Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 228 (2016) 222 – 228

Procedia
Social and Behavioral Sciences

2nd International Conference on Higher Education Advances, HEAd´16, 21-23 June 2016, València, Spain

Career Choice of Undergraduate Engineering Students

Hagit Mishkin[a]*, Niva Wangrowicz[b], Dov Dori[b,c], Yehudit Judy Dori[a]

[a] *Technion-Israel Institute of Technology, Faculty of Education in Technology and Science, Technion City, Haifa, Israel*
[b]*Technion-Israel Institute of Technology, Faculty of Industrial Engineering and Management Technion City, Haifa, Israel*
[c]*Massachusetts Institute of Technology, Cambridge, MA, USA*

Abstract

Choosing engineering as a profession has traditionally not been a top priority among women. Based on the theory of planned behavior (TPB), choice is contingent upon attitudes, subjective norms, and perceived behavioral control, all of which influence behavior. Our research aimed at determining whether the frequencies of these three factors are the same or different among women and men choosing engineering careers. We examined the set of three TPB factors for 330 undergraduate engineering students majoring in information and systems engineering and computer science. We asked the students what had led them to choose a future engineering career. Analyzing each response for recurring TPB factors and sub-factors, which were identified and validated, we found that undergraduate female students who did not express the attitudes factor in their statements are influenced by the subjective norm factor more than men. At a higher resolution, women are significantly more influenced than men by other people. Our study contributes to advancing our understanding about gender-dependent career choice by exploring factors and sub-factors that expand on TPB. These factors and sub-factors can serve researchers interested in developing tools for encouraging women to choose and retain STEM careers.

Keywords: Engineering; Gender; Career choice; Attitudes; Norm; Perceived behavioral control

* Corresponding author. Tel.: +972 77-887-5555
E-mail address: hagit.re@gmail.com

doi:10.1016/j.sbspro.2016.07.033

1. Subject and Problem Statement

Increasing demand for science, technology, engineering, and mathematics (STEM) careers in the labor market is in contrast to the lack of undergraduate students who pursue careers in these areas (NAS, 2010; NRC, 2012). This shortage is due to the decline of interest in and choice of STEM domains in both higher education and industry (Xie & Achen 2009; Riegle-Crumb et al. 2011). In particular, women have shown decreased interest in STEM careers, and subsequently, fewer women enter STEM careers (Hazari et al. 2010; Sadler et al. 2012). In our country, the proportion of women who choose to study engineering at the undergraduate level is below 15% (CBS data, 2012). Women tend to complete degrees in the humanities, social professions, education, and health, while men are more inclined towards professions in mathematics, science, and engineering (Sikora & Pokropek, 2012). Carlone et al. (2015) show that girls were more concerned with figuring out "what kind of girl to be" and less engaged with how to become "scientific". The phenomenon of referring or guiding students to specific domains is based on a stereotyped concept of the division of responsibilities between men and women. Although there have been many positive changes in the status of women in higher education and employment, some professions are still perceived as "manly" (Zohar & Sela, 2003; Teshner, 2014). Thus, in order to ensure the integration into and retention of women in STEM careers in general and engineering career in particular, it is necessary to tackle the decline of interest in, and choice of STEM disciplines, and especially of engineering, amongst women pursuing higher education.

2. The Theory of Planned Behaviour

In his theory of planned behaviour (TPB), Ajzen (1986; 1991) claimed that interest and choice is a result of decision-making processes, which depend on motivation as reflected in the intention to choose to engage or not engage in a behaviour. In this process, attitudes, subjective norms, and perceived behavioural control are considered motivational factors. These factors, when combined together, influence one's choices and behaviours. The degree to which a person displays a positive or negative evaluation towards performing a particular behaviour is considered one's attitude. A subjective norm is a social factor that refers to the perceived social pressure to perform or avoid performing a particular behaviour. Subjective norms represent extrinsic motivation (Ajzen 1986; 1991). An individual's perception about his/her particular behaviour is influenced by the judgment of significant others, such as parents, spouses, friends, and teachers (Amjad & Wood, 2009). Finally, perceived behavioural control refers to one's perception of his/her own ability to perform a behavior based on his/her past experiences, as well as on anticipated challenges and obstacles.

3. Women's career paths

Career trajectories differ between men and women (Liff & Ward, 2001); a woman's trajectory tends to be more influence by pre-defined societal roles, relationships, and responsibilities. Traditionally, a woman's role in society has been defined by husband's career(s), bearing and raising children, and caring for elderly family members; as such women are traditionally regarded as primary care-givers. Given these social assumption about women's roles, women are more likely to experience career disruptions due to these and other family responsibilities (Ackah & Heaton, 2004). Women's careers are also shaped by the male work culture (Liff & Ward, 2001). Some male-held stereotypes, such as the preconception of women's roles and abilities (Metz, 2005; Clarke, 2011), lack of ability to obtain mentoring, relative under-representation of women in higher level positions in organizations (Burke et al, 2005), and failure of senior management to take responsibility for women's promotions (Lyness & Thompson, 2000) are factors that impact a woman's career progress (Lyness & Thompson, 2000).

4. Role models

Role models are individuals that people want to follow or imitate, based on their attitudes, qualities, and choices (Shapiro et al, 1978). Metz (2005) and Craighead and Nemeroff, (2004) referred to four modeling stages: observation, interpretation, motivation, and performance. For decades, the use of role models has been proposed as a potentially powerful technique to influence more talented young women to pursue science-related careers.

Researchers showed that both men and women students are positively affected when they encounter women role model in science (Fox, 1981; Guthrie & Zusman, 1982; Smith & Erb, 1986). Exposure to role models can be achieved by incorporating career education into regular instruction, for example informing students about careers in science-related fields, and reading stories about women in nontraditional careers (Greene et al, 1982). Exposure to role models may help early adolescents see themselves as scientists or engineers (Smith & Hausafus, 1998). Impacts of role models were significantly related to educational aspirations and STEM-related career choices (Hackett et al, 1989).

In order to understand how women can be encouraged to choose a career in engineering, the goals of this study were to identify women's reasons for choosing to study engineering and to determine whether the frequencies of the three TPB factors—attitudes, subjective norms, and perceived behavioural control—differ among undergraduate female and male students who choose engineering careers.

5. Design and Procedure

This chapter describe the research design and procedure.

5.1. Research questions

The two research questions derived from this goal were the following; 1. Are there differences by gender in the extent of using each TPB factor and sub-factor in participants' explanations to their career choice?; 2. Are there significant relations between choosing one TPB factor and another by male and female students?

We conducted the research in an engineering department at a research university. The research population included 330 undergraduate engineering students during three consecutive semesters. About half (N=158) of these students were women and about half had a job in addition to their studies (N=179; 77 women and 102 men). The students' ages ranged from 21 to 35, averaging 25.75 years (SD=2.12).

5.2. Research tool

The research tool was an open-ended questionnaire, which included the following three questions: (a) What specific event or events (if any) led you to choose engineering education and a future career in engineering? (b) Was there a person who led you to choose engineering as a future career? (c) If there was no specific event or person, please describe the reasons for your career choice.

5.3. Research design

For each one of the three TPB motivation factors–attitudes, subjective norms and perceived behavior control–we identified and validated two main sub-factors, listed in Table 1. These sub-factors are based on pertinent literature. Four judges who are experts in science education and motivation theories validated the factors and sub-factors by classifying the same 40 responses as belonging to one of the six sub-factors. Inter-rater reliability analysis using the Kappa statistic value is 0.95, S.E: 0.47, $p<.001$.

Table 1. Motivation factors and Sub-factors based on TPB

Sub-factors	Related sub-factors from the literature	Examples from questionnaires
Attitudes toward the behavior stemming from intrinsic motivation		
PE - Prior experience includes: prior experience at young age, prior experience before choosing studies, and interactions at work	"Like school"(Riegle-Crumb et al, 2011b, p.466). "Experiences as an engineering student" (Barnard et al, 2012, p.200). "Interactions at work" (Brown, et al, 2012 p.756).	83.2.S13.F. *"My Mom says that since I was a little girl ...... my hobby was to solve problems and mathematical logic puzzles"* 2.76.S13.F *" …This job got me interested in the field of information systems and helped me understands the depth and challenge and I even like it."*
IE - Interest & enjoyment	"Want a Career in science", "Science enjoyment" (Riegle-Crumb et al., 2011b p. 466) "Interest" (Bhattacharya, 2015),	2.1.W13.M. *"Industrial engineers work with people and not at a computer all day, it appealed to me"* 60.3.W14.M*"I was more attracted to areas related to STEM."*
Subjective norms		
IO - Influence by others, includes: parents, family members, friends, or colleagues	"Parent education" (Riegle-Crumb et al., 2011 p.466)	94.3.W14.F. *"I got a recommendation from my big brother who studied Electrical Engineering at the university."* 49.2.S13.M. *"I consulted with engineers from different disciplines."*
PC - Prestige, family and financial considerations	"Future Career Self", "Future Personal Self "(Buday et al., 2012 p. 201)	68.1.W13.F. *"I knew that this university is a serious and prestigious institution."* 2.2.S13.M. *"I chose industrial engineering because I wanted to learn a trade that will open for me a wide range of employment opportunities."*
Perceived behavior control		
LI - Limitations		68.3.W14.F. "Industrial Engineering and Management was my second option with Computer Science (CS) being first. I chose Industrial Engineering and Management because I knew there was a chance I could not get accepted to (CS)." 56.3.W14.M. "[I chose my major by]… by ruling out other study programs."
SE - Self-efficacy	"Science self-concept", Science test scores" (Riegle-Crumb et al., 2011 p.466), "Science self-confidence" (Buday et al., 2012 p.201), "Math ability" (Wang et al., 2013 p. 772)	1.1.W13.F. *"As I knew about the profession before school, I thought it could fit my STEM abilities."* 11.2.S13.M. *"I began to study towards information systems engineering degree, not really knowing what I want to learn …Pretty soon I realized it was not for me and industrial management is sounds more generally, so I thought it might suit me more."*

6. Findings and Analysis

We classified all the students' statements into one of the six TPB sub-factors and compared their amount by gender. As Figure 1 shows, attitudes was the main factor that both female and male undergraduate students expressed in response to questions regarding their reasons for their career choice. As Figure 2 shows, within the attitudes factor, interest & enjoyment (IE) was the major contributing sub-factor.

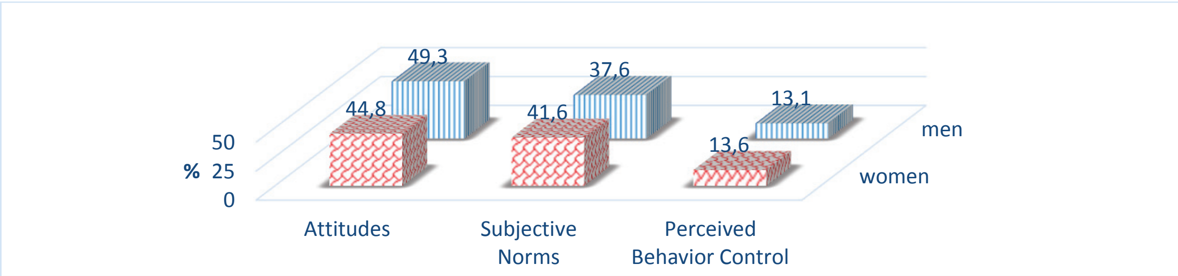

Fig. 1. Undergraduate students' motivational factors by gender (N Students = 330 N Stetment=636)

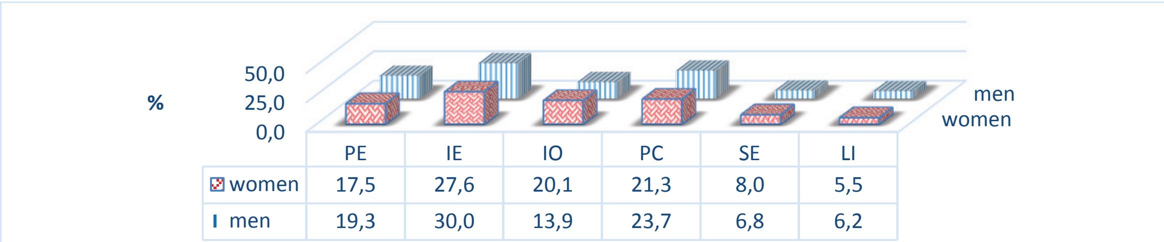

Fig. 2. Undergraduate students' motivational sub-factors by gender (N Students = 330 N Stetment=636)

7. Factors and sub-factors by gender

We used a *t*-test to compare differences in TPB factors by gender in order to answer the first research question. There was borderline significant difference in *subjective norms*, $t(311.80) = 1.79$, p =.07, between women (M = .91, SD = .97) and men (M = .73, SD = .84). There was no significant difference in *attitudes* and *perceived behavior control* between women and men. These results indicate that female students use more *subjective norms* than men to explain their career choice. In order to find out the source of the differences, we conducted another *t*-test in which we compared the TPB sub-factors by gender. The results indicate a significant difference in *influence by others(ID)*, $t(303.22) = 2.43$, $p < .05$, between women (M = .44, SD = .69) and men (M = .27, SD = .56). There was no significant difference between women and men within any other sub-factor. Thus, to explain their career choice, female students indicated that the *influence by others* sub-factor (within the *subjective norms* factor) was more influential to their career choice than male students.

In order to identify the types of career choosers, in response to research question 2, and to determine whether there were significant relation between choices (y/n) of TPB factors, we used a Chi square test for each factor couple, namely *attitude-subjective norms*, *attitude-perceived behavior control*, and *subjective norms-perceived behavior control* for male and female students separately. For males, the Chi squared analysis showed a significant relation between the use of *attitudes* and *subjective norms*, $\chi^2(1) = 13.57$, $p < .001$. This implies that *attitudes* based decisions were associated with not using *subjective norms* and vice versa. The same test also indicated significant relation between the use of *attitudes* and *perceived behavior control*, $\chi^2(1) = 8.55$, $p < .005$, i.e., using attitudes was associated with not using *perceived behavior control*. No significant relation was found between the use of the *subjective norms* and *perceived behavior control*, $\chi^2(1) = .46$, $p > .05$. For females, the Chi squared analysis also produced a significant relation between the use of *attitudes* and *subjective norms*, $\chi^2(1) = 22.58$ $p < .001$. Not using *attitudes* was associated with using *subjective norms*. No significant relation was found between the use of the *attitudes* and *perceived behavior control*, $\chi^2(1) = 1.3$, $p > .05$. No significant relation was found between the use of the *subjective norms* and *perceived behavior control*, $\chi^2(1) = .10$, $p > .05$. Table 2 presents the distribution of *attitudes* by *subjective norms* and the Chi square results for men and women. As we can see, the trend to use *subjective norms* is consistent with not using *attitudes* in both men and women, but in the women's group this tendency is more pronounced.

Table 2. Chi square analysis between attitudes and subjective norms by gender

	Men - χ^2 (1) = 13.58, p=0.00		**Women - χ^2 (1) = 22.58, p=0.00**	
	(+) Subjective Norms	(-) Subjective Norms	(+) Subjective Norms	(-) Subjective Norms
(+) Attitudes	43.4%	56.6%	46.6%	53.4%
(-) Attitudes	72.9 %	27.1 %	85.5 %	14.5 %

8. Discussion and Contribution

Undergraduate female students who did not express the attitudes factor in their statements are influenced by the subjective norm factor more than men: 85.5% vs. 72.9% (see Table 2). At a higher resolution, when analyzing sub-factors by gender, we found that women are significantly more influenced than men by others: 43.2% vs. 22.7%. These two results indicate that women who do not display attitudes towards engineering education, can be more influenced by the subjective norms factor. Therefore, exposing young women to role models may positively influence their attitudes toward choosing a career in engineering (Hackett et al., 1989). Our findings regarding female students being more influences by others is in line with the literature that indicates that role models may help early adolescents identify themselves as practicing scientists, engineers or mathematicians in the future (Smith & Hausafus, 1998). Women role models influence more talented young women to pursue science-related careers, (Fox et al., 1977; Smith & Erb, 1986), and women need encouragement in pursuit of their STEM trajectories (Tan, et al., 2013). In general, gender and social class influence persistence in STEM fields (Wilson & Kittleson, 2013). Therefore, we recommend that women be exposed to role models of women in STEM from an early age in order to foster women to engage in engineering studies and careers. Our findings contribute to advancing the theory related to the relationship between gender and career choice by exploring gender-differentiating factors and sub-factors that expand on the theory of perceived behavior. At the practical level, this research can provide a basis for encouraging women to choose engineering education and careers via a more elaborate version of our tool for assessing and analyzing motivation factors. The factors and sub-factors we have identified that are involved in the decision-making process of choosing to learn and specialize in engineering can serve interested parties in encouraging women to choose and retain engineering careers.

Acknowledgment

This work was partially funded by (1) the Gordon Center for Systems Engineering at the Technion, and (2) the Technion Doctoral Fellowships.

References

Ackah, C., & Heaton, N. (2004). The reality of “new” careers for men and for women. *Journal of European Industrial Training*, *28*(2/3/4), 141–158.

Ajzen, I. (1986). Prediction of Goal-Directed Behavior : Attitudes , Intentions , and Perceived Behavioral Control, *474*, 453–474.

Amjad, N., & Wood, A. M. (2009). Identifying and changing the normative beliefs about aggression which lead young Muslim adults to join extremist anti-Semitic groups in Pakistan. *Aggressive Behavior*, *35*(6),

Barnard, S., Hassan, T., Bagilhole, B., & Dainty, a. (2012). “They”re not girly girls’: an exploration of quantitative and qualitative data on engineering and gender in higher education. *European Journal of Engineering Education*, *37*(2), 193–204.

Bhattacharya, S. (2015). A Study on the Higher Education System in India and Factors Affecting the Choice of Teaching Career in IT Education. *Mediterranean Journal of Social Sciences*, *6*(4 S1), 62.

Brown, A., Bimrose, J., Barnes, S.-A., & Hughes, D. (2012). The role of career adaptabilities for mid-career changers. *Journal of Vocational Behavior*, *80*(3), 754–761.

Buday, S. K., Stake, J. E., & Peterson, Z. D. (2012). Gender and the choice of a science career: The impact of social support and possible selves. *Sex Roles*, *66*(3-4), 197–209.

Burke, R., Vinnicombe, S., O'Neil, D. A., & Bilimoria, D. (2005). Women's career development phases: Idealism, endurance, and reinvention. *Career Development International*, *10*(3), 168–189.

Carlone, H. B., Johnson, A., & Scott, C. M. (2015). Agency amidst formidable structures: How girls perform gender in science class. *Journal of Research in Science Teaching*, *52*(4), n/a–n/a.

Clarke, M. (2011). Advancing women's careers through leadership development programs. *Employee Relations*, *33*(5), 498–515.

Craighead, W. E., & Nemeroff, C. B. (2004). *The concise Corsini encyclopedia of psychology and behavioral science*. John Wiley & Sons.

Fox, L. H. (1981). Career Development of Gifted and Talented Women. *Journal of Career Education*, *7*(4), 289–298.

Fox, L. H., Fennema, E., & Sherman, J. A. (1977). *Women and mathematics: Research perspectives for change*. US Department of Health, Education and Welfare, National Institute of Education, Education and Work Group.

Greene, A. L., Sullivan, H. J., & Beyard-Tyler, K. (1982). Attitudinal effects of the use of role models in information about sex-typed careers. *Journal of Educational Psychology*, *74*(3), 393.

Guthrie, J. W., & Zusman, A. (1982). Teacher supply and demand in mathematics and science. *Phi Delta Kappan*, 28–33.

Hackett, G., Esposito, D., & O'Halloran, M. S. (1989). The relationship of role model influences to the career salience and educational and career plans of college women. *Journal of Vocational Behavior*, *35*(2), 164–180.

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, *47*(8), n/a–n/a.

Liff, S., & Ward, K. (2001). Distorted views through the glass ceiling: the construction of women's understandings of promotion and senior management positions. *Gender, Work & Organization*, *8*(1), 19–36.

Lyness, K. S., & Thompson, D. E. (2000). Climbing the corporate ladder: do female and male executives follow the same route? *Journal of Applied Psychology*, *85*(1), 86.

Metz, I. (2005). Advancing the careers of women with children. *Career Development International*, *10*(3), 228–245.

Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011a). Who wants to have a career in science or math? exploring adolescents' future aspirations by gender and race/ethnicity. *Science Education*, *95*(3), 458–476.

Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011b). Who wants to have a career in science or math? exploring adolescents' future aspirations by gender and race/ethnicity. *Science Education*, *95*(3), 458–476.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411–427.

Shapiro, E. C., Haseltine, F. P., & Rowe, M. P. (1978). Moving up-role models, mentors, and patron system. *Sloan Management Review*, *19*(3), 51–58.

Sikora, J., & Pokropek, A. (2012). Gender segregation of adolescent science career plans in 50 countries. *Science Education*, *96*(2), 234–264.

Smith, F. M., & Hausafus, C. O. (1998). Relationship of family support and ethnic minority students' achievement in science and mathematics. *Science Education*, *82*(1), 111–125.

Smith, W. S., & Erb, T. O. (1986). Early adolescents ' attitudes toward scientists and women in science, *23*(8), 667–676.

Tan, E., Calabrese Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching*, *50*(10),

Wang, M.-T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science*, *24*(5), 770–775.

Wilson, R. E., & Kittleson, J. (2013). Science as a classed and gendered endeavor: Persistence of two white female first-generation college students within an undergraduate science context. *Journal of Research in Science Teaching*, *50*(7), 802–825.

Xie, Y., & Achen, A. (2009). Science on the decline? Educational outcomes of three cohorts of young Americans. *Population Studies Center Research Report*, *9*, 684.

Zohar, A., & Sela, D. (2003). Her physics, his physics: Gender issues in Israeli advanced placement physics classes. *International Journal of Science Education*, *25*(2), 245–268.