AC 2012-4319: ENGAGING FRESHMAN IN TEAM BASED ENGINEERING PROJECTS

Ms. Lacey Jane Bodnar, Texas A&M University

Lacey Bodnar is a master's of engineering student in water resources engineering at Texas A&M University. Her undergraduate degree was from the University of Nebraska, Lincoln in 2010. She currently works for the Engineering Student Services and Academic Programs Office and is pleased to be involved in managing exciting freshman engineering projects.

Ms. Magdalini Z. Lagoudas, Texas A&M University
Ms. Jacqueline Q. Hodge, Texas A&M University

Jacqueline Hodge is a native of Giddings, Texas and currently the Project Manager for the Engineering Student Services & Academic Programs Office (ESSAP) at Texas A&M University (TAMU). She graduated from TAMU with a bachelor's of science degree in mechanical engineering. While obtaining her degree, Hodge was involved with several community service activities such as the Boys & Girls Club of Bryan, Help One Student To Succeed (HOSTS), and Habitat for Humanity. Upon graduation with her bachelor's degree, she began work with International Paper Company and became active with the local College Bound Academy as an instructor. While employed with International Paper, Jacqueline obtained her M.S.B..A from TAMU, Texarkana. After seven years of service in July 2004, she decided to resign her post at International Paper to pursue a master's degree in mechanical engineering at TAMU, College Station. In Fall 2005, Hodge accepted a full-time position with the ESSAP Office and completed her master's degree in mechanical engineering in May 2006. In her current position, Hodge is responsible for retention and enrichment programs for engineering students. Finally, Hodge continues to be committed to education and her community. She is the President for the Poplar Circle Neighborhood Association, member of the BVAA Chapter of Delta Sigma Theta Sorority, Inc., and a former board member of Habitat for Humanity.

Mr. Travis Austin Smith, Engineering Student Services and Academic Programs

Travis Smith is an undergraduate nuclear engineering major from Houston, Texas. He is the Engineering Mentor for the TSGC and Children's Museum team. He is intrigued by confusing and hard to understand concepts which helps drive him to discover new ideas. He wants to work with the new AP 1000 Westinghouse reactors and work abroad. He also plans on following a research path devoted to inherently safe, small nuclear power plants for neighborhoods and business parks.

Mr. Jesus A. Orozco
Mr. Joshua Grant Corso
Mr. Cristian R. Sanchez
Ms. Jillian Kathleen Freise, Texas A&M ELLC Children's Museum

Jillian Freise is a mechanical engineering major from Houston. She is a member of the Brazos Valley Children's Museum team. On the team, she contributes ideas for the design of the water table museum exhibit. Freise aspires to be an engineer because she loves to find solutions to challenging problems that make a difference in the world. She hopes to develop humanoid robots for a variety of applications.

Miss Hannah Ringler, Texas A&M University

Hannah Ringler is a freshman aerospace engineering major at Texas A&M University from San Antonio, Texas. She is currently working with a team on a freshmen engineering design challenge through NASA and the Texas Space Grant Consortium entitled "ISS Coffee System Adaptor." Ringler hopes to be an engineer because she enjoys designing and creatively solving problems. As well, she has long had an interest in the air and space industry. In the future, she would like to play a part in developing new military-related aircraft.

Ivan Cortes, Texas A&M University

Ivan Cortes is a mechanical engineering student from Harker Heights, Texas. Some areas of interest to him are the automotive industry and product design, but ultimately he simply enjoys the challenge of solving problems and innovating through the use of technology. One of Cortes's long-term goals is to travel abroad and gain international experience. Through involvement in programs offered at Texas A&M University, he sees an opportunity to learn by solving real problems through teamwork and collaboration.

Engaging Freshman in Team Based Engineering Projects

Introduction

Research demonstrates that early involvement in engineering projects during a student's freshman year increases his / her interest, excitement, and retention in engineering.[1-5] To meet the need for retaining engineering students, the Engineering Student Services and Academic Programs (ESSAP) Office at Texas A&M University initiated a team based Freshman Engineering Project (FEP) Program, in collaboration with community sponsors. This program is a continuation of a previous program at Texas A&M, known as the Space Engineering Institute (SEI).[1] The current FEP program utilizes a similar educational paradigm as SEI; both programs are based on establishing multidisciplinary engineering teams, but FEP is exclusively for freshman. For the 2011-12 pilot programs, the three project sponsors included 1) NASA and the Texas Space Grant Consortium (TSGC), 2) The City of College Station Public Works Department (PWD), and 3) the Brazos Valley Children's Museum. These partners have a genuine need for students' ideas and insights, and the young aspiring engineers were working with hands-on engineering design projects. Research shows that establishing professional interactions, such as with the project sponsors, positively influences student's retention in engineering fields.[6]

The purpose of this report is to describe the organization of this particular pilot program, assess the first semester program results qualitatively, and discuss the importance of the results and the future potential of the program. The results and discussion presented derive from feedback representing three levels of the program hierarchy: freshman team members, engineering mentors, and project sponsors. Four areas of skill acquisition for freshman students and mentors were identified by the researchers, and include personal, interpersonal, intellectual, and professional skills. This range of abilities promotes a well-round engineering education, and preparation for future employment.

Theoretical Foundation

A call for major reforms to the typical engineering education gained prominence in the early 1990s through a series of reports coming from ASEE, NSF, and the National Research Council's Board of Engineering Education.[7-9] The latter report identified a need for "including early exposure to 'real' engineering and more extensive exposure to interdisciplinary, hands-on, industrial practice aspects, team work, systems thinking, and creative design." Employers' needs paralleled these new educational paradigms, as changes in the marketplace placed greater importance on communication and persuasion, team leadership and problem solving, and an understanding of the multiple factors affecting engineering design.[10]

The criteria for implementing the above educational changes were codified by ABET as a set of six professional skills. Effective in 2001, these standards include: communication, teamwork, understanding professional ethics, understanding global and societal context of engineering, lifelong learning, and awareness of current issues.[10] Many educational strategies and programs emerged in an effort to meet these goals, including collaborative learning and team based projects. Cooperative learning is defined as "the instructional use of small groups so that students work together to maximize their own and each other's learning."[11] More specifically, a cooperative base group is a "long-term, heterogeneous cooperative learning group with stable membership."[11] In this particular program, the characteristics of a cooperative base group were combined with an engineering design challenge to produce a team-based project.

The intention of the Texas A&M ESSAP Office in launching the FEP Program was to enhance student education and increase engineering retention. The projects were especially designed to educate and train students in professional skills. This was accomplished by maximizing fidelity and complexity in the projects.[12,13] Fidelity represents the consistency and similarity of a training scenario to the existing and future working conditions of the students. A higher level of fidelity results in learning that is more applicable to the workplace. Aspects of fidelity include the "temporal environment" and "social context."[11,13] For example, in a high fidelity project, students will experience working under deadlines, and working cooperatively within and between groups. The acquisition and utilization of team skills is also positively correlated to project complexity.

Enhanced retention is expected from the Freshman Engineering Programs, since research demonstrates that engaging students in team-based extracurricular activities increases their interest and excitement in engineering in several ways. First, through working with peers, students gain a greater enjoyment of STEM fields.[1-5] Secondly, sharing science and engineering interests with peers enhances students' vision of themselves as future scientists. Finally, students begin to see themselves as problem solvers, with a role to play in "real world" engineering.[1] Improving engineering education and retention will further two of the main goals of any Engineering Department, and will help achieve the ultimate goal of producing skilled, professional engineers.

Description of Program

The program encompassed thirty (30) students in the Fall Semester, 2011. Each project team included five (5) freshman students. The students represented a diverse array of engineering backgrounds; there were at least three different majors present in each team, as identified in Figure 1 below. These students were recruited specifically, and exclusively, from the freshman engineering dormitory on campus. The projects were administered on a voluntary basis. Students successfully meeting the program requirements at the end of each semester received a cash incentive of $100.00. Students partnering with NASA also received additional cash rewards, depending on their performance through the semester. The FEP program at Texas A&M differed from many other national programs or capstone design programs in that no course credit was offered.[14-16] Rather, the selling points of the projects for students included gaining valuable experience involving engineering design, professional engineering groups, and team-based problem solving.

Freshman students were instructed on the use of computer software for engineering design and problem solving. Software applications include the use of Solid Works for modeling an International Space Station coffee adaptor system, Microsoft Excel for cost analysis of the College Station recycling program, and Visual Basic programming for options and cost analysis of College Stations' Green Building retrofitting plans. The deliverables of the projects included

1) a final report for the project sponsor, complete with engineering concept designs and descriptions, 2) a technical presentation to the sponsor at the end of each semester, 3) regular communication with the project sponsor, including weekly progress reports to NASA, and 4) a built prototype of the project design, if applicable.

The structure of the program is diagramed in Figure 1. The roles of each member of the project hierarchy are described below. The double arrows represent pathways of communication and collaboration within and between project teams.

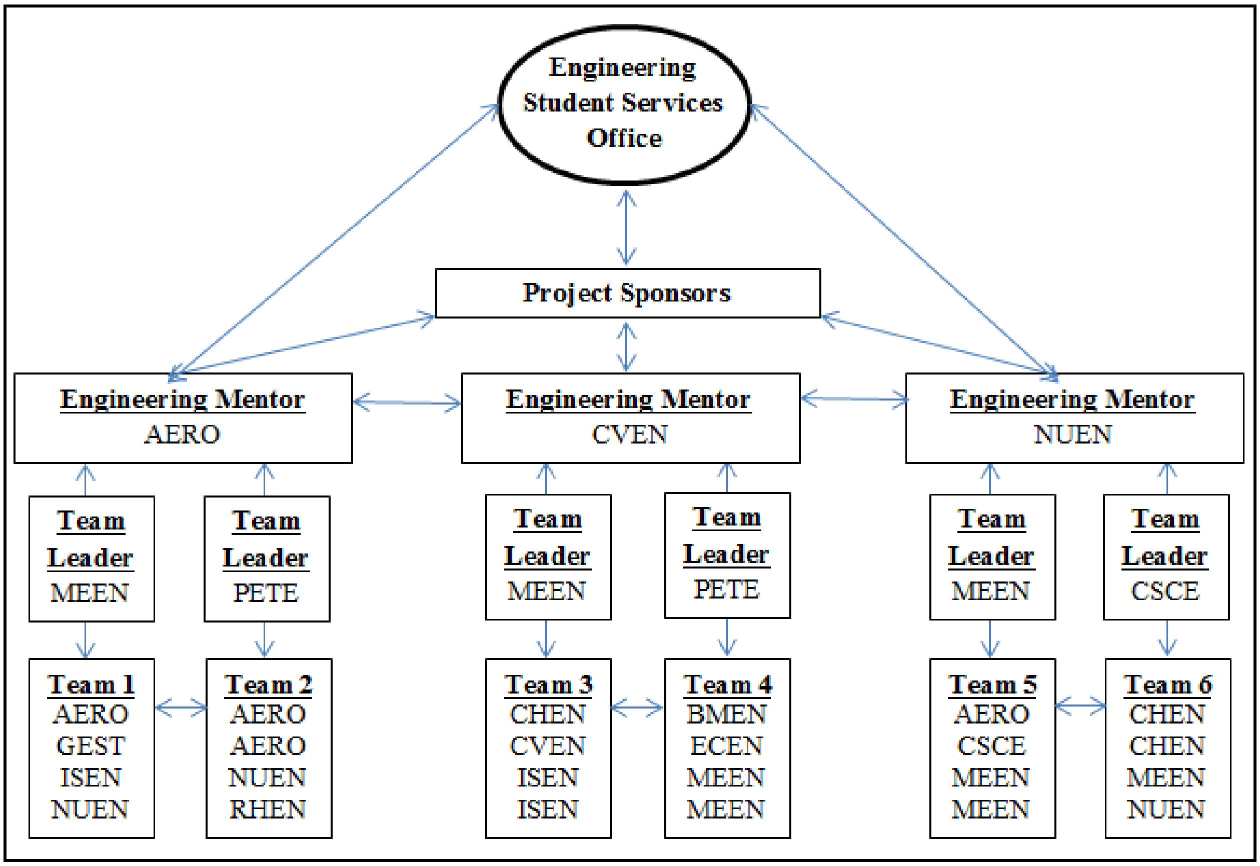

Figure 1: Freshman Engineering Project Organizational Chart

Key: AERO, Aerospace; BMEN, Biomedical; CHEN, Chemical; CSCE, Computer Science; CVEN, Civil; ECEN, Electrical and Computer; GEST, General Studies; ISEN, Industrial and Systems; MEEN, Mechanical; NUEN, Nuclear; PETE, Petroleum; RHEN, Radiological Health

The team leader was a member of the freshman team, and was elected by the student members. The team leader responsibilities included 1) coordinating work sharing amongst team members, 2) arranging team meetings independent of the engineering mentor, and 3) serving as the contact point between the team and the engineering mentors, project sponsors, and ESSAP office.

The engineering mentors were upper-class or graduate level engineering students who exhibited leadership qualities in engineering education. The responsibilities of the engineering mentors included: 1) working for approximately ten (10) hours per week, or five (5) hours per team, 2) organizing weekly team meetings and keeping track of deadlines, 3) providing technical feedback and guidance to freshman students, and 4) facilitating discussions with project sponsors and appropriate university faculty mentors.

Project sponsors were those individuals from community organizations who were contacted by the ESSAP office, and agreed to form engineering project partnerships with Texas A&M. Sponsors collaborated with ESSAP office to develop appropriate freshman projects. They served as the "client" for whom the freshman students were working, and were professionals who assisted teams with design and development. One of the goals of these projects was that they go beyond simply academic exercises. These projects were designed so that freshman engineering students could see that they were having a real impact in the community. Project sponsors helped achieve this goal.

The ESSAP office administered the FEP program. Advertisement, recruitment, hiring, scheduling, and funding were handled through this office. Funding for the engineering mentors and the freshman students' $100 semester cash incentives comes from this office. The cost to the ESSAP office to run the program for one semester totaled nearly $12,000. Approximately one half of the program cost supplied the wages for the engineering mentors, consisting of one graduate student and two undergraduates. The second largest program cost went to the freshman students' $100 semester cash incentive. The remaining expenses accounted for travel costs, advertising, food, and miscellaneous items.

A high level of fidelity and complexity were sought in designing the program, so that it provided the greatest benefit to students in terms of professional development. Fidelity and complexity manifested in the program in the ways identified in Table 1.

Table 1: Aspects of Fidelity and Complexity

Aspects of Fidelity	**Aspects of Complexity**
Project sponsors represented engineering clients.	Students worked on open-ended projects without a predetermined solution.
Projects and design challenges were based on actual needs of project sponsors.	Multiple solutions and design approaches were feasible.
Students worked on long term projects with deadlines.	Students identified and operated under project requirements and constraints.
Cooperation occurred within and between teams.	Projects incorporated multiple fields of study.
Students prepared technical reports and presentations, and were evaluated by project sponsors.	Project completion often required mastering new technologies.

Research Methodology

The project assessment was carried out qualitatively, from questionnaires distributed across all levels of the program hierarchy. All freshman students, engineering mentors, and project sponsors were invited to provide feedback. The results below include the experiences and thoughts of five freshman students, all three engineering mentors, and two project sponsors. Students and mentors who chose to provide feedback are represented in this report as co-authors.

Six questions were posed to freshman students via e-mail, from the ESSAP office. Students were asked to provide input in the following areas, with a half page paragraph describing positive and / or negative impacts for each question:

1. What was the impact of your interaction with other freshman engineering students working on the same projects?
2. What was the impact of your interaction with the sponsor?
3. What was the impact of your interaction with upper division engineering students or graduate students?
4. Did the team project experience have any impact on your engineering career?
5. What kind of skills did you acquire that you consider of value to your engineering career?
6. What would you change to make these types of projects of value to future freshman engineering students?

The following questions were posed to the engineering mentors, with the same instructions:

1. What was the impact of your interaction with the project sponsor?
2. Did the team project experience have any impact on your engineering career?
3. What kind of skills did you acquire that you consider of value to your engineering career?
4. What would you change to make these types of projects of value to future freshman engineering students?

Project sponsors were asked:

1. Please discuss what you perceive to be the benefits of the ELLC Freshman Engineering Project program to the students.
2. Please identify benefits and/or costs that you experienced as the project sponsor.

The results represent the combined, organized, and analyzed responses to the above research questions.

Results

The results were first organized into four main categories: freshman feedback, engineering mentor feedback, sponsor feedback, and suggestions for further improvement. Subcategories were further developed based on analysis of the responses received. Within the freshman and engineering mentor categories, analysis focused on what the authors of this report term "Skill Acquisition Areas". Four areas were identified, including: personal, interpersonal, intellectual, and professional. Specific examples, based on student feedback, are presented. In the third section of the results, comments from the sponsors are presented, and finally ideas to further improve and enhance the projects are enumerated.

<u>Freshman Feedback</u>

Involvement in the projects impacted the students in four distinct ways: personal, interpersonal, intellectual, and professional. Examples and effects of the skill acquisition areas are summarized in Table 2, below. Student quotes supporting each example are provided by five student co-authors. The quotes are identified with the student name. The following is a brief introduction to the student contributors.

Hannah is a freshman Aerospace Engineering Major. She worked with a team on a freshmen engineering design challenge through NASA and the TSGC entitled "ISS Coffee System Adaptor". Hannah hopes to be an engineer because she enjoys designing and creatively solving problems. In the future she would like to play a part in developing new military related aircraft. Ivan is a freshman Mechanical Engineering major. He also served as a member of ISS Coffee System Adaptor Team. His career goal is to gain a true international experience while tackling challenges in the automotive industry.

Cristian is a Mechanical Engineering major. He is a member of the Green Building Team focusing on alternative and renewable energies for the College Station PWD. Cristian is driven to work in engineering to become a key player in discovering alternative forms of energy to address the global energy crisis. His goal is to own an engineering firm and help invent the next "big" energy resource. Joshua is a biomedical engineering student, planning to major in biomechanics. He is also currently a member of the Green Building Team. Joshua is studying biomedical engineering because he is fascinated by the mechanics of the human physiology and wants to develop prosthesis that are more comfortable and passive for the many soldiers who have lost limbs, and for those born with physical defects.

Jillian is a mechanical engineering major. She is a member of the Children's Museum Team. On the team, she contributes ideas for the design of a water table museum exhibit. Jillian aspires to be an engineer because she loves to find solutions to challenging problems that make a difference in the world. She hopes to develop humanoid robots for a variety of applications.

Table 2: Summary of Freshman Student Skill Acquisition

Skill Acquisition Area	**Example**	**Effect**
Personal	Friendship Involvement Insight	Students were motivated to continue in engineering. They received peer support and encouragement to succeed in class, and in extra-curricular activities.
Interpersonal	Teamwork Collaboration Team Learning Strategies	Students learned to function successfully in a team setting, and how to work together to solve complex problems.
Intellectual	Creative Thinking In-depth Problem Solving Research Skills	Students were encouraged to think independently. They developed problem solving strategies, research skills, and a sense of self-efficacy.
Professional	Career Affirmation Communication Presentation Design Process Interdisciplinary Work	Students were excited and motivated about a career in engineering. They developed valuable professional skills, including communication and presentation experience. Students appreciated the contributions of all disciplines of engineering.

Personal

Students gained friendships and peer support in school.

> "Through this project, I came to know several students living in the same dorm, and a few of us had similar classes. Our shared connection with the FEP program encouraged us to work together. We were able to offer advice on homework as well as insight into other disciplines of engineering" (Jillian).

> "Early in the first semester of college, I began to create lasting relationships with fellow classmates. Getting to know other engineers was an opportunity for the freshman team members to get acquainted with the kind of people that they may encounter throughout an engineering career, and to be better prepared for such encounters" (Ivan).

Students became more involved in engineering extra-curricular activities.

> "The Freshman Engineering Projects resulted in an involved first semester of college" (Ivan).

Freshman students gained insight into the engineering education ahead of them.

> "Throughout the semester, my team and I have had the opportunity to interact with upper-level engineering students. Interacting with older engineering students provided insight into the workload to expect in the years to come. As a result, I have a better idea of what concepts and skills are especially important to learn this year and how they apply to actual projects" (Hannah).

Freshmen became more motivated for a degree in engineering.

> "It is encouraging to see upper level engineering students who are succeeding and staying in engineering. Even in my first semester I have seen several of my peers decide to switch to non-engineering majors, or start questioning their decision to pursue engineering. While I feel confident in my decision, seeing so many friends switch majors can be discouraging; so, interacting with older students who are succeeding helps to make my goals seem more attainable" (Hannah).

> "The opportunity to be involved in the project sparked an interest in me for engineering in general, but specifically for a career in NASA. What followed was a sense of motivation, and an assurance that with hard work, I can achieve a lot with an engineering career" (Ivan).

Interpersonal

Students learned the importance of teamwork and collaboration.

> "Through the team project, I learned how to think from multiple viewpoints when approaching a project, incorporate other student's ideas to create new concepts, and combine team members' skills to solve problems" (Cristian).

"Teamwork was an integral part of the design projects. In fact, if there was one expectation of the students, it was that each one was willing to grow through teamwork. A variety of engineering degrees were represented, from mechanical, to electrical, to nuclear engineering. The immediate result: a group of freshmen embarking on a new experience in which each could freely contribute, the commonality between them being that each was a freshman assimilating into the college life and looking to gain an enriching experience in engineering. Teamwork has finally become an important element of engineering for me. This is something that is hard to experience any other way" (Ivan).

Students developed personal learning strategies for a team environment.

"I have found that I work better and am more creative and productive when working on a team. For example, when brainstorming possible solutions in a team meeting, one team member and I had a similar design concept in mind. We were able to talk out some of the problems each of us were considering and with that I was able to draft up a basic design which eventually became one of the top three concepts that we presented at the end of the semester. Because this is the way that engineers work on problems in reality, I feel as though I could realistically picture myself becoming an engineer and working on actual problems in the workplace" (Hannah).

"Students had to develop teamwork skills corresponding to all stages of the project. To start with this new experience, each student had to acquire skills of responsibility and assume an active role to contribute to the team. With weekly meetings and assignments to attend to, commitment went hand in hand. Then, the projects challenged each of the teams to organize and brainstorm to produce possible solutions. Creativity and analysis of ideas quickly became valuable" (Ivan).

Intellectual

Students worked creatively on in-depth, real-life problems.

"The problems and design tasks presented in the TSGC Design Challenge allowed students to work creatively and more in depth with each other to solve more real-life applicable problems. I personally felt as though classes prepared us for the technical aspects of engineering problem solving, while the design challenge helped us to better understand the importance of creativity and teamwork in the problem" (Hannah).

Students cultivated more advanced research skills.

"The research aspect of the project was of a great benefit to my educational career. My experience in professional research had been limited before, and to be able to concentrate a whole project using this tool was an eye opening experience. The group's Engineering Mentor took the time to put together a presentation detailing how to find articles of merit thought the universities library." (Joshua).

Upper division and graduate students served as educational role-models.

> "Just as freshman teams were able to learn from each other, the opportunity to learn from upper division students became important. Being able to see upperclassmen and even graduates present at the TSGC Design Challenge Showcase gave the freshmen a firsthand experience as to what to aspire to in their projects. It also gave the freshman teams a general view of what the next few years of an engineering career can look like. The encounter provided motivation and inspired the participants to achieve more in the project" (Ivan).

Professional

Working on the projects reinforced the student's decisions to pursue a career in engineering.

> "The team project solidified my career choice of engineering, and showed me how the various disciplines in engineering worked together to solve a problem. Since I loved working on this project, I am sure that engineering is the right path for me" (Jillian).

Student gained insight and experience in professional engineering settings.

> "Interaction with the College Station PWD really taught me how ideas can be laid onto the table in real life applications, such as our green building guidelines. Attending meetings with PWD professionals taught me how to display confidence when sharing ideas, and to coherently communicate the reasoning behind the ideas" (Cristian).

> "Participating in the TSGC Design Challenge Showcase taught me how to present my ideas to other professionals, as we were tasked to present our design concepts to actual NASA employees and take their feedback. While this was at first intimidating, my team and I were quickly able to become comfortable and explain our problem and design concepts in a logical and concise manner. I believe this will be an incredibly useful skill in the future as it seems probable that as an engineer I will have to pitch my design concepts to other professionals in the workplace" (Hannah).

Students followed an accurate "real world" design process.

> "I found it very rewarding to work with the sponsor on this "real world" project, since she had several ideas for the design. The sponsor placed several constraints such as size, accessibility, and exhibit theme that directly affected the design. These constraints allowed the team to work through several design challenges, and allowed us to form a deeper understanding of the project sponsor's role in the engineering industry" (Jillian).

> "From working on this project I feel as though I have an understanding of how to approach a problem. As a team we started the problem solving process by first researching the topic and then brainstorming to come up with over twenty ideas. We then took these ideas and several times repeated the process of evaluating their strengths and

weaknesses and then altering them to make them more suitable. After this process we picked the top three designs which seemed to have the most promise and further explored them through detailed computer modeling. During the next semester we will take these designs and ultimately choose one to pursue as our final design. Going through this process has helped me to understand how to logically approach a big problem to come up with the best solutions" (Hannah).

Students learned to appreciate the role and contributions of all engineering disciplines in problem solving.

> "I'm a mechanical engineering major, but the PWD project experience sparked an interest in chemistry for me" (Cristian).

> "After the experiences of this project, I saw how every department in engineering is closely linked to increasing the welfare of the populous, and the effect of interdepartmental collaboration can have on a project. I also developed an interest in environmental engineering to which our group was closely related. The work done on making the products that humans enjoy more synergistic to natural decomposition and recyclability is a niche field worth examining" (Joshua).

Mentor Feedback

Table 3: Summary of Engineering Mentor Skill Acquisition

Skill Acquisition Area	**Example**	**Effect**
Personal	Time Management Skills Enjoyment of Teaching Networking	Mentors learned to balance the multitude of responsibilities associated with an engineering career. They also made favorable connections with students and professionals, possibly creating more opportunities for employment.
Interpersonal	Leadership Conflict Mediation	Mentors gained experience and strategies for leading collaborative teams, preparing them for managerial roles.
Intellectual	Complex Problem Solving Teaching Experience	Mentors were challenged to think creatively and guide students to do the same. Teaching freshman about engineering design forced mentors to understand it better themselves.
Professional	Communication Project Management Resume Building	Mentors trained for professional and management positions, providing them with confidence for the workplace.

Lacey is a Master's level Civil Engineering major, specializing in Water Resources Engineering. She currently serves as the engineering mentor for two teams partnered with the PWD. Travis is an undergraduate Nuclear Engineering major. He is the engineering mentor for the Coffee Adaptor System and Children's Museum team. Jesus is seeking his Bachelors of Science in

Aerospace Engineering. He served as the engineering mentor for two teams partnered with the TSGC and NASA in the Design Challenge Project.

Personal

Engineering Mentors cultivated and refined their time management skills.

> "As FEP developed, I learned that the key to keeping on schedule is planning ahead. I tried hard to break up the work into smaller, achievable milestones and deadlines for students. I attribute this to helping the students stay on track and budget their time on a week-to-week basis throughout the semester" (Lacey).

> "Time management is a crucial skill to have at any job. My time management skills were put to the test this past semester. Since I'm a Resident Advisor, my time was split between my RA duties, school, and this project. I completed all my classes successfully, but not as well as I could have done with fewer involvements. In the end however, I would say that my time management skills were enhanced" (Jesus).

Mentors experienced a real enjoyment of teaching.

> "I have worked in mentoring positions in the past, and this position reminded me of how rewarding it is to work with students. I find great satisfaction in helping students down a path of discovery, and am often surprised and impressed with their innovation. Since working on these projects, I have a greater interest in volunteer teaching, and perhaps even academia" (Lacey).

Mentors were able to network with engineering professionals.

> "By working with the project sponsors and project mentors, I was able to learn to make personal contacts and relationships with those above my own skill level" (Travis).

> "As a civil engineer interested in public works engineering, I appreciated the opportunity to work with the director and staff of the Public Works Department. Since I hope to work in the same state after graduation, I was glad to learn about local standards and operations" (Lacey).

Interpersonal

Engineering mentors practiced and developed team leadership skills.

> "My role as mentor to these freshmen working on complex, open-ended, technical problems was unlike any other teaching I'd done in the past. I had to learn how to find a balance between structuring the project, and also leaving it open enough for the students to contribute their own direction. I wanted to equip the students with the tools they needed to discover the answers for themselves. This required me to accurately anticipate

> the knowledge they would need, such as using the university library and working with Microsoft Excel" (Lacey).
>
> "By working in a group and in a leadership role, I learned that in order to lead a team, I must show motivation and zealousness towards the project. The students fed off of my passion for these projects which helped motivate them and increase their fidelity to the project. Another skill I acquired as a leader was to be outgoing and responsive to each of the students. Generally, freshmen engineering students are known to be socially distant, especially during their first technical engineering team meeting. However by being outgoing, I was able to harbor an environment that allowed each team member to openly share their personal ideas" (Travis).

Mentors gained experience in conflict mediation.

> "It seems that every job would have at least one conflict between workers or team members. Conflict mediation is something I deal with a lot in my RA job and is something I had to use a couple of times for both teams. It never escalated to anything extreme, but it did let me see how work related conflict, instead of dorm related, arises" (Jesus).

Intellectual

Mentors faced challenging problems when guiding their teams.

> "I think that these projects serve as exceptional educational opportunities for everyone involved because they are realistic, complex, and open-ended. Even as a graduate student, I was intellectually intrigued by the problems my teams were working on. As the Mentor, I made sure that I worked through the technical aspects of the projects before asking the students to do so. This way I knew the outcome was achievable, and was prepared to provide guidance and answer questions when necessary. For one project, I was even able to apply some skills in learned in a graduate class. I was eager and excited to pass along those skills to freshman students. Also, I gained greater confidence in my engineering abilities by tackling the problems myself as well" (Lacey).

Mentors experienced teaching engineering first hand.

> "I learned to explain engineering problems and constraints to those who have no engineering background or skills" (Travis).

Professional

The Mentors practiced professional communication with project sponsors.

> "I was the first from the Engineering Student Services Office to approach two of the project sponsors for this year's program. Having done this and received so much positive involvement from the Public Works Department and the Children's Museum, I am

encouraged at the power of e-mail in establishing collaborative partnerships. Through the course of the semester, I was able to practice initiating and sustaining professional relationships using e-mail, phone conferences, and personal meetings. I think that this is a very true representation of life as a full-time engineer" (Lacey).

The upper-level students gained experience in engineering project management.

"This was the first time I was able to work in a team setting on an engineering design problem. I was able to bond with the team members on a personal level, thus allowing me to understand each team member's personalities. I was able to solve any team conflicts by understanding how each team member thinks and the skills that they are able to contribute to the team" (Travis).

"Being in this project setting has let me experience the type of management that occurs as being an engineer" (Jesus).

Engineering Mentors enhanced their resumes for future internships and jobs.

"Being part of this project has helped me look better in the eyes of recruiters. My opportunities for an internship of Co-Op this summer look promising after attending a career fair at the national conference with the Society of Hispanic Professional Engineers" (Jesus).

Sponsor Feedback

The project sponsors are a valuable and integral part of the FEP program. Ms. Debbie Mullins is the Higher Education Program Coordinator for the TSGC Design Challenge at NASA's Texas Space Grant Consortium. Mr. Chuck Gilman, PE, PMP, is the Public Works Director for the College Station PWD. Their feedback on the benefits and costs of the FEP program are summarized in Table 4 below.

Table 3: Summary of Project Sponsor Feedback

	Example	**Description**
Benefits to Students	Real-world, hands-on engineering design	"Enhanced interest in engineering as a discipline; and an opportunity to learn where their course work will eventually lead them" (Ms. Mullins)
	Teamwork	"The program teaches entry-level engineers the challenges and benefits of working in a team. Not all members of the team will have the same communication style, work ethic, attention to detail, or availability, which are real-world challenges that engineers face each and every day in their profession" (Mr. Gilman)

	Accountability	"Individual success is dependent upon the success of the team; which is very true in the engineering profession" (Mr. Gilman)
	Public speaking and presentation skills	Presentation skills are vital to an engineer, but seldom emphasized strongly enough in the typical engineering education
Benefits to Sponsor	A relationship with Texas A&M	"The city appreciates the opportunity to build on an already strong partnership with the University" (Mr. Gilman).
	Useable research and programs	"One of the student groups developed a rate model in Microsoft Excel that allows us to forecast potential impacts to our sanitation rate if the number of citizens who participate in our recycling program increases or decreases." The research of the second team will "help the City reduce its carbon footprint" (Mr. Gilman).
Cost to Sponsor	Staff time	Minimal staff time was invested by the CS PWD

Suggestions for Further Improvement

The 2011-2012 academic year marked the start of the FEP program. As the program is still in its pilot stage, the ESSAP office gladly sought out suggestions for possible changes that will enhance the value of these types of projects to future freshman engineering students. Based on the responses of the freshman participants and the engineering mentors, areas for improvement or continued development exist in both the administration and content of the program.

Administratively, it was suggested that the ESSAP office may benefit from recruiting freshman earlier in the semester, even before the start of the school year. The anticipated benefit of this early action would be in providing more time to talk to these freshmen and introduce them to a selection of important introductory design concepts. Additionally, more detailed guidelines, expectations, and deadlines were recommended to improve the pace and structure of the program. As the FEP program moves into its second year, experience will enable codifying more effective guidelines. Another area for further development is expanding the support system for students. Ideally, this support system will span guidance and input from professors, the project sponsor, associated professionals, and widespread knowledge and assistance from ESSAP staff. Finally, it has been suggested that team-based engineering projects may be beneficially incorporated into engineering courses in the future. Another intermediary option could be offering course credit for students participating in the program the second semester.

To help ensure a beneficial engineering experience, students identified that it is important to ensure that tasks are reasonable for students based on knowledge, supplies, and time required. Giving students projects which are very wide in scope, or quite undefined, can make it challenging for students to initiate a solution. Additionally, projects which require a great deal of specialized supplies and construction may not be feasible given the budget, workspace, and time constraints of the students. However, this is not to discount the importance of model building. In fact, where feasible and practical, building models is highly encouraged by Jesus, and engineering mentor. He states, "seldom are the times we get to model anything in our classes. Without the model, the true virtue of engineering is lost. Anything looks good on paper, but having an actual model of this to show is imperative for a freshman that strives to be more than just an engineering student."

Discussion

The FEP program was started by the ESSAP Office with the goal of enhancing student education, professional and personal development, and overall retention in engineering. In the modern marketplace, "soft" professional skills are often considered to be of commensurate value as "hard" technical skills.[10] This provides a challenge for educators, as professional skills often must be mastered through experience, which may be difficult to achieve within the constraints of a classroom or a single semester. These freshman engineering projects are designed to complement students' classroom education, while supplementing it with team based, collaborative problem solving in a professional setting. The results observed above, after a single semester of the pilot program, provide encouraging evidence that the Engineering ESSAP office is achieving its goals.

The four Skill Acquisition Areas observed among students contribute to a well-rounded, holistic educational experience. On a personal level, students gained excitement and motivation to study engineering. The opportunities for peer support, student and professional mentors, and community involvement are all important aspects of student success and retention in engineering. The FEP program uniquely fosters peer connections by targeting students from the same dormitory and of the same educational level. The upper-class mentors devote a whole academic year to guiding students, offering insight into engineering, and inspiring students to work hard. Finally, the very formation of the projects, by incorporating outside project sponsors, encourages freshman students to envision themselves as leaders and innovators in the real world of engineering.

The opportunity to work in a sustained team environment, and collaborate with students of different backgrounds, improved the freshmen's interpersonal skills. The teamwork experienced by students involved in the projects went beyond what is possible in a typical freshman level engineering class in several ways. First, the time frame was twice as long, allowing students to form more meaningful relationships. Secondly, the projects fostered collaboration by often necessitating the study of multiple engineering fields. Finally, students worked in small groups with the institutional autonomy to shape the direction of their project based on discussion and agreement. For example, instructors may be limited in their ability to alter problem requirements due to large class sizes and grading fairness. Mentors, on the other hand, are flexible to different problem solutions, and different methods of achieving them. If students want to learn and incorporate a new skill or technology, mentors are responsive and willing to help. Students, then, share leadership responsibility, and must work together as a team to reach a consensus. The ability to work in a team, one of the ABET professional skills, will help prepare students to meet future workplace challenges.

Intellectual preparation is the foundation of engineering education, and is a prerequisite for the successful practice of engineering. The intellectual development of freshman students in engineering typically focuses on a set of core math and science classes. These courses tend to be regimented, and focus primarily on mastering predetermined content. The intellectual advances observed in the Freshman Engineering Program, including creative thinking, in-depth problem solving, and research skills, represent higher-order thinking which is often not emphasized so early in students' educational career. The opportunity to develop these individual abilities will serve students well in their continued studies. Students will be more comfortable and confident in applying math and science in complex problem solving settings.

Now equipped with interpersonal skills and intellectual aptitude, students may grow and succeed in the professionals setting. Students participating in the FEP program reaffirmed their choice of engineering as a career, and often gained interest in a specific job. This experience should increase retention, and enable students to better plan their future. The communication, presentation, and design skills acquired should serve students throughout their entire academic and professional careers. Perhaps most significant is the confidence which students gained, in themselves and their abilities.

The FEP program at Texas A&M differed from many other national programs or capstone design programs in that is was administered voluntarily, without course credit.[14-16] The design and execution of these Freshman Engineering Projects is applicable to any engineering college, with slight modifications perhaps. Implementing these projects requires moderate time and fiscal investment, but the benefits in terms of personal, interpersonal, intellectual, and professional are substantial. The program works best as a voluntary supplement to the traditional classroom education.

Opportunities for future research on the subject of the Freshman Engineering Projects include following this year's cohort of students over the next four years, until graduation. This longer term study will enable the researchers to better assess the impact of the projects on student's retention in engineering, as well as their academic and professional achievements.

Conclusion

The paper describes the theoretical foundation, organization, and results of a pilot program for freshman engineers. The program is team-based and project-oriented with collaboration from upper-class engineering mentors, engineering faculty and staff, and project sponsors. The results after a single semester indicate that freshman students benefit personally, interpersonally, intellectually, and professionally. They develop teamwork, problem solving, communication, and presentation skills which are highly valued in today's educational system, and by modern employers. These positive results, paired with opportunities for future improvements, suggest that the Freshman Engineering Project Program is effective in achieving the educational and professional goals of the College of Engineering at Texas A&M University.

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