Discrepancies between Female Student Perception and Reality of the Engineering Industry

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Abstract

Demographic trends predict a shortage of engineers with women being one group being targeted to fill this gap. While the percentage of engineering degrees attained by women has increased, there has not been an equal increase in the number of women working in the industry. This means women are either leaving the industry after they enter or not entering at all. The purpose of this study is to identify what can be done in the education of female engineering students to better prepare them for the engineering workforce reality and culture. A survey was conducted to collected information from female architectural engineering students about their perception of the industry. The results were then compared to the actual conditions of the workforce. The goal is to identify areas of discrepancy between perception and reality so that these areas can be addressed before students enter the workforce. The hope is with a better understanding of their career environment, women will be better prepared to deal with the issues that may cause them to leave the industry.

Keywords: engineering; women; education; retention; survey

Introduction

Recent demographic trends have predicted a shortage of engineers due to the retirement of the baby boomer generation. Due to this shortage, women are one of the groups being targeted to fill the gap. Significant investment of resources have been dedicated to recruiting girls and young women to study science, technology, engineering, and mathematics (STEM) fields. In the United States, women currently make up almost 19% of all engineering students and 13% of engineering professionals (NSF, 2014). A study by Fouad, Singh, Fitzpatrick, and Liu from 2012 found that that 15% of the more than 3,700 women with engineering degrees surveyed never entered the engineering field after obtaining their degree. Additionally, a study by the Society of Women Engineers reports that from a survey of nearly 1,800 women with undergraduate or graduate degrees in engineering, one in four women who enter engineering left the profession after the age of 30, compared to only one in ten male engineers (SWE, 2007). With the amount of resources being put into recruiting women to engineering, it is worthwhile to identify why women are not being retained in the engineering field as professionals.

A common misconception is that women who leave engineering do so to focus on their family when in fact, a majority (67%) of women that leave engineering as a profession continue to work in another capacity (Fouad et al., 2012). This surfaces the question: why would a woman who has worked to attain an engineering degree and entered the profession chose to do something else? Research has been conducted to address this question with the technique of data collection primarily consisting of interviews of women that have stayed or left the engineering profession. Questions included in these interviews commonly relate to their satisfaction or dissatisfaction with the engineering workforce. There are many reasons and influences that result in women leaving the engineering profession with work climate being nearly universally

identified as a factor (Ayre, Mills, & Gill, 2013; Frehill, 2010; Servon & Visser, 2011; Keen 2010). Changes to workplace climate cannot be expected to be immediate as it will require education, a desire of the employers to change the work culture, and ultimately an impetus which may not occur until the shortage of engineers is truly experienced. Recognizing that changing the workplace culture to better retain more women engineers will require significant time, it is appropriate to invest attention and effort into addressing how to positively impact retention in the interim. An area not considered in other research that has the potential for much more expeditious implementation is ensuring that women are being adequately prepared for the existing workplace environment and culture during their college experience. This is not intended to be a question of technical competence, multiple studies have been conducted which exemplify that women students are as prepared, if not more prepared, technically than their male peers (Powell, Bagilhole, and Dainty, 2006; SHEFC, 1997). Preparation in this instance is readiness for the work culture and the alignment of expectations with reality.

The purpose of this study was to collect information from current female engineering students about their perception of the engineering industry. The data was then compared to data that represents the industry reality. This comparison was used to establish inconsistencies between the engineering students' perception of the engineering workforce and the reality. Experience beyond the formal classroom environment has also been factored into this study by tracking the number of engineering internships that participants had been employed. It was anticipated that internships with engineering companies inherently provided preparation through actual experience of the workplace culture. The goal of this study was to identify areas of discrepancy between perception and reality with the anticipation that these areas could be addressed as part of college curriculums therefore providing women more of the tools they need

before entering the engineering workforce and enabling greater persistence in engineering careers. The comparisons showed that the student participants had a fairly good understanding of what to expect within the industry when it came to topics that related to pay, hours of work, and workforce composition, but there were fairly large discrepancies in the areas of employment benefits, academic degree attainment, and professional engineering licensure.

Method

A survey was emailed to 70 female students, of which 51 elected to complete. Each participant was assigned an identification number used for tracking data instead of their name to protect the participant's identity. The participation was fairly evenly distributed among students at the different levels of study as displayed in Table 1. The demographic data also revealed that the number of internship experiences increased based on seniority in the curriculum (Table 2). This is expected since internships primarily occur during the summer months between academic years and the further the students are in their academic career the more opportunity they have for internships.

The method for collecting data consisted of an electronic survey. The survey was composed of 5 demographic questions, and 21 quantitative questions related to the participant's perception of the engineering industry. All questions were closed ended. The sample was made up of female students at a Midwest university enrolled in architectural engineering and was administered in the spring of 2015. The participants were asked to answer questions based on their knowledge of the architectural engineering industry, thus all comparisons are to architectural engineering workplace norms unless otherwise stated. Architectural engineering students were selected for this study because industry data was available from a prior research

study conducted by Keen in 2010 that could be used for comparison in a number of question topic areas. The results of the 21 survey questions related to the perceptions of the engineering industry were compiled. When possible, these responses were compared to answers from the 2010 research study by Keen that collected information from 59 female alumnae of the same Midwest university architectural engineering program that had been actively employed in the engineering profession for a minimum of five years. When topical areas were outside of that contained in the 2010 alumnae survey, alternate data sources were used for the baseline reference for reality.

Consistencies

The consistencies between what students expect and what they are likely to experience in the workforce are important. These areas need little additional emphasis or change in presentation in the form of education since it can be presumed that what is being done today is effective. It is also likely that these issues do not play a significant factor in women's decision to leave the profession once in the workforce since it is what they expected when entering employment. The survey identified three areas of consistency: pay, work hours, and workforce gender composition.

The first area of consistency is related to pay. The survey asked participants to identify the average starting salary and the average salary of an engineer with 10 years of experience from a close ended set of salary ranges. For the starting pay, a majority of participants (59%) said the average pay to be in the range of $46,000-$60,000. The actual starting salary averaged over the last five years at the Midwest university the participants attended is approximately $53,000 per the exit survey data collected by the department (R. Yunk, personal communication,

September 16, 2015), so most participants have an accurate impression of the starting salary of an engineer in the building design industry, as displayed in Table 3. The disconcerting thing about the results of this question is those that did not select the accurate pay range overestimated the starting pay. Having 41% of students overestimate the starting salary and 10% being in the $76,000-$90,000 range is worth highlighting because it has the potential to lead to disappointment immediately upon entry in the workforce or may influence the decision to not enter the workforce at all. A majority of participants (55%) said the average salary of an engineer 10 years into their career in the building design industry to be $76,000-$90,000 (Table 4). In reality, the salary averages are approximately $87,000 per data collected by the American Society of Mechanical Engineers in 2012, which falls within the range that a majority of participants chose. The responses outside the accurate range to this question are not as concerning since they equally include the higher and lower ranges of the pay spectrum. When broken down by number of years in school and number of internships, there was little change in answers for each experience level. Knowledge of starting and average pay in the building design industry does not seem to be affected by an increase in the amount of workforce experience. (Survey data from the 2010 study of alumnae by Keen was not used as the reality baseline for questions related to pay because the results contained salary data for both full time and part-time employment and also did not have enough respondents at 10 year experience to be considered valid for comparison).

Participants were asked in a close-ended question with specific hour ranges listed how many hours an engineer in the building design industry works on average per week (Table 5). Overall, a majority (51%) of participants chose 45-50 hours. 25% of participants chose 40-44 hours and 24% of participants chose greater than 50 hours. None of the participant chose less

than 40 hours. Based on the 2010 survey by Keen of 59 alumnae actively employed in the engineering workforce, the average hours worked per week was 46.9 hours. When the survey responses of the female students were broken down by numbers of years in school and number of internships, there was little change in answers for each experience level; therefore, knowledge of work hours does not seem to be affected by an increase in the amount of workforce experience.

Most of the survey participants had an accurate impression of the engineering industry in terms of workforce gender composition when asked to identify the appropriate range in a close ended question (Table 6). 74% of participants said the entire engineering industry consists of 10-30% women engineers and only 6% of participants were under the impression that women represented more than 30% of the industry. Realistically, women engineers make up around 13% of all engineers per the 2014 data collected by National Science Foundation. 74% of participants said the percentage of women engineers in engineering management or ownership positions was less than 10% and 96% of respondents believed women made up less than 30% of the leadership roles within companies (Table 7). In the engineering, science, and technology industry, women engineers make up about 9.6% of engineering management or ownership positions, based on a survey of nearly 2,500 women with training in these fields (Servon & Visser, 2010). A majority of the participants are aware of the makeup of the engineering industry and the role of women in engineering firms.

Discrepancies

There is value in exploring the inconsistencies between what female students expect from the building design industry and what they are likely to experience, because these inconsistencies may lead to disappointment or dissatisfaction with their employment. It may be possible that this

disappointment can be avoided if female students are better prepared and provided a clear idea of what to expect from their employer and work environment. Identifying discrepancies will allow for educators to incorporate topics to address such misconceptions as part of their curriculum. The three areas of greatest inconsistency are: employment benefits, academic degree attainment, and professional engineering licensure.

The survey question related to employer provided benefits resulted in both consistency and disparity between the student responses and what is seen in industry. This question asked the participants to identify from a list of benefits which are provided by the average engineering design firm. A majority of participants were able to recognize commonly provided benefits such as 401k and health/life/disability insurance. They also recognized benefits not commonly provided, such as daycare and paid paternity leave. The biggest misconceptions were the belief that paid maternity leave was commonplace and that flexible work hours, part-time work, and leave without pay were not. In reality, per the 2010 survey of women graduates of the architectural engineering program most of the companies to which there are employed do not provide paid maternity leave, while many do offer flexible work hours, part-time work, and leave without pay as displayed in Table 8. When data was further analyzed taking into account the number of internships held by participants, there was no major difference in response with the exception of the answers for flexible work hours. Flexible work hours was chosen as a common benefit by 22% of participants with 0 internships, 33% with 1 internship, 75% with 2 internships, and 67% with 3 internships. The significance of this response trend is that internships provide an opportunity for students to better understand some facets of the engineering work environment.

Participants were asked what the highest college degree they anticipated earning during their career - bachelor, master, doctorate, or other (Figure 1). The majority of the students in the

first two years of their college education had greater aspirations for degrees above a bachelor, but this diminished to less than 50% in year 3 and 4 with a large change to nearly all focused on only a bachelor degree in the 5th year. The fifth year is also the final year of the five-year architectural engineering curriculum at the Midwest university where this research was conducted, therefore the student anticipation of completion may influence their response to this question. The students identifying themselves as >5th year are also likely to have responses impacted based on their position in the curriculum as they are very nearly complete with their bachelor degree or working on their masters. Based on the 2010 industry survey of female architectural engineering professionals, 58% of respondents listed a bachelor's degree as their highest earned degree, with the other 42% listing master's or other which closely reflects the opinions of the 4th year students (Keen). A potential reason that degrees beyond a bachelor becomes less a priority as students advance in their degree progress can be attributed to their exposure to the industry through internships. For many of the disciplines pursued by architectural engineering graduates at this Midwest university, anecdotal evidence suggests that students may perceive that degrees beyond the bachelor are not rewarded financially by employers, with the exception of structural design in which less than 25% of the graduates pursue within the program used for this study.

The survey included a series of questions related to the professional engineering licensure. When asked their likelihood to earn a professional engineering license (P.E.), 86% of participants chose either an 8, 9, or 10 on a Likert Scale (10 being very likely), with only 1 out of 51 identifying a value below neutral on the scale (5 being neutral and values below this being unlikely), as shown in Figure 2. The survey also asked the participants if they believed engineers made more, less, or the same amount as an engineer with their P.E. 94% of participants believed that engineers with a P.E. earn more than engineers without a P.E., which is consistent with

industry. The 2010 industry survey of alumnae, all of which were of P.E. eligible female architectural engineers based on years of practice, 49% had earned their P.E. while the other 51% had not. Based on this comparison, it is clear that female architectural engineering students understand the value of the P.E. and plan to earn a P.E. in the future, but sometime after graduation women are deciding not to earn their P.E. This difference is interesting as it is unclear to what it is attributed and requires additional research to resolve.

Limitation and Future Research

As with all research, there were limitations to this study with the primary concern being its generalizability. Only a small sample of a single Midwest university's female students were surveyed from a single major, so the data collected may not accurately represent students from other universities or fields of engineering and the findings may not be unique to females. In addition to the collected data, the data sets used for comparison were also limited. The 2010 survey by Keen used as the basis for many of the comparisons was limited in the fact that it was also composed of only alumnae from this single university's curriculum and the data was collected 5 years prior. Since the comparison sets, Keen and others, spanned many years the data such as pay can be expected to fluctuate due to economic conditions or other influences therefore the baseline may not be accurate. In some instances data for comparison representing only the engineering profession did not exist and in those situations data also encompassing science and technology were included i.e. Servon and Visser, 2010. The fact that only women were included in this study does not allow conclusions to be drawn that limit the results to only females, i.e. male students may have similar misconceptions about the industry for which they are studying in college. Conducting simultaneous surveys of both male and female engineering practioners and

students could correct for many of these limitations and allow greater reliability and generalizability in the results and would be an appropriate next step. Also modifying the survey beyond multiple choice questions would allow participants to further explain their answers and provide enhanced depth and insight into the provided responses.

This study contained a limited set of questions asked of female college students that were selected based on questions used in prior survey research (Ayre, Mills, & Gill, 2013; Frehill, 2010; Servon & Visser, 2011; Keen 2010). This prior survey research was conducted with women who remained and choose to leave the profession in an attempt to identify the reasons women leave the engineering workforce. Basing the content of this study on these previously established focus areas may be considered a limitation since the questions may not encompass all of the issues or factors affecting a woman's decision to stay or leave the engineering workforce.

Conclusion

This study was meant to find discrepancies between female engineering students' perception of the engineering industry and its reality. From the results of this research, one can conclude that female architectural engineering students are well aware that they are entering into a male-dominated industry and what this looks like as far as the composition of the workforce. In most ways, these students are also prepared for the realities of the profession, including the work hours, compensation in the form of pay, and some of the provided benefits such as 401k, and health and disability insurance. This being said, there are some areas of fairly large discrepancy between what students anticipate and what is indicated as reality by industry professionals. The most prevalent difference appears in the areas of academic degree attainment, professional engineering licensure, and employment benefits including paid maternity leave, flexible work

hours, part time employment, and leave without pay. By identifying these discrepancies, the goal is to communicate this to those that prepare female engineering students for their future career as engineers and encourage incorporation of these topics into their curriculum. Although some fairly large differences were identified in this research, likely none are so great to alone be the reason women are not persisting in the engineering profession. This research contributes to the overall body of knowledge for the engineering profession because it identified that there are some misunderstandings of the engineering profession by female students preparing for their career that should be addressed before entering the workforce. The one particular area that deserves additional research is the low percentage of women that attain their professional engineering license, when they appear to see it as a professional goal before starting their career. This disconnect may provide valuable insight into the issue of retention of women in the engineering profession.

References

American Society of Mechanical Engineers. (2012). The Engineering Income and Salary Survey. Retrieved from https://www.asme.org/getmedia/788e990f-99f5-4062-801c-d2ef0586b52d/32673_Engineering_Income_Salary_Survey.aspx

Ayre M., Mills J., & Gill J. (2013). 'Yes, I do belong': the women who stay in engineering. Engineering Studies, 5(3), 216-232.

Frehill, L. M. (2010). "Why do people give up engineering? Surveys of men and women engineers tell an unexpected story". *Mechanical Engineering: The Magazine of ASME*.

Fouad, N. A., Singh, R., Fitzpatrick, M. E., & Liu, J. P. (2012). *Stemming the tide: Why women leave engineering* (National Science Foundation Grant # 0827553 Report). Milwaukee, WI: University of Wisconsin, Milwaukee.

Keen, J. (2010). Retention of women architectural engineers in industry (Doctoral dissertation). ProQuest Dissertations & Theses Global. (Order No. 3408129)

Milwaukee School of Engineering (2014). Architectural Engineering. Retrieved from http://www.msoe.edu/community/academics/engineering/page/1186/architectural-engineering-overview

National Science Foundation. (2014). *Women, minorities, and persons with disabilities in science and engineering* [Data Files]. Retrieved from http://www.nsf.gov/statistics/wmpd/2013/tables.cfm

Powell A., Bagilhole B., & Dainty A. (2006). The problem of women's assimilation into UK engineering cultures: can critical mass work? *Equal Opportunities International*, *25*(8), 688-699.

Servon, L., and Visser M. (2010). Progress hindered: The retention and advancement of women in science, engineering and technology careers. *Human Resource Management Journal*, *12*(3), 272-284.

Scottish Higher Education Funding Council (1997). (Winning Women: Access Guide). Edinburgh.

Society of Women Engineers. (2007). Where are all the women going? Engineering and science struggling to retain women in academia and industry. [Press release]. Retrieved from http://societyofwomenengineers.swe.org/images/PDFs/07releases/swe_oct18congressbrief.pdf

Table 1. Number of participants per year in college.

Year in University	Number of Participants
1	11
2	9
3	6
4	11
5	10
>5	4
Total	**51**

Table 2. Number of participants per number of internships related to engineering.

Number of Internships	Number of Participants
0	23
1	9
2	19
3	3
4	0
Total	**51**

Table 3. Survey results for an engineer in the building and design industry's starting salary.

Pay Range	% Responses	
<$46k	0%	**Reality**
$46k-$60k	**59%**	$52k
$61k-$75k	31%	
$76k-$90k	10%	
>$90k	0%	

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<$46k	0%	**Reality**
$46k-$60k	**59%**	$52k
$61k-$75k	31%	
$76k-$90k	10%	
>$90k	0%	

Table 4. Survey results for the pay of an engineer in the building and design industry that is 10 years into their career

Pay Range	% Responses	
<$46k	0%	
$46k-$60k	2%	**Reality**
$61k-$75k	18%	$87k
$76k-$90k	55%	
$91k-$105k	18%	
>$105k	8%	

Table 5. Survey results for average hours engineers work per week.

Hours	% Responses	
<40	0%	
40-44	25%	**Reality**
45-50	**51%**	46.9
>50	24%	

Table 6. Survey results to the question what percentage of engineers are women.

% Composition	% Responses	
<10%	20%	**Reality**
10-30%	74%	13%
31-50%	6%	

Table 7. Survey results to the question what percentage of engineering management or ownership positions belong to women engineers.

% Composition	% Responses	Reality
<10%	74%	9.6%
10-30%	22%	
31-50%	4%	
>50%	0%	

Table 8. Benefit expectation versus companies offering.

Provided Employment Benefit	**Survey Results** **(percent of participants who believed benefit to be commonly offered)**	**Industry** **(percent of engineering companies that offer benefit)**
Paid Maternity Leave	76%	37%
Flexible Work Hours	44%	77%
Part-time Work	24%	53%
Leave Without Pay	30%	67%

Fig. 1. Participant's answers when asked about the highest degree they anticipate earning, sorted by participant's year in college.

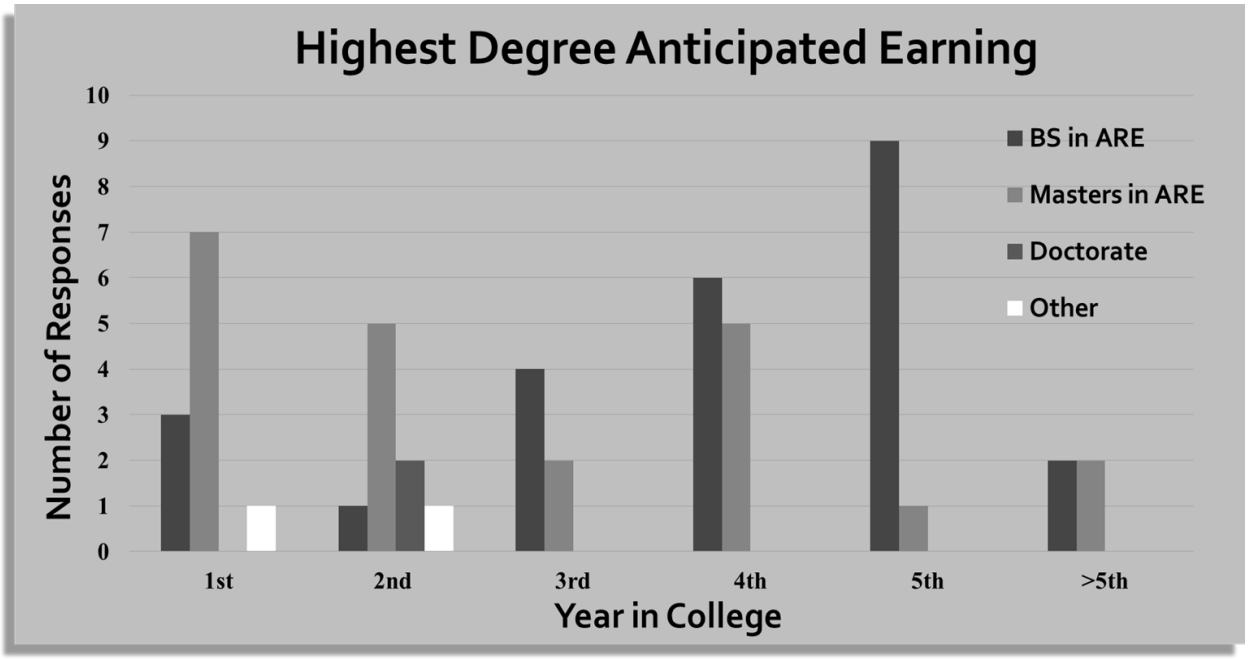

Fig. 2. Participants' likelihood to earn a professional engineering license based on a Likert scale, with 1 being very unlikely and 10 being very likely. 86% of participants chose 8, 9, or 10.