

Understanding how students view Surveying Engineering at Penn State University and updating their self-beliefs

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This is an evidence-based practice paper related to Surveying Engineering. Surveying Engineering, sometimes referred with the modern term “Geomatics”, is an essential field of engineering. Surveying engineering has a significant role in construction and highway projects, mapping and boundary determination, building information management, land information management, monitoring engineering structures, and more. Surveying makes use of many revolutionary technologies including Global Navigation Satellite System (GNSS), laser scanning, photogrammetry, and mapping using small unmanned aerial systems (sUASs). However, the surveying profession suffers from low public profile, making it difficult to attract students in surveying / geomatics programs, with many surveying programs experiencing low enrollment. This issue has led to significant problems in the profession such as increasing the average age of surveyors, with unofficial estimates indicating that the average age of surveyors is between 55 and 60 years old. In our previous work we examined surveying students to understand how they found out about surveying and what got them interested in this major. While this provided us with some important insights, it only reflected the opinion of students who already selected surveying. In Fall of 2022, we expanded our sample by surveying first-year students at six Penn State campuses in order to understand their perceptions about surveying. The online survey helped students to understand the main characteristics of surveying engineering and helped them update their self-beliefs about surveying. The paper also examines survey results considering college major, racial, and gender. The important insights of this survey greatly advance our knowledge about student perceptions related to surveying and assist in recruitment and marketing efforts to create pathways into surveying engineering.

Keywords: Surveying engineering, broadening participation, increasing awareness

Introduction

Surveying in the early years (1800-1850) was mostly taught through apprenticeships and formally in mathematics departments [1]. In later years, surveying was taught in civil engineering departments. The average number of surveying credits in civil engineering departments was about 14.3 in 1930s [2] and declined to 5.5 in 1960s [3], and then to only 2.1 credits in 2010s [4]. The reduction in surveying credits was the result of the need to make room for other courses (e.g., courses to satisfy general education requirements). This gave the opportunity for independent surveying programs to be created. The first programs that emerged were 2-year programs around the 1950s [5]-[7], followed soon after by bachelor programs in geodetic science and surveying in the 1960s and 1970s [5], [8]-[11]. Today there are more than 20 programs, 2-year or 4-year programs, accredited, by the Accreditation Board for Engineering and Technology (ABET) [12]. Surveying programs sought accreditation by one of the following ABET commissions, namely, Engineering Accreditation Commission (EAC), Engineering Technology Accreditation Commission (ETAC), and Applied and Natural Science Accreditation

Commission (ANSAC). Surveying Engineering programs in the EAC have to compete with other engineering disciplines, making it more challenging to attract students compared to surveying programs in the ETAC and ANSAC. Arcidiacono et al. [13]; Wiswall and Zafar [14] found that earnings expectations and ability / aptitude perceptions have a critical role major selection. Of note is that surveyors have one of lowest median pay among the architecture and engineering professions [15], making it extremely difficult to persuade students to follow a major that has the same mathematics requirements and settle for a considerably lower salary.

The choice of career selection for students entering college is a combination between their personal interests, abilities / aptitudes, and limitations / needs of the marketplace [16]-[20]. While some students have an idea of what major to follow upon entering college based on their personality, characteristics, and abilities [20], other students are undecided, exploring different career paths mostly during their first academic year [20],[21]. Many universities follow first-year introductory programs to improve knowledge of different engineering disciplines and increase major certainty [22],[23]. A necessity for following an engineering major is to have strong math abilities, as success in math strongly affects retention and graduation rates in engineering [24]-[26].

A big challenge in bringing students into surveying is the low public profile of the profession, as most students graduating from high school do not know (or at least they have a limited understanding) what surveying engineering is. This has created enrollment challenges in many surveying programs e.g., [4], [12], [27], [28]. It is worth mentioning that some surveying programs (undergraduate and/or graduate) that have developed online programs have experienced great success [29]-[31]. In our previous work we surveyed current students and alumni, focusing on the reasons why they selected surveying as a career and how they learned about surveying [12]. While the survey provided many insights that are useful in refining our recruitment plans, current surveying students and alumni provide half of the picture, because they have already selected surveying as a career. They were able to learn about surveying, they found it interesting, and they selected surveying as their major. Instead, we are missing very important information from the students who did not select surveying or did not know about surveying. Therefore, we need to examine this part of the population in order to obtain a complete picture.

The objective of this paper is to survey first-year students of any major and obtain additional insights about their perceptions related to surveying engineering. This information can be used to understand the level of awareness of surveying engineering in first year students and assist in making plans for creating new pathways into surveying engineering. The focus was placed on first-year students, as their first year of college plays a critical role in the process of selecting their major [21]. As a secondary objective, we attempt to update the participants' self-beliefs about surveying to increase awareness of surveying engineering.

Background and Study Design

Participating Penn State Campuses

Penn State University is one university geographically dispersed to 20 campuses in Pennsylvania (Figure 1), with University Park having the highest enrollment of about 41,000 undergraduate students, with another 22,000 being in the remaining 19 Commonwealth campuses. There are about 8,400 undergraduate students in engineering at University Park, and about 2,400 engineering students in the remaining Commonwealth campuses. The enrollment data for each campus and academic plan can be retrieved from [32].

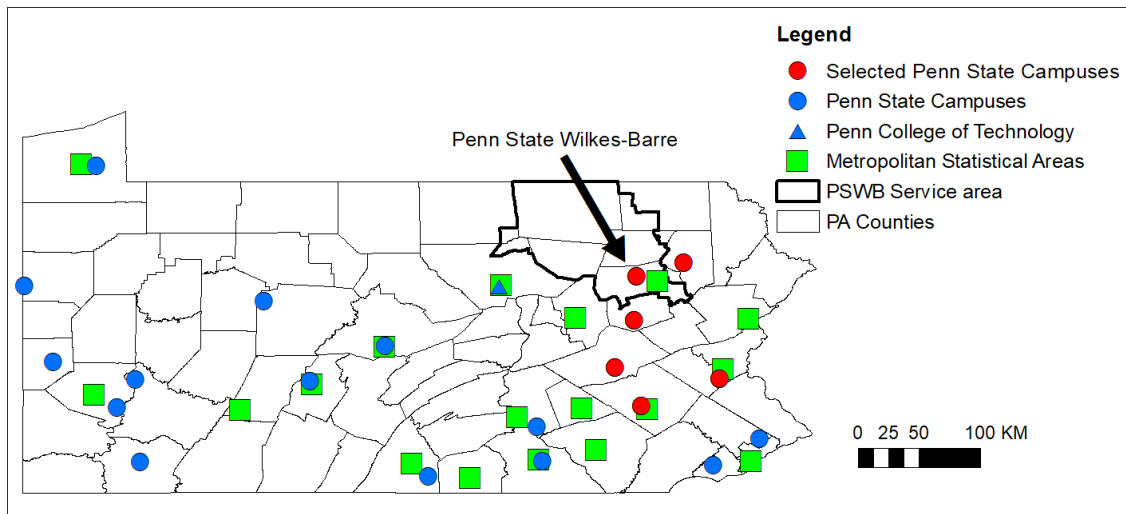


Figure 1. Penn State Campuses and major metropolitan statistical areas. In red circles we show the Penn State campuses that were selected for this study.

The Wilkes-Barre campus offers two ABET accredited degrees. The campus offers a 2-year Surveying Engineering Technology degree, which was created in 1957 and received accreditation in 1962 by ETAC [7], [33]. In addition, it offers a 4-year Surveying Engineering degree which was created in 1994, received accreditation by ANSAC in 1997, and then by the EAC in 2004 [33],[34]. Although, it is worth mentioning that the campus started offering surveying courses as far back as 1916 in order to fulfill the need of the local anthracite mining industry.

Survey questions and distribution

The first seven questions of the survey aimed at understanding the background of students such as their campus, their race, gender, major and why they selected their major, and their rating of academic ability and ability in mathematics. The question about their academic ability with regards to mathematics was asked because surveying is a math intensive major. Next, we asked them to define surveying in their own words, if they knew about surveying engineering before going to college, and if at any point they considered surveying engineering as a major.

The next series of questions were developed based on the characteristics of the surveying profession. The questions were: where they like to work (indoors, outdoors, or both), if they like working with modern technologies (e.g., drones), if they like mathematics and problem solving, if job security is important to them, if they like to complete paid internships while studying, and if the entry salary level for surveyors (typically between \$45,000 and \$65,000) is satisfactory to them. In each one of the above questions, there was explanatory text indicating that surveying is a profession with mostly outdoor activities, that uses modern technologies (GNSS, drones, laser scanners), requires math and problem-solving skills, that has a high job placement, and that students have no issues in finding paid internships, and a job upon graduation (see Figure 2). The explanatory text helped in providing some key elements of the surveying profession; therefore, students would be able to relate with some of those key elements and update their self-beliefs. Finally, we asked students whether they would have considered surveying as an option if they knew about this. The survey was short, and it was designed to take about 5 minutes to complete.

Is job placement and security important to you?

Surveying has a high job placement and security. 75% of students find a job before graduation!

- Yes
- No

Figure 2. Question example with additional text to provide key information about the surveying major and profession.

Wilkes-Barre is the only Penn State campus with surveying programs. Student recruiting for each Penn State Campus typically focuses on its vicinity (about 30 miles) to avoid competition between the campuses. This creates a challenge for the Wilkes-Barre campus to bring students into surveying, as there are two Penn State Campuses, Scranton and Hazleton, within 20 miles of each other, which serve the greater Wilkes-Barre / Scranton / Hazleton metropolitan statistical area (Figure 1). Because of the unique recruiting strategy, we limited our survey to the six northeastern campuses, as recruiting efforts would be difficult to plan and coordinate for the remaining campuses. The six campuses are: Berks, Hazleton, Lehigh Valley, Schuylkill, Scranton, and Wilkes-Barre. The survey was distributed to first-year students enrolled in Fall of 2022. Of the 1,760 first-year students in the abovementioned six campuses, 215 of them completed the online survey of this study, which yields a participation percentage of about 12%. The survey was available for them in October (30 days) of 2022 and regular reminders were sent.

Survey Results

Participant characteristics

The majority of the participants are from the Berks campus (Table 1), as the Berks campus has about two to four times the enrollment of the other campuses in this study. In terms of race, most participants indicated “white” (Table 2), which is expected from the demographic characteristics of northeast Pennsylvania. Participation in terms of gender is balanced with equal male and female participation (49% each), and 2% indicated that they identify themselves as non-binary or other. The survey was open to all first-year students, and about 29% of them responded that they have selected an engineering major, with 65% following non-engineering majors, and 6% being undecided.

Table 1. Survey participants by Penn State Campus. There are 215 total participants.

Penn State Campus	Participants by Campus
Berks	44.2%
Hazleton	6.5%
Lehigh Valley	15.3%
Schuylkill	8.4%
Scranton	14.9%
Wilkes-Barre	10.7%
Total	100%

Table 2. Survey participants by race. There are 215 total participants.

Race	Participants by Race
American Indian or Alaskan Native	0.5%
Asian	13.0%
Black or African American	12.1%
Native Hawaiian or Pacific Islander	0.5%
White	65.1%
Other	8.8%
Total	100%

Figure 3 shows the student ratings on their overall academic ability, and their ability with respect to Mathematics. Most students rated themselves with an above average academic ability. Ratings are slightly worse with respect to mathematics, perhaps because most participants follow non-engineering majors (65% of the participants follow a non-engineering major). It is worth noting that attitudes toward math and math self-efficacy beliefs are very important factors for students to choose a Science Technology Engineering and Mathematics (STEM) field [21].

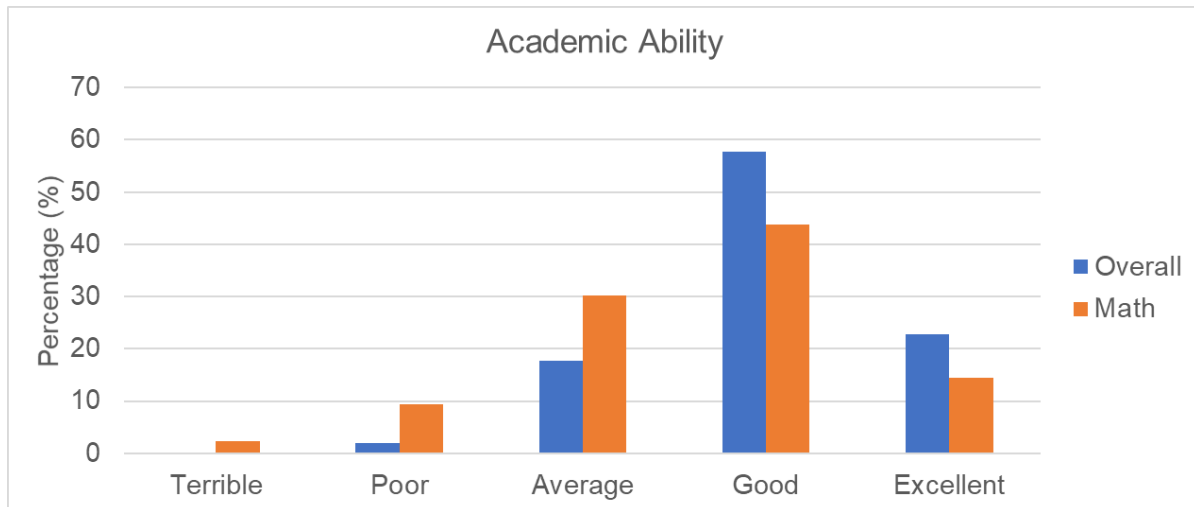


Figure 3. Participant academic ability, as rated by participants. The figure shows student ratings for overall academic ability, and academic ability in Mathematics.

Knowledge of surveying engineering

The students were asked to describe in their own words why they selected their major. Their responses were entered in a word cloud generator (Figure 4). Some of the words that we can notice are “want”, “interested”, “interesting”, “love”, “enjoy”, “career”, “help”. Their responses indicate that students need to get intrigued by a profession / career and they want to enjoy or love what they are doing. This is in accordance with findings of previous studies that have identified earnings, student ability / aptitudes, and finding the career path interesting as the main factors affecting students’ major selection [13], [14], [19]. Unfortunately, it is well known that surveying is a major with low public profile. Most students are unaware that this major exists or they may be confused about what surveying is. In our sample only 15% indicated that they knew what surveying is before college with 85% indicating that they did not know what surveying is. Note that 3.7% of the sample (8 students) are first-year surveying students; therefore, they knew about surveying before or upon entering college.

We further examined the 15% (32 students) who indicated that they knew what surveying is, how they learned about surveying (Table 3). Professionals already working in surveying (whether they are related to students or not) or a friend who graduated from surveying, they add up to 28% of the responses. This indicates that efforts from within the profession and word-of-mouth marketing have a strong impact in acculturating students in surveying. In addition, 19% of the students learned about surveying from high school and another 22% from Penn State recruiting activities. Surprisingly, 13% indicated that they found out about surveying by searching on their own.

Surveying plays an extremely important role in many branches of engineering. For example, surveys are required to plan, construct, and maintain highways, railroads, buildings, bridges, tunnels, canals, dams, and urban land subdivisions.”

Updating student self-beliefs about surveying

The next series of questions in the online questionnaire aimed at helping students to understand the main characteristics of the surveying profession and update their self-beliefs about surveying. This is difficult to accomplish in a simple survey that takes 5 minutes to complete; therefore, we picked the main characteristics of surveying: working mostly outdoors, working with modern technology, involves math and problem solving, high level of job security, paid internships while studying, and entry level salary that can range from \$45k to \$65k. Note that the salary figures were derived from what our students typically get as starting salary in our region, although this is a figure that can greatly vary based on location, qualifications, and company.

Table 4. Questions related to the characteristics of the surveying major.

Question	Responses		
Where do you like to work?	Indoors – 30%	Outdoors – 10%	Both indoors and outdoors 60%
Do you like to work with modern technology?	Yes – 30%	No – 46%	Maybe – 24%
Do you like math and problem solving?	Yes – 35%	No – 29%	Maybe – 36%
Is job placement and security important to you?	Yes – 69%	No – 19%	Maybe – 12%
Would like to have a paid internship while studying?	Yes – 62%	No – 10%	Maybe – 28%
Typical salary for surveyors at entry level is between \$45k to \$65k. Is this satisfactory for you?	Yes – 41%	No – 17%	Maybe – 42%

Only 10% replied that they would like to work outdoors (Table 4), although 60% indicated that they would like to work both outdoors and indoors, which is something that the surveying profession can offer. It is likely that most graduating students will spend more time in the field than in the office; however, as they get more experience and they obtain their license in surveying, they will probably transition in the office environment in the role of a project manager. 30% indicated that they would like to work with modern technology and another 35% that they like mathematics and problem solving (Table 4). Surveying offers these aspects and recruiting efforts should emphasize on the modern aspects of surveying i.e., inclusion of fascinating technologies such as sUAS and laser scanning.

The next three questions focused on job placement and the monetary aspects of surveying. 69% of the students responded that job security is important for them, and 62% responded that they

would like to have a paid internship while studying. Both are important selling points for surveying, as the lack of surveyors has increased job security, and almost all students can find a summer internship. The latter is increasingly important as tuition costs and student debts rise. In addition, 41% of the students responded that they are satisfied with the entry salary for surveyors. For the salary question, despite the significantly lower median salary for surveyors compared to other engineering majors, very similar percentages for “yes”, “no”, and “maybe” were found for participating students who are following an engineering major, i.e., 42%, 16%, and 42%, respectively.

Note, that in each of those questions there was a short text explaining that surveying offers working both indoors and outdoors, uses modern technology such as drones, involves math and problem solving, has high job security, almost all students complete internships, and have offers of good paying jobs before even graduating. The hope was to educate participants about surveying and update their self-beliefs about surveying. This prepared the ground for the final question, which was “Would you have considered selecting surveying if you knew about it?”. This question was without doubt the most important question of the survey. The responses (Table 5) indicate that 13% would have selected surveying, 45% indicated “maybe”, and 42% indicated “no”. Although it is difficult to educate students about surveying in a 5-minute questionnaire, the responses are encouraging. Only eight of the responders (3.7%) were already surveying students; therefore, the 13% that indicated “yes” is very positive, as there are about 20 students (9.5%) who have not selected surveying, but maybe they would if they knew about it. In addition, the fact that 45% students answered maybe, shows a large potential pool of students. This could suggest that these students found something intriguing and maybe they would like to find out more about surveying. Their combination, $13\% + 45\% = 58\%$, shows an important potential to increase enrollment. This can be achieved with proper recruiting and marketing strategies in order to reach out to those students before college or during their first year.

Of the 13% that indicated “yes”, 78% are males and only 22% are females, which prompts us to discuss another important issue in surveying, the low number of female surveyors. According to the Bureau of Labor Statistics women working as surveying technicians were only 6.8% [37], and typically they are less than 10%. No data exist for surveyors past 2012, although in 2012 women working as surveyors was estimated to be 27.8% of the total surveying workforce [38],[39]. However, in the “maybe” responses, we find that 47% are female and 53% male. This shows a great potential for increasing women participation. Such students should be approached with information that considers women role models in surveying (e.g., guest speakers), provide additional incentives such as scholarships for women in engineering, and develop a strategy to attract more females in surveying engineering [40]. Particularly, making efforts to battle false perceptions that may still exist today, e.g., “females are not as good in math as males are” [41], or that engineering is less humanitarian [42]. In addition, white race consists 78% of those who responses “yes” and 67% of those who responded “maybe”. The national statistics indicate that 90% of surveying technicians are white (no data for surveyors) [43]; therefore, the percentages found on this study also indicate somewhat encouraging responses from non-white races.

Looking at the selected major, 44% of participants who indicated “yes” follow a non-engineering major or they are undecided, this percentage rises to 70% of participants who indicated “maybe”. This result suggests that students of any major may be interested in surveying, not exclusively engineering students. Therefore, reaching to those students and assisting them by taking advantage of existing programs related to women, racial minorities, and increasing participation in engineering would also enhance diversity.

Table 5. Participant responses in the question “would you have considered selecting surveying if you knew about it?”.

Response	Percentage
Yes	13%
No	42%
Maybe	45%

Engineering students can easily transfer from any Penn State campus to another in their first two years and before applying for entrance to major, which is usually done in their 3rd or 4th semester. At Penn State, general education courses in the first two academic years are very similar for most engineering majors, facilitating transferring between campuses and majors. However, for surveying engineering things are a little bit more complicated, as there are two fundamental surveying courses (one in the fall and one in the spring semesters) in the first academic year that are prerequisites for all other courses in the curriculum. This can make it a bit difficult for transfer students who have already completed a year at a Penn State campus. The surveying engineering program is in the process of updating its curriculum removing all surveying courses from the first academic year, and therefore reducing barriers of transferring into the program. In our previous study, we found that 30% of the students in the Penn State surveying programs were transfer students [12]. In combination with the results of this study, improving advising to identify students interested in surveying, and enhancing and facilitating student transferring can significantly enhance program enrollment.

Conclusions

Despite the rich history of surveying in the US and the important role of surveyors in the community, the profession is characterized by a low public profile. The limited number of accredited surveying programs in combination with the low awareness about surveying make it difficult for surveying programs to attract students into the profession and satisfy the industry demand for surveyors. This paper surveyed first-year students of any major at six Penn State campuses in order to understand their perceptions about surveying engineering.

The survey results highlight that 85% of the participants did not know about surveying before college, and that they had a general misconception that surveying engineering is about asking questions. This emphasizes the already stated problem that most students do not know what surveying engineering involves.

The survey also aimed at helping students to understand the main characteristics of the profession and help them update their self-beliefs about surveying. We focused on the following characteristics of the surveying profession: working mostly outdoors, working with modern technology, involves math and problem solving, high level of job security, paid internships while studying, and satisfactory entry level salary. Asking participants, after we provided the above information, whether they would have selected surveying if they knew about it, the responses were 13% “Yes”, 42% “No”, and 45% “Maybe”. While it is difficult to educate participants and change their perception about surveying in a 5-minute survey, the results are encouraging. There is a 13% that would have considered surveying if they knew about it, and another 45% that indicated “Maybe”. This suggests that there is a large pool of potential students that may be interested in surveying, but currently they do not have the necessary information. Improving communication and collaboration with the neighboring Penn State campuses could create new pathways for students who are interested to transfer in surveying engineering. In addition, the surveying program will need to make adjustments and create a new academic plan to facilitate student transferring without creating delays in graduation.

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