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Examining the Experiences and Perceptions of First-Year Engineering Students

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Abstract

The College of Engineering at a mid-Atlantic research University is working on a multi-year study that seeks to understand the undergraduate engineering experience and how engineering undergraduates are being prepared to become engineers of 2020: engineers who are good communicators, creative, and ethical, and who have the skills to work in global and multidisciplinary teams. One of the components of this study consists of understanding the first-year engineering experience.

The purpose of this paper is to describe the first-year engineering experience at the University. It answers the following research questions: (1) How do students define engineering? (2) Why are students planning to major in engineering? (3) What are some of the positive experiences in students' first year of engineering? and (4) What are students' perceptions of the following engineer of 2020 skills and attributes: communication, creativity, global and multidisciplinary teamwork, and ethics?

Data for this study was collected using surveys and interviews. A total of 665 first-year engineering students completed a survey in the fall 2011 semester. Forty first-year engineering students who completed the survey participated in one one-hour semi-structured interview in the spring 2012 semester. The results shared in this paper can be useful to universities and departments interested in understanding and improving the first-year engineering experience.

Introduction

The work described in this paper is the beginning of a longitudinal study of the experiences of engineering undergraduates at a large mid-Atlantic University. There are three major motivations for the study. The first is to track changes that occur in students' understanding of and their perceived preparation for the professional skills and attributes embodied in the engineer of 2020, e.g., creativity, ethics, and global engagement. The second motivation is to establish a base line against which the impact of initiatives to enhance learning relative to the engineer of 2020 professional skills and attributes can be measured. Lastly, the study is also motivated by the desire to determine whether the pressure of increasing enrollments is affecting students' experiences.

This paper explores the first-year students' definitions of engineering, reasons for majoring in engineering, and perceptions of some of the engineer of 2020 skills and attributes: communication, creativity, global and multidisciplinary teamwork, and ethics. This paper is guided by the following research questions:

- How do students define engineering?
- Why are students planning to major in engineering?
- What are some of the positive experiences in students' first year of engineering?
- What are students' perceptions of the engineer of 2020 skills and attributes?

Previous studies have looked at the different ways in which engineering students define engineering and at students' various reasons for choosing to major in this field. For example, in Chachra et al.'s[1] study, first-year students mostly conceptualized engineering as involving designing, creating, and building. In the interviews, some students also talked about the application of math and science, and problem solving, and a minority talked about "improving humankind" (p.7). Regarding students' motivations to study engineering, in a study by Korte and Smith[2], a survey asked the students about their motivations as related to financial, family, social good, and mentor influences. Social good and financial motivations received the highest ratings. The authors also write that in the focus groups they conducted, "students described motivations to study engineering due to fascinations with problem solving, math and science, as well as parental influence and financial motivation"[2] (p.9). Stevens, et al.[3], on the other hand, write that for the engineering students in their study, the main motivation to study engineering was "to make good money and have a comfortable lifestyle" (p.4).

Because it is the goal of the College of Engineering to educate engineers that have the engineer of 2020 skills and attributes, the participants in this study were asked to share their perceptions of these skills and attributes. According to the National Academy of Engineering[4], the engineers of 2020 "are broadly educated,…see themselves as global citizens,…can be leaders in business and public service, and…are ethically grounded" (p.5). They are also creative and have leadership skills. The engineer of 2020 framework very closely aligns with the University's mission to educate World-Class Engineers: engineers who are solidly grounded, technically broad, globally engaged, ethical, innovative, excellent collaborators, and visionary leaders. In this paper, we look at students' perceptions of these skills and attributes, specifically focusing on how students define some of these skills, why they think these skills are important for engineers, and how they think the University has been preparing them for these skills.

Previous studies have looked at engineering students' perceptions of engineering and engineering identity[1, 5], skills successful engineers need[6], and educational experiences[2]. This study is unique in that it looks at these factors while also looking at students' perceptions of the engineer of 2020 skills and attributes. Because the engineers of the future are expected to have these skills and attributes in order to be successful, it is important to see what their perceptions are and if/how these perceptions evolve during their undergraduate studies. This paper presents the findings from the beginning stages of our longitudinal study.

Context of the study

This study is part of a larger, multi-year study conducted with the goal of understanding the undergraduate engineering experience and how the University is preparing engineers of 2020. Quantitative and qualitative methods are being used to learn about the experiences of current undergraduate students and alumni[7]. One of the components of this study consists of understanding the first-year engineering experience.

Methods

Data for this study was collected using surveys and interviews. The data collection process, instruments, and analysis are further described below.

Survey

A survey was sent out to all first-year engineering students at the University – a total of 2766 potential participants. A total of 665 (77% male, 23% female) completed the survey, for a response rate of 24%. The survey consisted of 42 items that asked students about their reasons for choosing engineering, their confidence in their abilities to become engineers, and their openness to experiences that would help them become engineers of 2020.

Because the goal of this survey was to answer research questions that were specific to this study and population, it was necessary to create a new instrument, rather than use an existing one[8]. Some of the steps outlined by Creswell[8] and adapted from Benson and Clark[9] were followed:

1. The purpose of the instrument and the target population were identified.
2. The literature was reviewed to learn about other studies that had related research questions, and these studies were used to inform the item creation process. While the majority of the items were created by the research team, some items were either taken or adapted from previous studies, such as those by Chachra, et al.[1], and by Korte and Smith[2].
3. After the items were created, the survey was evaluated qualitatively and quantitatively by both the research team and volunteer participants.
4. The survey was modified and revised based on the feedback resulting from the evaluations.

The survey was sent out at the beginning of the fall 2011 semester. This timing was chosen with the purpose of getting students' perceptions before they were fully engaged in their coursework and before they had experiences that might affect their opinions.

In addition to looking at means and distributions by gender, the survey items were also analyzed using a factor analysis to determine what factors emerged. The results of the factor analysis provide validity evidence based on the internal structure of the instrument. The principal axis factors procedure in SPSS, with direct oblimin rotation, was used. The results are presented in the next section.

Interviews

Forty first-year engineering students (50% male, 50% female) were compensated to participate in one one-hour interview mid semester in the spring 2012. In order to have a sample consisting of 50% female students, female students were over sampled. The students who were interviewed had also completed the survey sent out in the fall 2011. The factor scores resulting from the factor analysis (see Table 1 in the Results section) were used to select potential interview participants. Potential interview participants had either high or low scores in the engineering

identity and doubts about engineering factors, and they had either high or low scores in the factors related to openness to global experiences and teamwork.

The semi-structured interviews were intended as a follow-up to the survey, so participants answered questions about their reasons for choosing engineering, their confidence in their abilities to become engineers, and their perceptions of and experiences with the engineer of 2020 skills and attributes. In addition, they shared some of the positive experiences that characterized their first year of engineering.

The interviews were coded by an engineering education researcher who followed the steps suggested by Patton[10]. First, all the interviews were read to determine possible coding categories. Then, the interviews were again read with the purpose of "coding in a systematic way" (p.463). Finally, categories were determined by looking at the "recurring regularities" (p.465), or patterns, in the data. This process was used to determine categories for each participant, and then to determine categories that were common across participants.

Results

When developing the survey, we had classified items into the following categories: self-efficacy, knowledge of the engineering profession and the skills required to be successful, reasons for wanting to be an engineer, engineering identity, global awareness, creativity, and leadership. One of the main motivations for running a factor analysis was to see how the items would be grouped, and whether these groupings compared to our original groupings. The results indicated several similar categories, with a few additional ones.

The factor analysis resulted in ten factors, based on eigenvalues greater than 1. However, we considered only six of these to be meaningful (see Table 1). Three of the four remaining factors were not considered significant because they consisted of very few items (one or two items per factor). The fourth remaining factor was not considered significant because it consisted of what seemed to be unrelated items.

Table 1: Factor analysis factors

Factor	Sample Item
Engineering identity	I am happy that I am going to be an engineer[1].
Openness to global experiences	I would be willing to accept a job outside the United States.
Doubts about engineering	I sometimes wonder if I have the skills to be a successful engineer.
Problem solving	I am good at developing creative solutions to problems.
Leadership	I would like to assume a leadership position within a team or group.
Teamwork	I would like to work with people from different disciplinary fields.

Factor scores by gender were obtained for each of the factors. The mean statistics are shown in Table 2.

Table 2: Mean statistics for factor scores, by gender

Factor	Mean Statistic - Females	Mean Statistic – Males
Engineering identity	0.09	-0.03
Openness to global experiences	0.43	-0.14
Doubts about engineering	-0.10	0.06
Problem solving	-0.11	0.03
Leadership	-0.02	0.01
Teamwork	-0.22	0.07

In the remaining sub-sections, each of the four research questions is answered. Both interview and survey data are provided.

Research question #1: How do students define engineering?

The four most common ways students define engineering are:

1. Engineering is improving or helping things and/or the world. It deals with finding ways to make life easier. For example:

   "I guess an engineer is supposed to…change the world and make everything better. So to change the world, you have to take these ideas that are already there and make them better."

   "I guess engineering would be defined as an innovation of products that we are looking – or problems we're looking to solve and products that we already have to make them better and safer for everybody. I guess it can also be considered research and expansion to new, better ways to do different things that we look forward to doing."

2. Engineering is using math, science, and/or technology. For example:

   "I'd say engineering is a very scientific, very hardcore major where you have to combine the best of a lot of sciences and mathematics to figure out how you want to design and build stuff for a greater purpose."

   "I don't know about a definite definition. But something that's very challenging, works the technical parts of your abilities like the math and the science and the reasoning through why it's the best way to go about doing it – so it's like the mechanics of it."

3. Engineering is solving problems. For example:

   "I define engineering as solving problems to make life easier."

   "Engineering – well, a person who's an engineer is a problem solver. They're given a problem by the client or anyone, and they address that problem, and they provide an answer for them."

   "Using problem-solving techniques, teamwork, a lot of collaboration to solve problems, find solutions to current problems."

4. Engineering involves application of knowledge – it is not just about knowing something, but rather about applying that knowledge. For example:

   "Engineering – it's – I guess from what I understand, it's science but with practical applications. That's really how I would describe it."

   "It's applying science and math to practical things. It could be a lot of different things. It could be building new things, new technology and so it could be industrial kind of stuff…But yes, basically using science and math to do things instead of just doing science and math for like science and math's sake."

Research question #2: Why are students planning to major in engineering?

Students provided several reasons for deciding to major in engineering. The predominant reason is that they were good at and/or enjoyed math and science. One participant described it as follows:

"My strong points in high school were math and physics, so that kind of leads to engineering, I guess."

"Well, I chose engineering first because I've always been really interested – I love math so much, and sciences have always come pretty easy to me, so I figured the best way to combine those two would be engineering."

In the survey, 91% of female and 82.7% of male participants either agreed or strongly agreed that they wanted to be engineers because they were good at math and science. A chi-square test showed a significant difference between genders at the α=0.05 level: χ^2 (4, N=616)=16.823, p=0.002.

Another reason why interview participants said they chose engineering was because they liked to build and make things. For example:

> "I've always wanted to build things, and I heard that's what engineers do. And I was always good at math and science. That's where my passion was at in school, so I thought why not pick something I'm good at and I like to do?"
>
> "Because I like how engineers are creative. I like making things, so when I was younger – when I was a kid – I'd always make trains and play with Lincoln Logs and stuff like that, so I always wanted to build stuff, and then I'm good at math, and they make a lot of money."

A desire to make money and an enjoyment of hands-on work were also mentioned by the interview participants as reasons for wanting to be engineers. In the survey, 85% of female and 83% of male participants either agreed or strongly agreed that they were interested in engineering because engineering would provide them with a high-paying job in the future. A chi-square test showed no significant difference between genders at the 0.05 level.

In addition to discussing the reasons why they chose engineering, interview participants talked about what they like about engineering. There are three main things the interview participants like about engineering:

1. They like a challenge, and that's what they like about engineering. Two participants described it as follows:

   "I like the challenge. I like the changing challenge. How you think you solved a problem, but you didn't actually solve it yet."

   "I like the challenge and the personal fulfillment. I like being able to work hard at something…"

2. They like learning how things worked, doing hands-on work, and applying knowledge. For example:

   "I enjoy the hands-on work as well as the mental requirements of it. I like being hands-on…I want to be the one that creates the process and understands more about it. So that's how I liked engineering."

   "I like making things. I like problem solving, so I like stuff like that. And I like doing something and then looking at the final product and be like, 'I made that.'"

3. They like that engineering helps people and society.

> "[I like] the potential to make a change in the world."

> "I like the course work and just the fact that you get to work with other people and also the fact that whatever you do, you're basically helping the world in some way."

In the survey, 87% of female and 83% of male participants either agreed or strongly agreed that they wanted to be engineers to help people and society, and 97% of both female and male participants either agreed or strongly agreed that engineers have helped society. A chi-square showed no significant differences in either of these items between genders: χ^2 (4, N=617)=4.337, p=0.362.

Interview participants also talked about how they learned about engineering and/or became interested in engineering. Participants talked about members of their family or teachers who either were engineers, told them about engineering, or encouraged them to become engineers. For example:

> "I chose engineering because in my past family experience, a lot of people have worked in the engineering fields so – like my grandpa. He was [an engineer] and worked for a while with that, so I was introduced to that at an early age, and I thought it would be a really interesting field to go into. And I love math and science, so I thought it was a good fit."

> "Yeah, in high school, my calculus…teacher,…he definitely talked to me about engineering a lot…He just felt like it would be right for me since I really liked sciences, and he saw that. So he kind of pushed me in that direction."

Some interview participants were engaged in various engineering-related activities prior to starting their undergraduate program. These activities include math, science, engineering, or technology clubs; high school engineering courses; and summer engineering camps or programs. This is how two participants described it:

> "My high school actually had like a – we have different departments sort of and we had engineering classes, and I took an introductory class there…It was Introduction to Engineering Design, and we did things like a program kind of like SolidWorks... And it was just about learning about the basic drawings and just kind of learned about the basics of engineering."

> "In high school, I went to an engineering summer camp…during the summer between sophomore and junior year…[I learned] a lot of the design process that goes with designing things."

Finally, although interview participants were motivated to become engineers, they also shared some concerns they had about the engineering profession. Some were concerned about their

abilities to adapt to the work place and to be able to do the work they would be required to do. One participant described it as follows:

> "I guess getting stuck in an office building all day and maybe not quite knowing what I'm doing…getting to a job and having people expect that I know lots of things, but I really might not."

Others were concerned about ultimately not liking the work they would be doing and finding it uninteresting. For example:

> "Other concerns about entering the profession – like that I would end up doing something that like, 'Yeah, I got through it. I can take classes. I was smart enough.' But then I get into it, and I'm doing like boring stuff or I realize I'm not interested in it. It's just too boring or something."

Research question #3: What are some of the positive experiences in students' first year of engineering?

Interview participants shared some of the positive experiences that characterized their first year as an undergraduate engineering student. There were four main experiences described by the interview participants as being positive:

1. Having good, helpful, and understanding instructors. One participant said:

   "It's definitely something new compared to high school. I really enjoyed the engineering department. The guidance counselors I guess is what they are – they're helping me out step by step. I know if I ask any of my teachers, they're always there. So it's really been probably a really good experience."

2. Joining extracurricular activities. One participant described it as follows:

   "And then completely not engineering related, there's a dance club that I'm doing which is nice to keep up with. So I'm not just focusing everything on engineering but be able to balance it out…I keep all my interests in mind."

3. Having good and enjoyable classes. For example:

   "I just love that [engineering design] class. My teacher has been great. I've learned a lot, really…I really like the fact that we're working on real projects, not just some made up. But it's a real company that's come in and asked us to design this new process for them, so I think that's really cool."

4. Meeting people from different backgrounds:

   "…meeting dozens of people from different backgrounds with different interests. The entire experience has been…positive…"

Research question #4: What are students' perceptions of the engineer of 2020 skills and attributes?

Communication

According to the survey, 97% of female participants and 94% of male participants either agreed or strongly agreed that successful engineers need to be effective communicators. A chi-square test showed no significant difference between genders at the α=0.05 level: χ^2 (4, N=631)=3.597, p=0.463.

There are two main reasons, according to interview participants, why engineers need to be good communicators. First, they believed engineers need to be able to effectively sell and communicate their ideas. Second, they believed engineers need to successfully communicate with the people they work with – team members, employers, and customers. These reasons were described as follows:

> "Because no matter how brilliant the ideas in your mind are, if you can't tell them to your boss or people you're working with, then they're useless."

> "It's helping a lot with working in the teams. And you have to be able to communicate with who you're working for. If you're having problems or you're updating with what's going on or your teammates are all like, 'I don't think this is the path we're going down.' Even though you might butt heads, I've thought you've got to voice your opinion and be able to communicate well with your group."

In the interviews, participants mentioned several ways in which they believed the University was helping them improve their communication skills. These include, among others: working in groups, taking communication classes, taking an engineering design class, taking English classes, and being required to present their work in different courses.

Creativity

The survey results indicated that 93% of both female and male participants either agreed or strongly agreed that successful engineers need to be creative. In the interviews, participants shared how they defined creativity and why it is important for engineers. Creativity was defined in three ways:

1. Creativity refers to coming up with unique/different solutions or ideas. For example:

   > "Creativity – how do I define it? I'd say being creative is thinking of things that no one else thought of before – so being original…I'd say being creative is being original and figuring out problems in the best way possible."

2. Creativity means thinking outside the box. For example:

   > "I would define creativity as thinking outside of the box. If you're given a strict procedure to go with and something else requires you to do something else besides that

procedure, you have to come up with that to work with your situation. So that's how I'd define it."

3. Creativity refers to finding ways to improve or change something for the better. For example:

   "Innovation and creativity, in the engineering aspect – I would see it as just the ability to make something improved. You don't really have to be the one who made it, but you can be the one that made it 10 times better. So I guess that's how I see that."

Interview participants also talked about why they considered creativity to be important for engineers. They believed creativity was important in engineering because it is necessary to design, create, and generate ideas; it is necessary to be able to solve problems; and it is necessary when improving things.

According to the interview participants, the main way in which the University was helping them develop their creativity was through the engineering design projects. For example:

> "I know Engineering Design was probably a really good class. I think I learned a lot from that class. Being creative – we had to do a lot of brainstorming. We learned different methods… which helps us to brainstorm ideas and then come up with even more ideas based on our first ideas. But anyways, we also learned different ways to narrow down ideas, choose the best one in the situation… I'd say just working on the design projects gives us practice at being creative and also working as a team and being creative with a team. So Engineering Design definitely helped with learning how to be creative."

Global and multidisciplinary teamwork

Interview participants provided three main reasons why teamwork is important for engineers. First, they said working in teams provides access to complementary skills. According to them, this is important because one single engineer would rarely be able to successfully complete a big task on his/her own. Second, they said it was simply the nature of engineering to work in teams. Therefore, it was important for engineers to have teamwork skills. Third, they believed teamwork was important because working in teams would result in better products and ideas.

Perhaps for these reasons, survey participants considered global and multidisciplinary teamwork to be important for engineering. Eighty-five percent of female participants and 76% of male participants either agreed or strongly agreed that engineers often work in teams with members from other countries. In addition, 91% of female participants and 86% of male participants either agreed or strongly agreed that successful engineers work well in teams with people from different disciplines. A chi-square test showed no significant difference between genders for either of these items at the 0.05 level.

The survey also included items to learn about participants' openness to experiences related to global and multidisciplinary work. Some examples can be found in the table below:

Table 3: Items looking at openness to global and multidisciplinary work

Item	% of female participants who agree or strongly agree	% of male participants who agree or strongly agree
I would be willing to accept a job outside the United States.*	61%	46%
I would like to work with people from different disciplinary fields.	77%	73%
I would like to work with people from different countries.*	76%	55%

*indicates a significant difference at the $\alpha<0.05$ level between male and female participants, based on a chi-squared test.

Female participants seemed to be more open to global work than male participants. This is seen both in individual items and in the factor scores. Chi-square tests reveal significant differences at the $\alpha<0.05$ level among male and female participants in individual items related to interest in or willingness to work globally, where a significantly higher number of female participants expressed more interest in and willingness for this type of work. Mean statistics obtained for the factor scores show that compared to male participants, female participants have a higher score in the "Openness to global experiences" factor (see Table 2).

Ethics

The survey results indicated that 86% of female participants and 83% of male participants either agreed or strongly agreed that engineers need to consider the ethical implications of their work. The interviews revealed how participants thought about ethics. They defined ethics in two main ways:

1. Ethics is knowing right from wrong, doing the right thing, and is associated with morals. For example:

   "Ethics – I could define it as saying it's what you think is right or what is the right thing to do in situations I guess."

2. Ethics is being aware of the effects of certain actions and thinking about how to minimize bad effects. For example:

   "Ethics – ethics is having integrity so you're making decisions so that you're minimizing the bad effects on other people, I guess."

Interview participants provided reasons why ethics is important for engineers. They expressed that ethics is important because engineers need to know how engineering work affects people and the environment. One participant described it as follows:

> "Also, engineering allows you – if you design something a certain way – say you use a certain chemical that's toxic. That has huge implications on the environment, so ethics and ethical implications – I'd say that for any job you do it's important, but maybe more so for engineering than other jobs just because engineers have a huge influence on everyday things that people interact with like cars, buildings – just everything."

Another reason why ethics is important to engineers, according to the interview participants, is that they need to be able to understand others' backgrounds. Two participants said:

> "Just because you are working in teams and you're working with other people and you're working for other people and trying to help other people. So it's a lot of interaction between others, and you have to watch other people's views and all that kind of stuff."

> "Ethics and ethical implications – that's definitely important. If you're building something for Buddhists, say, you can't design anything that would conflict with their points of view or else it won't be a successful product."

The above responses indicate that some students may be somewhat confused about ethics. Future interviews with these same students will show whether these students have gained a better understanding of ethics.

Interview participants also said ethics was important simply because engineers need to do the right thing.

Interview participants also shared how they were learning about ethics at the University. Participants learned about ethics through their courses – either design courses that discussed ethics, or electives that focused on ethics. Participants also described how the University's academic integrity policies introduced them to ethics. This is what the participants said:

> "I think maybe in my engineering design class we might have talked about it a little bit…we did – a little bit about designing ethically."

> "Well, there's all the codes and academic honesty and everything you're told to do here. You're expected to do it in the right way. So I think having those expectations now in college just prepares you so much for the future because you're used to that and having those high standards."

Discussion

In this paper, we used survey and interview data to answer several research questions. The data revealed that first-year engineering students defined engineering as improving or helping things and/or the world; as using science, math, and/or technology; as solving problems; and as involving the application of knowledge. Participants in Kilgore et al.'s[11] study defined engineering in similar ways: definitions fell under four main categories titled problem solving, math and science application, designing/creating/building, and improving humankind. Similar to Chachra et al.'s[1] participants, the participants in the current study mostly defined engineering "to

include the action components of engineering (i.e. problem solving, application of math and science skills) in contrast to the thinking component of the definition (brainstorming, critical thinking)" (p.7). Because these students will be interviewed as they continue their engineering programs, future data will show if and how these definitions change as a result of continued exposure to and involvement in engineering.

The data showed that students' reasons for deciding to major in engineering include being good at math and science, enjoying building and making things, and having a desire to make money, which are reasons and interests that have been previously mentioned in the literature[2, 3, 12]. Closely related to their reasons for majoring in engineering are the things that they like about engineering. As the students described in the interviews, what they liked about engineering was the challenges it presented, applying knowledge and learning how things worked, and the potential to help people and society. While students may typically decide to major in engineering based on their pre-college perceptions of or experiences with engineering (such as participating in high school engineering courses or summer camps), what they learn about engineering in college can certainly impact their desire to continue in or leave engineering. It is important for students to identify aspects of engineering that they are attracted to and that they like, because it will likely be these aspects that fuel their motivation to continue with their engineering studies. In future interviews with these students, as they continue to learn about engineering, we will see what aspects of engineering continue to attract them.

Interview participants also shared some of the positive experiences that characterized their first year as undergraduate engineering students. There were four main experiences described by the interview participants as being positive: (1) having good, helpful, and understanding instructors, (2) joining extracurricular activities, (3) having good and enjoyable classes, and (4) meeting people from different backgrounds. These are all experiences that likely helped students adjust to their new statuses as college students, and helped ease the transition from high school to college. These experiences, especially having good instructors and good classes, will also likely motivate them to continue with their engineering studies. Future interviews with these students will reveal whether they continue to have these positive experiences, and whether new positive experiences have emerged.

Finally, students shared their perceptions of some of the engineer of 2020 skills and attributes, specifically communication, creativity, global and multidisciplinary teamwork, and ethics. Participants agreed that all these skills were necessary to be successful engineers. There were no significant differences by gender, except on items related to openness to global work, where female participants reported being more likely than male participants to be open to and interested in this type of work. This is not entirely surprising. Compared to male students, female students tend to see engineering more broadly and to be "more engaged in a wider spectrum of educationally productive experiences"[11] (p.5), which could be factors affecting their perceptions of global work. The follow-up interviews and surveys will reveal if and how these students' perceptions of the engineer of 2020 skills and attributes evolve, and whether female and male participants' responses regarding global work continue to be significantly different.

Conclusion and implications

This study used quantitative and qualitative methods to learn about first-year engineering students' perceptions and experiences in a mid-Atlantic University. 665 survey participants and 40 interview participants shared the ways they define engineering, their reasons for choosing engineering, and their perceptions of the engineer of 2020 skills and attributes.

Results from this study have implications for engineering programs interested in their students' persistence in engineering. As stated by Meyers and Mertz[12], students' interests and abilities, and not just a desire to make money, were important "pathways into engineering," and it is therefore necessary "for students to understand the nature of engineering to make sure that their interests and abilities do coincide with the demands of the discipline" (p.13). The first year of engineering is an excellent time to make students aware of the nature of this field. First-year courses and seminars should embrace the opportunity to introduce students to engineering and to help them find their place in engineering.

Engineering departments interested in their students' persistence should also look at the different experiences students in this study described as being positive. These experiences will likely motivate students to continue in engineering. As such, engineering departments should encourage these types of experiences, especially if they contribute to what Meyers, et al.[13] describe as the "human element" (p.5). These authors write that:

> "the key to persistence in engineering is infusing the first-year experience with the human element. Students must be shown that ideas and personalities have been and continue to be essential to engineering success. Further, students must be privy to the transformative power of engineering, to the idea of how engineering has changed society, often for the better… [B]ringing the human element to engineering in very personal and real ways can be accomplished by engaging a student's personal accomplishments and struggles to show that someone cares about their success" (p.5).

Engineering departments and first-year courses can consider incorporating this human element by showing students how engineering impacts people and society, by showing them how their diverse interests and abilities can contribute to engineering, and, through the use of relationships and interactions, by helping them find that they "belong" as engineering students.

Our future work will continue to survey incoming first-year engineering students, so that in future papers, we will be able to discuss survey responses from various cohorts of first-year students. Surveys at the sophomore and junior levels will also be administered.

In addition, we will be tracking the interview participants from this study. The first-year survey participants will be invited to take the second-year and third-year surveys in the respective years, and interview participants will continue to be interviewed as they progress through their engineering studies. This will allow us to learn more about how their experiences in and perceptions of engineering change, as well as how they continue to think about and be prepared for the engineer of 2020 skills and attributes.

List of references

1.Chachra, D., Kilgore, D., Loshbaugh, H., McCain, J., & Chen, H. (2008). Being and Becoming: Gender and Identity Formation of Engineering Students. *Paper presented at the American Society for Engineering Education Conference and Exposition*. Pittsburgh, PA, June 22-25.

2.Korte, R., & Smith, K. (2007). Portraying the Academic Experiences of Students in Engineering: Students' Perceptions of Their Educational Experiences and Career Aspirations in Engineering. *Paper presented at the American Society for Engineering Education Conference and Exposition*. Honolulu, HI, June 24-27.

3.Stevens, R., Amos, D., Jocuns, A. & Garrison, L. (2007). Engineering as Lifestyle and a Meritocracy of Difficulty: Two Pervasive Beliefs among Engineering Students and their Possible Effects. *Paper presented at the American Society for Engineering Education Conference and Exposition*. Honolulu, HI, June 24-27.

4.National Academy of Engineering. (2004). *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, DC: The National Academies Press.

5.Loshbaugh, H. & Claar, B. (2007). Geeks are Chic: Cultural Identity and Engineering Students' Pathways to the Profession. *Paper presented at the American Society for Engineering Education Conference and Exposition*. Honolulu, HI, June 24-27.

6.Kilgore, D., Yasuhara, K., Saleem, J. J., & Atman, C. J. (2006). What Brings Women to the Table? Female and Male Students' Perceptions of Ways of Thinking in Engineering Study and Practice. *Paper presented at the ASEE/IEEE Frontiers in Education Conference*. San Diego, CA, October 28-31.

7.Mena, I., Zappe, S., & Litzinger, T. (2012). Preparing the Engineer of 2020: Analysis of Alumni Data. *Paper presented at the American Society for Engineering Education Conference and Exposition*. San Antonio, TX, June 10-13.

8.Creswell, J. W. (2008). *Educational Research*. Upper Saddle River, New Jersey: Pearson Education, Inc.

9.Benson, J. & Clark, F. (1983). A Guide for Instrument Development and Validation. *The American Journal of Occupational Therapy*. 36(12): 789-800.

10.Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods*. Thousand Oaks, CA: Sage Publications, Inc.

11.Kilgore, D., Chachra, D., Loshbaugh, H., McCain, J., Jones, M., & Yasuhara, K. (2007). Creative, Contextual, and Engaged: Are Women the Engineers of 2020? *Paper presented at the American Society for Engineering Education Conference and Exposition*. Honolulu, HI, June 24-27.

12.Meyers, K. & Mertz, B. (2011). A Large Scale Analysis of First-Year Engineering Student Essays on Engineering Interests. *Paper presented at the American Society for Engineering Education Conference and Exposition*. Vancouver, B.C., June 26-29.

13.Meyers, K., Uhran, J., Pieronek, C., Budny, D., Ventura, J., Ralston, P., Estell, J. K., Hart, B., Slaboch, C., & Ladewski, R. (2008). Perspectives on First Year Engineering Education. *Paper presented at the American Society for Engineering Education Conference and Exposition*. Pittsburgh, PA, June 22-25.