed. Based on survey data freshman students were the least interested in doing research or graduate school, with 21% of the 54 students surveyed who would consider attending graduate school. Next, of the 14 community college students who have decided to pursue chemical engineering, 28% of them want to pursue graduate school. Of the 87 sophomore students surveyed, 32% want to pursue graduate school and of the 163 combined undergraduate students, 39% of them want to pursue graduate school.

	Categories	Total Surveyed for each category	Yes (after presentation)	% for research
1	Category A Students	37	28	32
2	Category B Students	54	11	21
3	Category C Students	163	64	39
4	Category D Students	14	4	28
5	Aimee Oz (student-author)	1	1	100

Table 3: Results of survey

Key: (F = freshman, S = sophomore, J = junior, Sr = senior), UoU = University of Utah, SLCC = Salt Lake Community College

A flowchart, illustrated in figure 1, indicates how getting started in research early as a freshman or sophomore may lead to more opportunities.

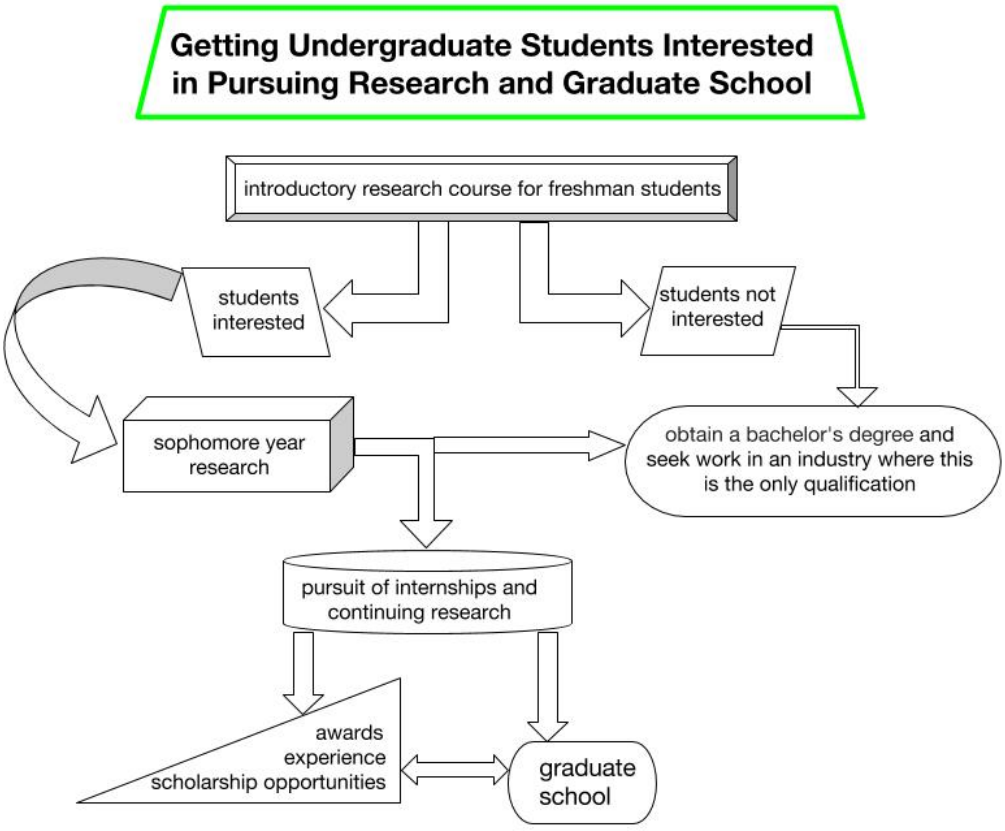
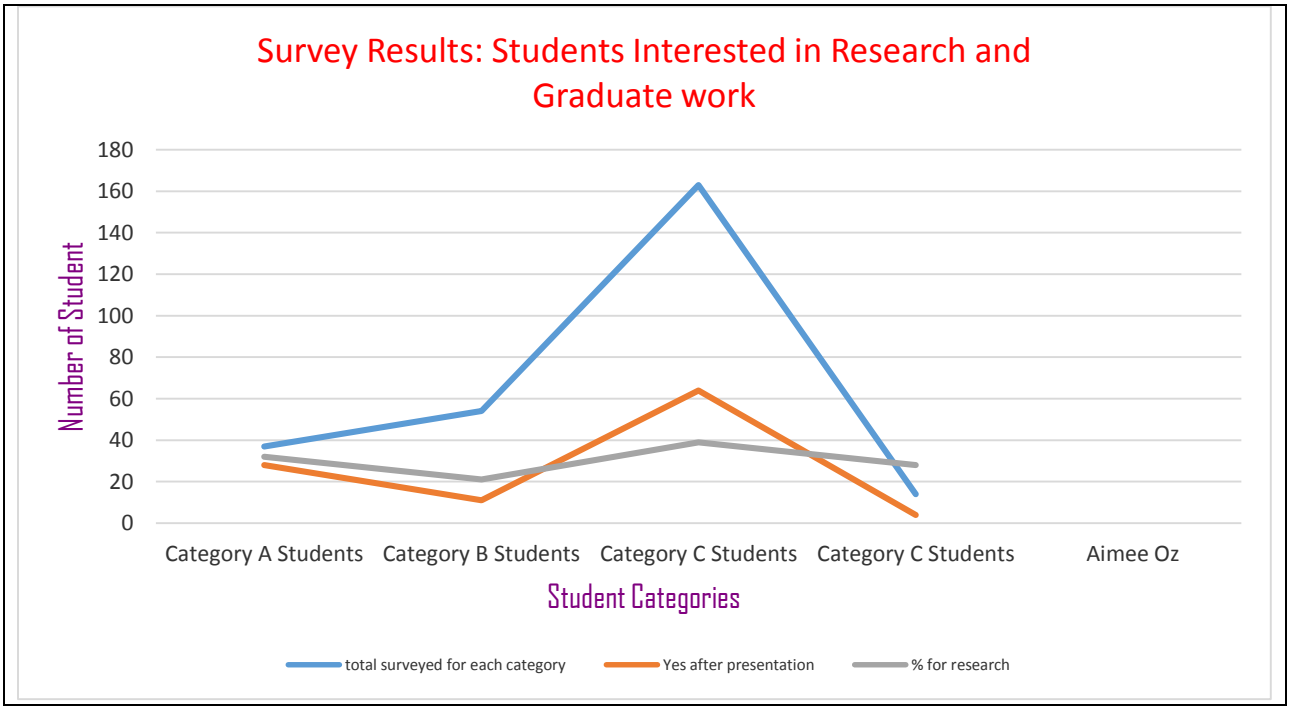


Figure 1: Flowchart of the process of getting started in research early leading to potential opportunities.

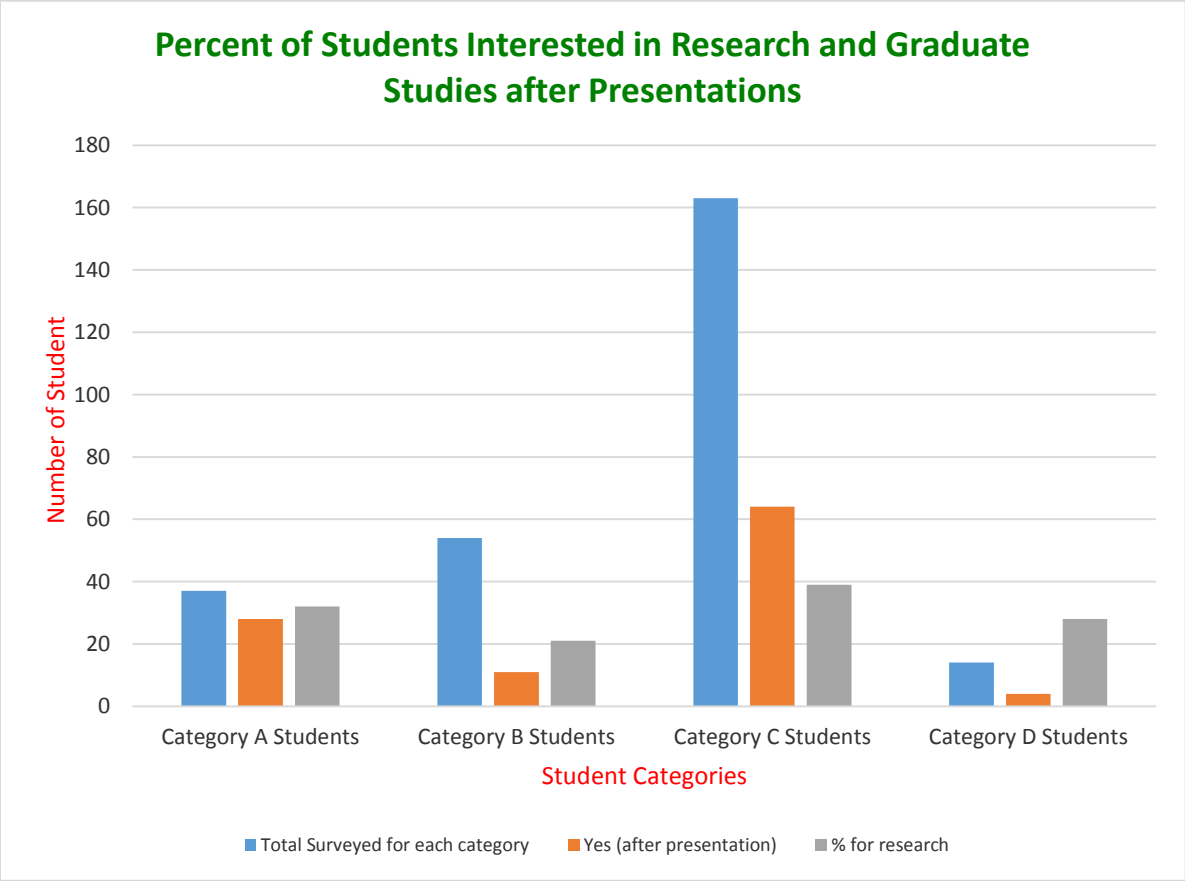
The following graph illustrate the figures for each student category (Type) for the survey which were performed during Spring, Summer and Fall 2015 semesters for various engineering classes.



The students before and after hearing each presentation filled out the survey sheets. The results are shown in the bar chart below for the different student types (categories).

As has been already stated the survey questions were handed-out before each presentation and again were asked afterwards. Below are examples and types of the questions which were used in these surveys (Safai & Thomson et al.).

The results of these surveys are illustrated in the bar chart below. The results show the percentages for each student category (type) interested in research and graduate studies after the research topics were presented to them.



Conclusion:

Based on these results, the overall interest in pursuing graduate school appears to increase with class-level, i.e., sophomores appear more interested than freshman. However, the sample size of the population was very small and the survey was conducted for three academic semesters in 2015. Having a larger sample size and a longer time-span would produce more accurate results.

The surveys done and the example of one student demonstrate how awareness of ongoing research and opportunities provide students with the interest and insight to begin to explore the pathways available to them. The next steps would be to include courses aimed at introducing students to graduate level research and exposing them to opportunities that exist beyond an

undergraduate degree: “Perhaps the greatest advantage for using cases in an engineering classroom is that students must focus on the applications in the workforce by solving real world problems” (Safai et al., 2002, p. 3). And by introducing students to these real world applications an interest to not just work in industry, but to change it, with research and design may be the end result.

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Student Bio:

Aimee Oz (one of the authors) is finishing an engineering associate degree at Salt Lake Community College (SLCC) and will begin working on a bachelor's degree in chemical engineering at the University of Utah in the fall of 2016. Currently she is interning for the American Chemical Society's nanotech group at SLCC. They are working on building an ultramicroelectrode using silver nanowires. In addition to this she is participating in a community college aerospace scholars program conducted by the National Aeronautics and Space Administration (NASA) and she is the treasurer of the Society of Women Engineers at SLCC. She is a chemistry and mathematics tutor for SLCC's Learning Center.

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