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The Influence of Beliefs and Gender on Choosing, and Feeling Like You Belong in Engineering

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Abstract

After decades of research and interventions, the gender gap in STEM fields has narrowed, and even closed in some sub-fields, such as the life sciences. This trend toward gender parity has plateaued, however, in engineering. Efforts to encourage young women to study engineering often portray the field as affording opportunities for collaboration and helping others. The success of such efforts rests, arguably, on the accuracy of the assumption that women value these qualities in a career. It also depends on the degree to which women's perceptions of the field of engineering reflect this portrayal. For the present study, measures of career motivation, beliefs about the field of engineering, and beliefs about the self were administered to first-year engineering students. The results suggest that this strategy for drawing more women into engineering aligns well in some ways, and not in others, with the motivations and beliefs of young engineering students.

Keywords: gender-gap; STEM; engineering; field-specific beliefs; math self-concept; belonging; academic fit

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The Influence of Beliefs and Gender on Choosing, and Feeling Like You Belong in Engineering

In both post-secondary education, and the workforce, there is a persistent gender gap, favouring men, in science, technology, engineering, and math (STEM) fields overall (Dionne-Simard, Galarneau, & LaRochelle-Cote, 2016; National Science Foundation, 2014). After decades of research and interventions focused on this issue (see Kanny, Sax, & Riggers-Pieh, 2014), this gap has closed, or even reversed somewhat, in certain STEM fields, such as biology and mathematics (Cheryan, Ziegler, Montoya, & Jiang, 2017; Dionne-Simard et al., 2016; National Science Foundation, 2014). The increase in female representation appears to have plateaued, however, in other STEM fields, including engineering, in which fewer than 25% of undergraduate degrees are earned by women (Cheryan et al., 2017; Dionne-Simard et al., 2016; National Science Foundation, 2014). This disparity, coupled with a projected shortage of engineers in general, has prompted extensive efforts at encouraging more young women to pursue education in engineering. Recruitment programs aimed at drawing more women into the field of engineering often include some version of the message that engineering careers provide opportunities for collaboration and helping others (Corbett & Hill, 2015; National Academy of Engineering, n.d.). A good example of this can be found at *engineergirl.org*, a website created by the National Academy of Engineering to promote engineering as a viable career choice to American and Canadian girls, which includes a page titled *Why should I become an engineer.* Of the five points on this page, the first states that by becoming an engineer, “You’ll have the power to make a difference”… and “help solve problems that are important to society.” The second point states that “You’ll be working with other talented people”… and “engineering is a team effort.” These types of messages appear to be based on the assumption that females are more likely than males to be motivated to pursue collaborative, *helping* careers (Diekman et al., 2017; Su, Rounds, & Armstrong, 2009), and aimed at combatting the perception that engineering, like other STEM fields, does not provide opportunities to work with or help others (Diekman et al., 2010; Lips, 1992; Morgan, Isaac, & Sansone, 2001; Weisgram, Bigler, & Liben, 2010). Research does suggest that people tend to express greater motivation to enter careers they believe to be more collaborative and focused on helping people, as opposed to those offering little opportunity to work with or help others (Brown, Thoman, Smith, & Diekman, 2015; Duffy & Sedlacek, 2007), and that this preference is greater for women than it is for men (Buser, Niederle, & Oosterbeek, 2014; Diekman et al., 2010; Freund, Weiss, & Wiese, 2013; Konrad, Ritchie, Lieb, & Corrigall, 2000; Wang & Degol, 2017), so the portrayal of engineering as a field in which there are opportunities to collaborate and help others might be an effective recruiting strategy. What is less clear, however, is the degree to which this gender-difference pattern in preference for fields offering opportunities for collaboration and helping others applies to the women who *do* pursue STEM careers. Do some women enter a field even if they believe it doesn't provide their desired opportunities for collaboration and helping others? Do they believe that, despite stereotypes to the contrary (Diekman et al., 2010; Lips, 1992; Morgan et al., 2001; Weisgram et al., 2010), these fields *do* involve helping and collaboration? Or, are some women the exception to gender expectations, in that they are no more driven by a desire to collaborate and help people than are their male colleagues? If some individuals hold ambivalent –or even negative– attitudes toward teamwork and/or helping others, they might, arguably, not be swayed by these types of recruitment messages. For those whose career choice *is* motivated by its affordances for collaboration and helping others, experiences in the field of engineering that align well with encouraging messages received during the recruitment process might well bolster affinity for the field. It has been argued that STEM fields often do, in fact, offer opportunities to collaborate and benefit society (Waldman & Terzic, 2010; Woolf, 2008). There is some evidence, on the other hand, that students who are initially attracted to engineering based on these messages, once exposed to the field, sometimes get the impression that engineering is not the collaborative, helping profession they were led to believe it would be, and might feel that they do not belong, and perhaps even leave in favour of a career with a better fit (Brown et al., 2015; Cheryan et al., 2017). If so, this could exacerbate the "leaky pipeline" problem (see Xie & Shauman, 2003), by contributing to the loss of women engineers at increasing levels in the education and career paths.

Social Cognitive Career Theory, Person-environment Fit, and Communality

The social cognitive perspective has long been applied in attempts to understand why some fields of work attract fewer women than others. Bandura's self-efficacy theory (1986) was offered as an explanation for these disparities by Hackett and Betz, who, in their 1981 study, found that college women had lower self-efficacy for skills required in traditionally male vs. traditionally female occupations, especially when it comes to math skills. Lent, Brown, and Hackett (1994) further refined this idea into what is known as Social Cognitive Career Theory (SCCT), which posits that self-efficacy and outcome expectations combine in the development of interests, which in turn lead to career choices. Researchers have continued to build upon the SCCT framework in their attempts to better understand the causes of gender disparities in STEM fields (Fouad &

Santana, 2017).

Others have framed their research around the concept of person-environment fit. Person-environment fit refers to the way in which behavior is determined by an interaction between personality and environment (Holland, 1997), or more specifically, as an interaction between an individual and a work environment in which each has requirements of the other, such that the motive of work behavior is to try to achieve and maintain this balance (Dawis & Lofquist, 1984). A recent line of research expanding on the concept of person-environment, or person-job fit, employs Goal-Congruity theory, which posits that individuals will seek out a career that they perceive will fulfil the goals that they value (Brown et al., 2015). Applying goal-congruity theory to the motivation to pursue opportunities affording *communality* or *communion,* (i.e., an orientation to care about other people; Bakan, 1966), Brown et al. (2015) hypothesized that the degree to which STEM careers are perceived as affording communion would be associated with greater STEM career interest. Results from a series of studies conducted to test this notion, which they referred to as the Communal Affordance Hypothesis, suggested that for individuals higher in communal value orientation, communal affordance beliefs about STEM fields are related to motivation to pursue those fields. Similarly, in their 2010 study, Diekman et al. found that an individual's endorsement of communal goals predicted interest in STEM careers above and beyond measures of self-efficacy for skills required in STEM fields, such as math, and that individuals who strongly endorsed communal goals tended to be less interested in STEM careers. This incongruity between goals and beliefs about the affordances of STEM careers, including engineering, is likely to influence women more often than men, given the evidence that women tend to, on average, more strongly endorse such goals. A large survey of over 30,000 first-year college students, for example, revealed that women placed higher importance on working with people and contributing to society, while men tended more so to endorse economic motivations (Duffy & Sedlacek, 2007).

One component of this concept of communality, working collaboratively with others (or teamwork), deserves particular attention in the context of the field of engineering. Over the past several decades, the emphasis on team-based work has increased across almost all fields, and engineering is no exception. In response to this trend toward team-based work, engineering educational programs now commonly include some component of team-work experience and skill-building in their curricula (Froyd, Wankat, & Smith, 2012). If women are more likely to seek out and thrive in collaborative environments, positive teamwork experiences in undergraduate engineering programs could help to attract and retain female students. In order to evaluate this impact, however, an understanding of how female engineering students tend to regard teamwork, both at the outset of their education, and after engaging in these teamwork opportunities, is needed. Hartman and Hartman (2006) investigated this issue in an engineering program at an American university which included a mandatory team-based project course. The goal of the study was to determine how gender might influence attitudes toward teamwork, and whether these attitudes changed in response to participating in the teamwork components of the program. At the outset of the program, women held somewhat more positive attitudes about team-based learning than men. After a year of participating in the team-based project course, however, the gender difference in teamwork attitudes was close to eliminated, due to the average regard for teamwork *decreasing* in women. Interestingly, women in the sample whose team included at least one other female, tended to become more positive about teamwork, a reaction in the opposite direction of the overall trend for women in the study. They also found that a positive regard for teamwork related to a stronger sense of community and pride as an engineering student, and to the quality of relationships with peers; a finding that led them to conclude that this relation could be reciprocal (Hartman & Hartman, 2006). These results suggest that, in an engineering student setting, attitude towards teamwork might be influenced by gender, and might relate positively to a sense of social belonging, both of which are important factors to consider in better understanding the experiences of female engineering students.

Field-Specific Beliefs Regarding Innate Talent

Of particular relevance to the idea of person-environment fit, are people's beliefs about what contributes to success in different careers. One factor theorized to contribute to the lack of female participation in certain fields is the belief that success in these professions requires innate ability. A study conducted by Meyer, Cimpian, and Leslie (2015) showed that lay people's impressions of the degree to which success in a given career requires innate ability, and thus is not attainable through hard work alone, correlated with gender distribution in careers. Specifically, those careers thought to require innate ability are disproportionately filled by men. When asked to consider a list of professions, and indicate which require innate ability and which can be accomplished through hard work, both lay people and those with exposure to the fields in question tended to give answers that align with gender representation (Meyer et al., 2015). Interestingly, this "innate ability" distinction better aligned with gender distribution across various sub-fields than did the broader (and typically assumed) STEM vs. non-STEM categorization. Specifically, it better reflected some careers in each category, such as earth sciences and philosophy, that do not fit with the assumption that STEM is male dominated, and the humanities are female-dominated. Beliefs about the innate ability required for success in a field held by those with college exposure to that field, were shown to predict gender distribution even more accurately than the beliefs of those with no exposure. From these results, the researchers concluded that exposure to a field might serve to further refine beliefs about the innate ability it requires, in a pattern that further reinforces gender distributions (see Meyer et al., 2015). Presumably, if students with such exposure to a field do not see themselves as possessing this innate ability, they could become *more* likely to feel that they do not belong, and *less* likely to persist in their studies. Two possible indications that women tend not to see themselves as possessing such innate talent are as follows. Research has suggested that female undergraduate students might be 1) less likely to *believe* that they are talented at math, despite evidence that they are no lower than men in math performance (Ackerman, Kanfer, & Beier, 2013; Ellis, Fosdick, & Rasmussen, 2016; Sax, 2008), and 2) more likely to believe that they are exerting more effort than their peers in order to be successful (Smith, Lewis, Hawthorne, & Hodges, 2013). Relatedly, female engineering students have been found to be more likely than male students to believe that engineering aptitude is a fixed entity rather than a skill that can be developed (Heyman, Martyna, & Bhatia, 2002, as cited by Sax, Kanny, Jacobs, Whang, Weintraub, & Hroch, 2016), and to attribute their own poor performance in engineering courses to lack of ability as opposed to lack of hard work or unfair treatment (Felder, Felder, Mauney, Hamrin, &

Dietz, 1995, as cited by Sax et al., 2016). Holding the incongruent beliefs that one is lacking in natural ability, and that engineering requires innate talent, could make the prospect of studying engineering less desirable. This is especially troublesome given the evidence that the gap in self-reported abilities, with women reporting lower ability levels than men, might grow over time spent in engineering school (Cech, Rubineau, Silbey, & Seron, 2011, as cited by Sax et al., 2016). This potential mismatch between beliefs about the field, and self-perceptions, could pose a problem for the recruitment and sustained participation of women in engineering. A caveat is in order, however. Although engineering was found to fall into the category of ‘brilliance required’ in Meyer et al.’s 2015 study, it was not at the *extreme* end of this continuum. On a measure of the degree to which one believes success in a particular career requires innate talent, rather than being achievable through hard work, engineering was rated approximately half way between psychology and math, with the latter falling closer to the “brilliance required” end of the continuum. Clearly, a better understanding of the beliefs held by engineering students, and the impact of these beliefs, is needed.

Sense of Belonging

A potential consequence of a perceived *lack of fit* between an individual and a particular field, which could be an important influence on one’s likelihood of persisting to the point of degree completion, is one’s sense of belonging. People are strongly motivated by a desire for social belonging (Baumeister & Leary, 1995; Hawkley & Cacioppo, 2010; Maslow & Lowry, 1968). In college and university settings, sense of belonging has been found to relate to academic achievement, including grades (Pittman & Richmond, 2007), self-efficacy (Zumbrunn, McKim, Buhs, & Hawley, 2014) and intentions to persist in university (Hausmann, Schofield, & Woods, 2007). There is some evidence that a lack of belonging, or *belonging uncertainty*, can be particularly troublesome for people from groups that are marginalized within a given field. In an experiment in which students were led to believe that would not have many friends in a particular field of study, white students were unaffected, but a measured significant drop in sense of belonging was observed among black students (Walton & Cohen, 2007). Further, an intervention that reduced doubts about social belonging raised the grades of black students, but not white students, suggesting that a sense of belonging was especially influential on the more marginalized group (Walton & Cohen, 2007). Doubts about belonging have been shown to be especially salient for women in fields in which they are under-represented (Good, Rattan, and Dweck, 2012; Walton, Logel, Peach, Spencer, & Zanna, 2011). In their 2013 study of graduate students, for example, Smith et al. (2013) found that a reduced sense of belonging in a scientific field related to decreased motivation for women to pursue further education in that field. A similar study, conducted by Good et al. in 2012, revealed that sense of belonging to math predicted college students' intent to pursue math in the future. It is not entirely clear, however, how consistent this effect is for women in such fields. In the Walton and Cohen study, described above, the effect seen on black students did not carry over to women, despite their similar level of under-representation. They speculated that this lack of effect in female participants, as opposed to black participants, could have been due to the fact that the stimulus was designed to elicit uncertainty about social belonging, and the stereotypes women face relate more to their quantitative ability (Walton & Cohen, 2007). Still, sense of belonging appears to have some impact on women who are considering entering, or are currently members of male-dominated fields.

Disaggregation of STEM fields

The notion, alluded to earlier, that categorizing careers as being STEM and non-STEM does not reflect gender distribution as clearly as one might expect, was emphasized by Kanny et al., in their 2014 narrative review of research examining gender disparity in STEM fields. The authors discussed the need to consider gender gaps at the sub-field level, rather than in aggregate as was common in the research. In their review of the literature, they found a lack of research at the sub-field level, despite clear indications that gender distribution varies wildly between sub-fields. They argued that this imprecision is based on an unrealistic assumption that the reasons for women's lack of participation in different STEM fields are identical. They suggested that examining individual fields could uncover factors contributing to gender disparity that vary across subfields, such as culture and the nature of work. Other researchers, such as Cheryan et al. (2017) agree, proposing that disaggregation of STEM fields allows for a more accurate evaluation of the causes of underrepresentation. Similarly, Fouad and Santana (2017) contrast the way in which STEM is intended to describe technical and scientific fields, against evidence that it should be considered as including a very broad range of fields, each with different distributions of gender (and race). Research focusing specifically on engineering environments is necessary, in my view, so as to better understand the issue of gender disparity in engineering.

In order to begin the investigation of these inter-related issues, the following hypotheses are forwarded.

Hypothesis 1: Male first-year engineering students will less strongly endorse the desire to help others as a motivation for their choice to study engineering than will female first-year engineering students, to a small-to-moderate extent.

Hypothesis 2 a: In both males and females, there will be a small positive relation between the belief that engineering is a helping profession, and academic fit/sense of belonging in the engineering program.

Hypothesis 2 b: The positive relation between the belief that engineering is a helping profession, and academic fit/sense of belonging in the engineering program, will be moderated by the degree to which a desire to help others is endorsed as a motivation to study engineering, such that it will strengthen the relation.

Hypothesis 3 a: There will be a small negative relation between the degree to which one believes engineering involves mainly solo/competitive work, and one's academic fit/sense of belonging in the engineering program.

Hypothesis 3 b: The negative relation between the degree to which one believes engineering involves mainly solo/competitive work, and one's academic fit/sense of belonging in the engineering program, will be moderated by attitude towards teamwork, such that the more positive attitude towards teamwork is, the stronger the relation will be.

Hypothesis 4: To a small, but significant degree, male first-year engineering students will be more likely than female first-year engineering students to indicate that they are talented at math.

Hypothesis 5 a: There will be a small-to-moderate positive relation between the belief that one is talented at math, and academic fit/sense of belonging.

Hypothesis 5 b: The degree to which one believes that the field of engineering requires innate ability will moderate the relation between the belief that one is talented at math, and academic fit/sense of belonging in the engineering program, such that it will strengthen this relation.

Hypothesis 6: Male first-year engineering students will be moderately less likely than female first-year engineering students to indicate that they exert more effort than their engineering-student peers to achieve the same level of success.

Hypothesis 7 a: There will be a small-to-moderate negative relation between the belief that one exerts more effort than ones' peers to achieve the same level of success, and academic fit/sense of belonging in the engineering program.

Hypothesis 7 b: The degree to which one believes that the field of engineering requires innate ability will moderate the negative relation between the belief that one exerts more effort than ones' peers to achieve the same level of success, and academic fit/sense of belonging in the engineering program, such that it will strengthen this relation.

Hypothesis 8: Male first-year engineering students will score moderately higher than female first-year engineering students on a measure of the degree to which one believes engineering comes easily and naturally.

Hypothesis 9 a: There will be a small-to-moderate positive relation between the degree to which one believes engineering comes easily and naturally, and academic fit/sense of belonging in the engineering program.

Hypothesis 9 b: The degree to which one believes that the field of engineering requires innate ability will moderate the positive relation between the degree to which one believes engineering comes easily and naturally, and academic fit/sense of belonging in the engineering program, such that it will strengthen this relation.

Personality

In addition to investigating the hypotheses stated above, relations between personality traits and key variables were explored in the present study. Previous studies comparing male and female engineering students, with respect to various personality measures, have reported mixed results. Some, for example, have shown both similarities on some, and differences on other, facets of personality (Horn, Holzemer, & Meleis, 1990), or no gender differences in personality (Brown & Cross, 1992). Interestingly, a 2015 study by Chen and Simpson found that a strong social personality was negatively related to choosing a STEM major for men, but positively related to the choice of a STEM major for women. Similarly, higher scores on a measure of feminine traits were found to positively predict the choice of a STEM major for male university students, but to negatively predict the choice of a STEM major for female students (Simon, Wagner, & Killion, 2017). Significant, though generally modest, relations between the personality traits of the Five-Factor model (NEO-FFI: Costa & McCrae, 1992) and Holland’s Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (RIASEC; Holland, 1997) vocational interest domains have been found.

More recently, McKay and Tokar, in their 2012 study of college students, sought to determine whether the HEXACO model would provide a better prediction of RIASEC interests compared to the commonly used NEO Five-Factor Inventory (NEO-FFI: Costa & McCrae, 1992). The HEXACO model conceptualizes personality as consisting of six dimensions: Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness to Experience (O) (Ashton & Lee, 2009). Though fewer than half of their hypothesized relations were supported, their results did show a clear advantage of the HEXACO model in accounting for more variance in RIASEC interests over and above the Five-Factor model, making it ideal for research into the relations between personality and vocational interest. To explore the inter-relation of personality, gender, and other variables of interest in the present study, the HEXACO personality scale was administered. Insight into the personality differences and similarities of male and female engineering students, in comparison with norms for college students in general, could improve our understanding of the way in which personality and gender might combine to influence the choice to study engineering, and the experience of being an engineering student.

Method

Experimental Sample and Procedure

Students in their first year of the undergraduate Engineering program at Western University participated in the study, as part of their voluntary participation in ongoing research conducted under principal researcher, Dr. Natalie Allen, of the Department of Psychology at Western University. This population presents an opportunity to study students at the beginning of their engineering education, after having had some experience as students working on team-based projects throughout the year.

Measures

After reading the Letter of Information describing the study, and signing the Consent form (see Appendix A), students completed a measure of personality (HEXACO-60 Personality Inventory: Ashton & Lee, 2009), and demographic items (including age and gender), at the first session of testing during regular class meetings in September 2016. The HEXACO personality measure consists of 6 10-item subscales with 5-point response scales: 1) Honesty/Humility (α = .77), 2) Emotionality (α = .77), 3) Extroversion (α = .83), 4) Agreeableness (α = .75), 5) Conscientiousness (α = .75), and 6) Openness (α = .73). As part of a third and final session of testing conducted with the same participants during regular class meetings in March, 2017, students completed the remaining measures relevant to this study, along with several other measures for the purposes of other studies conducted concurrently by colleagues. For the purposes of this study, the following questionnaire-based measures were administered: 1) beliefs about success in the field of engineering requiring innate talent (Field-Specific Ability Belief Scale: Meyer et al., 2015; 8-item 7-point response scale, α = .75), 2) beliefs about the field of engineering involving solo/competitive work (subscale of the Field-Specific Ability Belief Scale: Meyer et al., 2015; 2-item 7-point response scale, α = .60, 3) beliefs about whether engineering is a profession which involves helping others (helping subscale of the APPLES survey, Sheppard et al., 2010; 3-item 4-point response scale, α = .72), 4) the degree to which a desire to help others motivated the choice of engineering as a field of study (MICC scale, Skatova & Ferguson, 2014; 5-item 5-point response scale, α = .84), 5) individual effort in relation to the effort perceived to be expended by peers (single item adapted from Smith et al., 2013), 6) belief that one must exert more effort than one's peers to be successful (Effort Expenditure Comparison scale, Smith et al., 2013) 7) academic fit and sense of belonging (items adapted from the Academic Fit scale, Walton & Cohen, 2007; items adapted from the College Satisfaction and Persistence scale, Cabrera, Castaneda, Nora, & Hengstler, 1992; 6-item 7-point response scale, α = .87), 8) math self-concept (math subscale of SDQII, Ellis, Marsh, & Richards, 2015; 3-item 6-point response scale, α = .83), 9) and attitude towards teamwork (Attitude Towards Teamwork Scale, Bremner & Woodley, 2013; 9-item 7-point response scale, α = .85). Several "careless responding" items were also included. See Appendix B for all measures administered. See Appendix C for Ethics Approval for this study.

Results

Demographics

Of the 478 students participating in this study, 316 were males and 96 were females, and ages ranged from 16 to 36 (M = 18.37, SD = 1.79). Data regarding gender and age were missing for 66 participants; this was due mainly to the number of participants who completed the final survey but did not complete the first survey, which included the demographic items.

Tests of Hypotheses

See Table 1 for means and standard deviations for all measures.

A *t*-test analysis revealed that males (*M* = 4.33, *SD* =1.03, *SE* = .06) scored significantly lower than females (*M* = 4.53, *SD* = .84, *SE* = .09) on a measure of the degree to which they endorse a desire to help others as a motivation for their choice of engineering as a field of study, $t(190.17) = -1.887$, $p = .061$. In other words, females more strongly endorsed a desire to help others as motivating their choice of engineering. As a two-tailed test, the *p* value was non- significant, but since the hypothesis was directional, a one-tailed *t*-test *p* value (.03) does reach significance, so Hypothesis 1 was supported. This difference, however, represents only a small effect size ($r = .13$).

A significant, small, positive relation between scores on measures of the degree to which one believes that engineering is a helping profession, and academic fit/sense of belonging was found, $r(476) = .310$, $p < .001$, supporting Hypothesis 2a. The moderated multiple regression analysis, however, did not reveal any significant moderating effect of scores on the measure of the degree to which a desire to help others is endorsed as a motivation to study engineering on this relation, $b = .08$, $t(474) = 1.19$, $p = .236$, so Hypothesis 2b was not supported.

A significant, small, negative correlation between scores on measures of the degree to which one believes engineering involves mainly solo/competitive work, and academic fit/sense of belonging was found, $r(476) = -.211$, $p < .001$, supporting Hypothesis 3a. A moderated multiple regression analysis revealed a significant moderating effect of attitude towards teamwork on this relation, $b = .07$, $t(474) = 2.18$, $p = .03$. The moderation, however, was not in the hypothesized direction, so Hypothesis 3b was not supported. Specifically, the belief that engineering is solo/competitive work had a significant negative effect on academic fit/sense of belonging when attitude toward teamwork was below the mean, $b = -.20$, $t(474) = -3.87$, $p < .001$, at the mean, $b = -.14$, $t(474) = -4.17$, $p < .001$, and above the mean, $b = -.07$, $t(474) = -2.13$, $p = .03$. The higher the score on the attitude towards teamwork scale was, the weaker the relation between the belief that engineering is a solo/competitive profession and academic fit/sense of belonging was, but only when scores on the measure of attitude toward teamwork were below 5.47 (on a range from 0 (negative attitude) to 7 (positive attitude). At scores at and above 5.47, there was no significant moderating effect of attitude toward teamwork.

A *t*-test analysis did not reveal a significant difference between scores of males ($M = 4.48$, $SD = 1.07$, $SE = .06$) and females ($M = 4.30$, $SD = 1.13$, $SE = .12$) on the measure of math self-concept, $t(410) = 1.441$, $p = .150$, so Hypothesis 4 was not supported.

A significant, small, positive correlation between scores on the measures of math self-concept and academic fit/sense of belonging was found, $r(476) = .225$, $p < .001$, supporting Hypothesis 5a. A moderated multiple regression analysis did not reveal any moderating effect of scores on a measure of the degree to which one believes engineering requires innate ability on the relation between math self-concept and academic fit/sense of belonging, $b = .07$, $t(474) = 1.53$, $p = .128$, so Hypothesis 5b was not supported.

A *t*-test analysis revealed that males ($M = 2.92$, $SD = .68$, $SE = .04$) scored significantly lower than females ($M = 3.39$, $SD = .66$, $SE = .07$) on a measure of the degree to which they believe they exert more effort than their engineering student peers to achieve the same level of success, $t(410) = -5.90$, $p < .000$, $r = .28$, so Hypothesis 6 was supported.

A significant, small, negative correlation was found between scores on measures of the degree to which one believes that one exerts more effort than one's peers to achieve the same level of success, and academic fit/sense of belonging, $r(476) = -.17$, $p < .001$, supporting Hypothesis 7a. A moderated multiple regression did not reveal any interaction effect of scores on the measure of the degree to which one believes that the field of engineering requires innate ability on the relation between scores on measures of the degree to which one believes that one exerts more effort than one's peers to achieve the same level of success, $b = -.09$, $t(474) = -1.36$, $p = .175$, so Hypothesis 7b was not supported.

A *t*-test analysis showed that males ($M = 3.92$, $SD = .82$, $SE = .05$) scored significantly higher than females ($M = 3.43$, $SD = .10$, $SE = .11$) on the measure of the degree to which one believes engineering comes easily and naturally, $t(132.97) = 4.27$, $p < .000$, $r = .35$, supporting Hypothesis 8.

A significant, moderate correlation between scores on the measure of the degree to which one believes engineering comes easily and naturally, and academic fit/sense of belonging in the engineering program was found, $r(476) = .35$, $p <.001$, supporting Hypothesis 9a. A moderated multiple regression analysis did not show any significant interaction effect of scores on a measure of the degree to which one believes that the field of engineering requires innate ability on the relation between the scores on a measure of the degree to which one believes engineering comes easily and naturally, and academic fit/sense of belonging in the engineering program, *b* = .06, *t*(474) = 1.49, *p* = .137, so Hypothesis 9b was not supported.

Exploratory Analyses/Non-hypothesized Results

Correlations. Analyses were conducted to determine the correlations between all measured variables for male and female participants (see Table 1).

Gender as a moderator. Based on gender differences evident in the correlations between academic fit/sense of belonging and other measured variables, moderated multiple regression analyses were conducted to test for gender effects. Moderating effects of gender on the relation between sense of belonging and two variables (self-ratings of the degree to which engineering comes easily and naturally, and Agreeableness) were found.

The overall model examining the relation between Agreeableness and academic fit/sense of belonging, moderated by gender, was significant, $F(3, 408) = 5.64$, $p < .001$, $R^2 = .04$. The relation between Agreeableness and academic fit/sense of belonging, *b* = .37, *t*(408) = 3.99, $p < .001$, was moderated by gender, such that the relation was stronger and positive for males, and negative and non-significant for females, *b* = -.38, *t*(408) = -2.05, *p* = .04. For males, the effect of Agreeableness on academic fit/sense of belonging was .37, *b* = .37, *t*(408) = 3.99, $p < .001$. Thus, for every one unit increase in score on Agreeableness, there was a .37 unit increase in score on the measure of academic fit/sense of belonging. The effect of Agreeableness on academic fit/sense of belonging for females was -.02, *b* = -.02, *t*(408) = -.11, *p* = .92, so for females there was a non-significant negative relation between Agreeableness and academic fit/sense of belonging, such that for every one unit increase in Agreeableness, there was a (non-significant) .02 unit decrease in scores on the measure of sense of belonging in the engineering program.

The overall model of the relation between the degree to which one believes engineering comes easily and naturally and academic fit/sense of belonging, moderated by gender, was significant, $F(3, 408) = 22.54$, $p < .001$, $R^2 = .14$. The relation between the degree to which one believes engineering comes easily and naturally, and academic fit/sense of belonging, $b = .50$, $t(408) = 8.11$, $p < .001$, was moderated by gender, $b = -.42$, $t(408) = -3.93$, $p < .001$, such that there was an effect for males, but the effect was much smaller and non-significant for females. For males, the effect was .50, $t(408) = 8.11$, $p < .001$. Thus, for every one unit increase in scores on the measure of the degree to which one believes engineering comes easily and naturally, there was a .50 unit increase in scores on the measure of academic fit/sense of belonging. For females, the effect was .08, $b = .08$, $t(408) = .86$, $p < .391$. Thus, for every one unit increase in scores on the measure of the degree to which one believes engineering comes easily and naturally, there was a (non-significant) .08 unit increase in scores on the measure of academic fit/sense of belonging.

Personality. Scores on the 6 subscales of the HEXACO personality measure were analyzed to reveal significant differences in scores for males and females. Gender differences were examined using *t*-test analyses. Males scored significantly lower than females on the Emotionality [$t(132.47) = -7.202$, $p < .000$, $r = .53$] and Conscientiousness [$t(410) = -2.513$, $p = 012$, $r = .12$] subscales, and significantly higher on the Extraversion [$t(410) = 2.313$, $p = .021$, $r = .11$] and Agreeableness [$t(410) = 2.614$, $p = .009$, $r = .13$] subscales. No significant gender differences were found for the

Honesty/Humility [$t(410) = -1.360$, $p = .174$] and Openness [$t(410) = -1.608$, $p = .109$] subscales. The pattern in gender differences across the six HEXACO personality subscales was very similar, for the most part, to the pattern found by Ashton and Lee (2009) in a sample of post-secondary students, hereafter referred to as students in general. The female engineering students in the present study tended to share personality patterns with their male engineering student peers that set them apart, presumably due to their being engineering students, from students in general, but also varied from their male peers in ways that were consistent with gender differences shown in students *across* fields. Scores of females in the present study for the Honesty/Humility subscale were very similar to the scores of males in the present study, and female students in general. Scores for females in the present study on the Emotionality subscale were higher than scores for males in the present study, but lower than scores for female students in general. Scores on the Extraversion subscale for males in the present study, and both male and female students in general, were all very similar, but were slightly *lower* for females in the present study. Scores for females in the present study on the Agreeableness subscale were slightly lower than scores for males in the present study and for male students in general, and almost identical to scores for female students in general. For the Conscientiousness subscale, female engineering students scored higher than males in the present study and both male and female students in general, presumably due to the relation between gender and conscientiousness combining additively with the tendency for engineering students to score higher on measures of conscientiousness. Males and females in the present study had scores on the Openness subscale that were very similar to each other, and lower than scores for male and female students in general.

Several significant correlations were found between scores on the HEXACO personality measure subscales and other measured variables. When analyzed separately for male and female participants, personality subscale scores were found to relate differently, in some instances, to other measured variables (see Table 1). Note that the smaller sample size for female participants translated into insufficient power for the smallest correlations to reach significance. A power analysis conducted using gPower, based on the sample size of 96, and alpha of .05, indicated that for the size of the sample of female engineering students for this study, a correlation sized at .25 or above is needed if a desired power of .80 is to be achieved.

Discussion

Effort Expenditure Concerns/ Beliefs About "Innate Talent"

Recall that in their study of graduate students in STEM, Smith et al. (2013) found that female students tended to believe that they exerted more effort than their peers in order to succeed, and that for women, but not for men, this belief about effort expenditure predicted a reduced sense of belonging, which in turn decreased motivation for continued study in STEM. In the present study, females also scored more highly on a measure of effort expenditure concerns than males, indicating that they were more likely, on average, to believe that they *need* to exert more effort than their peers to be successful. The correlation between effort expenditure concerns and academic fit/sense of belonging was significant but small for male participants, and, for females, was *extremely* small and non-significant. So, there is evidence that the women in this sample tend to believe that they must exert more effort than their (mainly male) peers in order to be successful, but, contrary to Smith et al.'s findings, this belief does not appear to impact the degree to which they feel as if they belong in the program.

The comparison of beliefs regarding how "easily and naturally" engineering comes to oneself vs. one's teammates, and the relation of these beliefs to academic fit/sense of belonging, were influenced by gender. Males and females provided similar ratings of team-mates, but males tended to report higher ratings, and females tended to report lower ratings, for themselves than for their team-mates. Since males and females provided similar team-mate ratings, this difference is mostly attributable to the higher *absolute* self-ratings provided, on average, by males compared to females. If the females in this sample tended to hold a strong belief that success in engineering requires innate talent, and cannot be achieved through hard work, this tendency to believe that they are not as "natural" at engineering, and that they exert more effort to succeed than their peers, could be problematic. The results suggest, though, that both males and females tended to indicate fairly *neutral* beliefs about whether success in engineering requires innate talent.

For males, but not for females, one's belief that engineering comes easily and naturally related positively to academic fit/sense of belonging. For females, the relation between these self-ratings and academic fit/sense of belonging were extremely small and non-significant. These results suggest that feeling that one's field comes easily and naturally might be more consequential, on average, for males than for females. There are several possible explanations for this. Perhaps the belief that women are not as "innately talented" at engineering acts as a buffer against the negative impact of believing engineering does not come as easily and naturally to oneself as it does to one's peers. If women are not expected to be as innately talented as men, but instead thought of more as achieving success through hard work (Bennett, 2000; Furnham, Crawshaw, & Rawles, 2006; Tiedemann, 2000) the belief that one is less innately talented than one's peers might be *less* troublesome for females than for males This explanation is consistent with scores on the measure of the degree to which one believes success in engineering requires innate talent (as opposed to being attainable through hard work), since the mean response was fairly neutral, even leaning slightly in the 'innate talent *not* required' direction. One might predict that the negative relation between such effort expenditure concerns and academic fit/sense of belonging would be strengthened by the degree to which one believes that success in engineering requires innate talent, given that extra effort could be perceived as being incongruent with natural ability, but no such interaction effect was shown by the data. Although the belief that one exerts more effort than one's peers to achieve success in the engineering program was found to relate negatively to academic fit/sense of belonging, this relation was not moderated by the degree to which one believes that the field of engineering requires innate ability. These results suggest that effort comparison concerns might relate negatively to academic fit/sense of belonging *regardless* of whether one perceives success in one's field as being attainable through hard work.

Math self-concept. Previous research on math self-concept has revealed gender differences, with female post-secondary students typically indicating lower levels of confidence in their math abilities than males (Ellis, Fosdick, & Rasmussen, 2016; Sax, 2008). No such difference was evident in this sample. Female students did not score significantly differently from males on a measure of math self-concept, and both male and female participants tended to agree that math is a subject in which they are competent, with mean scores between 4 and 5 out of a possible 6. Of course, the females participating in this study could be expected to report a stronger math self-concept than would be reported by the average female undergraduate student, given the required secondary school math course pre-requisites, and challenging math component of the program. What remains uncertain, however, is whether or not the gender equality in math self-concept found here is indicative of potential female engineering students who are *objectively capable* of fulfilling the program's math requirements, self-selecting out of engineering due to an unrealistically low opinion of their own suitability for a math-intensive field of study.

Math self-concept was found to relate positively to academic fit/sense of belonging, to a small degree. The degree to which one believes that success in engineering requires innate talent was not, however, found to influence the strength of this relation. Interestingly, the relation between math self-concept and academic fit/sense of belonging was smaller and non-significant for the female participants in this study, suggesting that math self-concept could be a *less* important influence for them than for the male participants. Societal expectations for women to be less talented at math (Guiso, Monte, Sapienza, & Zingales; Hyde, Mertz, & Schekman, 2009) might act as a buffer against the influence of math self-concept on academic fit/sense of belonging. Relatedly, it is also possible that, at least in this setting, females, more so than males, tend to derive their sense of belonging from sources outside direct feelings of competence in their field, such as supportive social networks (London, Rosenthal, Levy, & Lobel, 2011).

The apparent lack of influence of math self-concept on the level of academic fit and sense of belonging in this study's female participants might also reflect a larger trend. In their 2016 analysis of data from a national longitudinal study of college students in the United States from 1971-2011, Sax et al. found several shifts over time, one of which was a decrease in the influence of math self-concept on women's choice of engineering as a major. Women persistently reported lower confidence in their math abilities over the years, despite evidence that they were not inferior in terms of objective math ability, but being less confident in math than their male peers exerted a weaker influence on field choice over time. The weak correlation between math self-concept and sense of belonging, found in this study, appears to be congruent with this pattern, in that, despite continuing to report lower confidence in their math abilities, the women embarking on post-secondary education at this point in history are less concerned about math abilities getting in the way of their success in engineering. This would be consistent with the finding in this study that female participants did not seem to believe that engineering is a field in which success is derived solely from innate talent, but instead believe that hard work plays an important role.

Another interesting possibility is that what has been conceptualized as women's unrealistic lack of confidence in math abilities would be more accurately described as an *inflated* level of math self-concept in males. In their 2015 study of American undergraduate college students, Bench, Lench, Liew, Miner, and Flores asked participants to complete a math test, and then estimate how many questions they answered correctly. Male participants tended to overestimate their scores, but female participants tended to provide accurate estimates of their performance. Perhaps a more accurate way of framing the lack of congruence between self-reported math abilities, and more objective performance indicators, such as grades, is as a tendency for individuals to inaccurately estimate their own abilities, such that the gender discrepancies are due not only to conservative self-perceptions in women, but also to inflated self-perceptions of men. This pattern would suggest that perhaps women appear to be less concerned about math self-concept in determining whether they belong because they tend to more accurately assess their ability level as being sufficient for success, and it is the inflated self-concepts of males which are inaccurate.

Desire to Help Others/ Beliefs About Engineering as a Helping Profession

The measure of the degree to which a desire to help others is endorsed as a motivation in the choice of engineering ranged from 1 ("not at all") to 6 ("very much so"). The average score in this sample was between 4 and 5, indicating a fairly high level of endorsement. Female students scored significantly higher than males, but this difference was quite small. It would appear that, at least for these students, gender plays only a small role in the degree to which students desire a career that will allow them the opportunity to help others. Similarly, average scores were high, between 3 and 4 on a 4-point scale, on a measure of the degree to which one believes engineering is a career which involves helping others; further, there were no significant gender differences. If students in this sample had tended to indicate that they *did not* perceive engineering to be a career which provides opportunities to help others, one might predict a reduced academic fit/sense of belonging for those more highly motivated by a desire to help others, given the lack of fit between motivations and impressions of the field. The degree to which a desire to help others is endorsed as a motivation to study engineering, and the degree to which one believes that engineering is a helping profession, did both relate positively to academic fit/sense of belonging, but the desire for a helping career did not affect the relation between the belief that engineering is a helping profession, and academic fit/sense of belonging.

It is possible that a decline over the years in the impact of the desire for a helping career on field choice is responsible, at least partially, for the results observed in this study. In their 2016 study, described above, Sax et al. found evidence that an *activist orientation* - defined as a desire to help those in difficulty or to influence social values, tended to deter both males and females from choosing engineering - but has become a less important influence on females' choice of engineering over the years. According to their data, contemporary women with social activist goals are now more likely to enter engineering than were women in the past who had such goals. This *activist orientation* is similar conceptually to the desire for a helping profession examined in the present study. Thus, it is plausible that a similar trend is occurring, with a reduction in the negative relation between this individual preference and the choice to pursue engineering.

Attitude Towards Teamwork/ Beliefs About Teamwork in Engineering

Overall, attitude towards teamwork was fairly neutral for both male and female students, but female students' attitudes were slightly less positive. Participants tended to disagree slightly with the characterization of engineering as a field mainly involving solo and competitive work, with female students disagreeing more strongly, on average, than male students. There might be a better match between teamwork attitudes and beliefs about the field of engineering for males than for females, since males tended to have less positive attitudes toward teamwork, and also to believe more so than females that engineering involves solo and competitive work. These gender differences are small, however, so this conclusion is not strongly supported by the data.

If students in this sample had tended to strongly agree that engineering involves mainly solo and competitive work, and, presumably, less teamwork, one might predict that there would be a negative relation between this belief and academic fit/sense of belonging, and that this relation would be strengthened by a positive attitude towards teamwork. Although there was a small negative correlation between the belief that engineering involves solo and competitive work and academic fit/sense of belonging, this relation was not strengthened by attitude towards teamwork. Though not hypothesized, a moderate positive correlation between attitude towards teamwork and academic fit/sense of belonging was found. Students in this sample tended to disagree at least somewhat with the characterization of engineering as involving mainly solo and competitive work, with mean scores close to 3 out of a possible 7 on a scale from “completely disagree” to “completely agree.” Thus, it is perhaps not surprising that a more positive attitude towards teamwork would relate to a greater sense of belonging.

Academic Fit and Sense of Belonging

On average, scores on the measure of academic fit/sense of belonging were quite high (close to 6 out of a possible 7), with no significant difference between the scores of males and females. The degree to which one identifies oneself as having engineering “come easily and naturally”, the degree to which one endorses the desire to help others as a motivation in the choice of engineering as a career, attitude towards teamwork, and extraversion were all found to correlate moderately and positively with academic fit/sense of belonging. Smaller positive correlations were also found with math self-concept, conscientiousness, honesty-humility, the belief that engineering is a helping profession, the magnitude of the discrepancy between one's self-ratings and one's ratings of team-mates as having engineering come easily and naturally, agreeableness, and the degree to which one rates one's team-mates as having engineering come naturally. Small negative correlations were found with the belief that engineering involves solo and competitive work, the belief that success in engineering requires innate talent, and the belief that one exerts more effort than one's peers in their engineering studies. If the students in this sample had identified engineering as being a field characterized by solo and competitive work, one might predict that a positive attitude towards teamwork would relate negatively to academic fit/sense of belonging in the engineering program. They tended, instead, to disagree at least slightly with this characterization of engineering, with mean scores of approximately 3 out of a possible 7, so the *positive* correlation between attitude towards teamwork and academic fit/sense of belonging is perhaps not surprising.

The influence of gender on academic fit/sense of belonging. In their study of the persistence of undergraduate students in STEM, Ackerman et al. (2013) found interactions between trait complex scores and gender on STEM persistence. This led them to conclude that women who leave STEM majors tend to have different personality profiles than men who leave STEM majors. Specifically, they found that men who left STEM majors for non-STEM majors had lower scores on the Mastery/Organization trait complex on the Anxiety trait complex, but women who left STEM majors for non-STEM majors had lower scores on Math/Science Self- Concept and higher scores on the Anxiety trait complex, than those who persisted in STEM. Similarly, the results of the present study indicate that the personality, math self-concept, and effort perception patterns of male and female students in relation to academic fit/sense of belonging in the engineering program are quite different. For males, academic fit/sense of belonging was found to relate most strongly to feeling as if engineering "comes easily and naturally," followed by 1) extraversion, 2) the endorsement of a desire to help others as motivating the choice of engineering as a career, 3) the belief that engineering is a helping profession, and 4) attitude towards teamwork. Among females, academic fit/sense of belonging was only weakly, and non-significantly, related to feeling like engineering "comes easily and naturally." Academic fit/sense of belonging instead related significantly and most strongly in females to attitude towards teamwork, followed by several small and non-significant relations with 1) extraversion, 2) the belief that success in engineering requires innate talent (a negative effect), 3) the belief that engineering is a helping profession, and 4) honesty/humility.

Females' sense of belonging does not appear to relate to feeling that engineering comes easily and naturally, as it does for the male participants. One possible explanation for women feeling that they belong in engineering school -- despite feeling like they aren't naturals at engineering, *and* that they must work harder to be successful at engineering -- is that they tend to lean more on social connectedness. If this explanation is accurate, efforts to improve female engineering students' educational experiences aimed more at developing *social* connections, such as the proliferation of clubs and mentorship programs aimed at girls and women in engineering, could be on the right track. Several studies have shown positive effects of social support on sense of belonging in college STEM majors, including the effectiveness of mentors and peers acting as "social vaccines" against stereotype threat (Stout, Dasgupta, Hunsinger, & McManus, 2011; Dasgupta, 2011). Another study, employing a diary study in which female first-year STEM college majors were tracked daily, revealed that reports of higher belonging coincided with reports of higher levels of support from close others, such as friends and family (London et al., 2011). It appears that social influence might play an important role in sense of belonging for women in male-dominated fields, which might explain the lesser impact, compared with male peers, of other factors, such as believing engineering comes easily and naturally.

Similarly, gender was found to moderate the relation between the personality dimension of agreeableness, and academic fit/sense of belonging. Agreeableness was positively related to academic fit/sense of belonging for males, although the correlation was small, but for females this relation was negative, smaller than it was for males, and non-significant. An explanation of this interaction effect of gender is beyond what can be inferred from the data in the present study. One could speculate, however, that the trait of agreeableness typically relates positively to sense of belonging/academic fit, but *not* when one's choice of field runs *counter* to what is expected, based on one's membership in some group. In this case, being *lower* in agreeableness might make it more likely for a woman embarking on a more unusual career course for women, such as engineering, to feel that she belongs.

Personality

The pattern of gender similarities and differences in HEXACO personality scale scores in the present study is fairly similar to that reported in a large-scale study of post-secondary students (Ashton & Lee, 2009). Hereafter this latter sample will be referred to as "students in general" (see Table 2). Differences in personality between the female engineering students in the present study, and the female "students in general" sample suggest that personality does play some role in the likelihood of a woman choosing to study engineering. The engineering students in the present study, whether male or female, tended to be higher in conscientiousness, and lower in openness, than students in general. Higher scores on the conscientiousness scale were characteristic of engineering students vs. students in general, *and* of female vs. male students both in the present study and in general, making female engineering students the highest overall in conscientiousness. The personality trait of conscientiousness could, arguably, be considered the trait that most sets engineers and engineering students apart from those in other fields, which would, in one way, make females a *better* fit for engineering, on average, than males. Female participants in the present study were, however, also higher than their male peers in emotionality, a similar pattern to what is seen in students in general. It would be more difficult to explain how a higher level of emotionality would be characteristic of engineers. Clearly, a better understanding of the influence of personality on success in the field of engineering is needed, to accurately assess the impact of gender-based personality differences on choosing to study engineering.

"Leaky Pipeline"

The goal of recruitment strategies aimed at young women entering post-secondary education appears to be to increase the proportion of females who will ultimately work in fields in which their numbers are fewer. Thus, in the pursuit of such goals, the decline in female representation at advancing stages in some educational and career trajectories, often referred to as the *leaky pipeline,* is concerning. At the undergraduate level of engineering education, a “leak” in the pipeline involves students beginning, but not graduating from an engineering program. The nature of the sample included in this study is such that issues of retention could not be directly explored, given the fact that nearly all students in the engineering program at which this study was conducted continue from year 1 to year 2. Variability *was* shown, however, in scores on the measure of academic fit/sense of belonging, allowing for an investigation into the way in which several variables relate to this variable, and the interacting effect of gender on these relations. A better understanding of possible influences on academic fit/sense of belonging is, arguably, relevant to the well-being and sustained motivation of women in engineering, and, ultimately, to the “leaky-pipeline” problem.

Limitations and Future Research Directions

Participant Characteristics and Context

The participants in this study were students in their first-year of a university engineering program. This somewhat limits the conclusions which can be reasonably drawn from the data. By including only those who have chosen engineering, we can only improve our understanding of those who make that choice, and not of those who chose another path. Also, we gain only a snapshot of the beliefs and experiences thus far for a group with, arguably, minimal exposure to engineering education, let alone engineering as a profession. Other pieces of the puzzle can only be found at earlier stages, such as when students make choices to complete necessary pre-requisite math courses at the secondary-school level, and at later stages, when they make decisions about pursuing graduate school, or embarking on career paths.

Disaggregation of STEM… Disaggregation of Engineering?

The argument, described earlier, for considering the various fields of STEM *separately* when researching issues around gender distribution, is a compelling one. There are also reasons to extend this approach to a more fine-grained level for research focused on the field of engineering. It is easy to see how different sub-fields of engineering are quite different in their knowledge and skill requirements, and the nature of the work itself. The gender balance of these different sub-fields of engineering varies widely. Women are found in greater numbers in biomedical and environmental engineering, for example, than in mechanical or electrical engineering (Ceci, Williams, & Thompson, 2011). For biomedical engineering in particular, its higher proportion of women is thought to be at least partly explained by the fact that the specialty was formed to address the need for interdisciplinary collaboration in the effort to improve health (Benderly, 2010). For the present study, disaggregation beyond the general engineering level was not possible, given that first-year students have yet to commit to one area or another, but it would be prudent for future research to take these sub-field differences into account when at all possible.

Is Engineering Competitive, Collaborative, or Both?

Participants in the present study were asked to indicate the degree to which they agree that engineering involves mainly competitive, solo work. This measure was developed by researchers investigating the way in which fields can be classified in terms of the beliefs people hold about the amount of innate talent required for success. The idea was that solo competitive work, would generally be considered more characteristic of fields requiring innate talent, and that more collaborative and non-competitive work is indicative of careers in which success can be achieved through hard work. In the case of engineering, however, and especially for students enrolled in a year-long team-based project course (as were the participants in the present study), the dichotomy between collaboration and competitiveness might not hold. Insight from the Hartman and Hartman (2006) study of engineering students completing a year-long team-based project course, described above, supports this claim. They found that the students tended to display a competitive nature, in combination with an intense focus on excelling *as a team*; this led the researchers to ponder whether the trend in engineering education towards teamwork has simply shifted the stereotypical competitiveness of engineering to the team level. Future research, especially that which focuses on engineering and teamwork, should take into account this potential for simultaneous competitive and collaborative strivings and work climates.

Beliefs and Interventions

The present study examined student beliefs about the field of engineering in relation to beliefs about the self, and academic fit/sense of belonging. It did not, however, examine students' perceptions of what their teachers and peers in the field of engineering believe. In their 2012 study assessing sense of belonging to math, described earlier, Good et al. found that for women, but not for men, a reduced sense of belonging in math was associated with perceiving that teachers and *other* math students in one's program believe that: 1) women are less talented at math, and 2) math ability is the result of innate talent.

The promising results of interventions designed to increase sense of belonging and interest in a field by instilling the belief that those within it achieve success through effort and hard work (Smith et al., 2013; Walton et al., 2011), and by normalizing the experience of lack of belonging (Walton & Cohen, 2007), suggest that these beliefs could be malleable. The results of the present study, however, are not consistent with there being an effect of effort expenditure concerns on belonging. Clearly, a better understanding of these effects is needed. Future research should further explore the inter-relations of beliefs about the self, about different fields, and about the people within those fields, while taking into account the effects of context (field, level of study, etc.) so as to best inform the design of effective interventions.

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Tables

Table 1

Intercorrelations for Scores on Measured Variables as a Function of Gender

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	*M* (*SD*)
1. AFCSP	--	.32**	-.27**	-.18**	.35**	.35**	.29**	-.16**	.41**	.16**	.23**	.10	-.09	.36**	.22**	.29**	-.06	5.90 (.99)
2. ATT	.24*	--	-.16**	-.13*	.21**	31**	-.04	-.03	.24**	.27**	-.02	.12*	-.11	.35**	.17**	-.01	.13*	4.54 (.93)
3. FSAB_SC	-.12	-.06	--	.34**	-.09	-.12*	-.13*	.21**	-.06	-.03	-.02	-.21**	.01	-.12*	-.19**	-.10	.09	3.04 (1.36)
4. FSAB	-.18	-.07	.22*	--	-.08	-.19**	-.15**	.00	-.01	-.11	.10	-.31**	-.01	-.06	-.24**	-.12*	-.01	3.62 (1.06)
5. APPLES_SG	.18	.24*	-.21*	-.27**	--	.43**	.17**	.02	.24**	.13*	.10	.14*	-.08	.23**	.15**	.17**	.06	3.37 (.63)
6. MICC	.14	.09	-.26*	-.33**	.40**	--	.20**	.03	.24**	.13*	.10	.21**	.06	.26**	.22**	.18**	.16**	4.33 (1.03)
7. SDQ	.14	-.00	-.04	-.01	.06	.22*	--	-.30**	.32**	.02	.26**	-.01	-.15**	.16**	.01	.15*	-.10	4.48 (1.07)
8. EECC	-.10	.07	-.05	-.03	.03	.06	-.35**	--	-.31**	.05	-.31**	.062	.25**	-.09	.08	.09	-.03	2.92 (.68)
9. EC_SELF	.09	.05	.01	-.09	.18	.12	.44**	-.33**	--	.31**	--	.04	-.16**	.28**	.08	.23**	.07	3.92 (.82)
10. EC_OTHERS	.09	.27**	-.11	-.24*	.08	.06	-.20	.17	.21*	--	--	.08	.07	.09	.16**	.02	.02	3.74 (.78)
11. EC_SELF-EC_OTHERS	.03	-.11	.08	.06	.13	.08	.53**	-.41**	--	--	--	--	-.20**	.17**	-.08	.17**	.08	.18 (.93)
12. HEX_H	.17	.09	-.31**	-.34**	.11	.43**	.01	.04	.01	.03	.01	--	.10	-.13*	.43**	.17**	.09	3.24 (.67)
13. HEX_E	.02	.15	.10	.07	.05	.08	-.14	.22*	.12	.21*	-.02	-.08	--	-.21**	-.00	-.04	-.09	2.89 (.56)
14. HEX_X	.20	.19	-.26*	-.04	.06	.21*	.12	.03	.09	-.14	.16	.23*	-.22*	--	.03	.29**	.07	3.47 (.63)
15. HEX_A	-.01	.02	-.13	-.10	-.01	.06	-.02	.17	.09	.14	-.00	.26**	-.15	.08	--	.14*	.07	3.27 (.58)
16. HEX_C	.14	.10	-.06	-.08	.03	.14	.07	.15	-.05	.02	-.06	.22*	.00	.30**	.06	--	.06	3.69 (.52)
17. HEX_O	.01	-.09	.05	-.13	.05	.06	-.20	.08	.04	.12	-.03	.08	-.13	.08	.61	.13	-	3.24 (.61)
M (SD)	5.79 (.87)	4.34 (.85)	2.75 (1.30)	3.51 (1.00)	3.47 (.52)	4.53 (.84)	4.30 (1.13)	3.39 (.66)	3.43 (1.03)	3.83 (.65)	-.41 (1.10)	3.34 (.55)	3.46 (.72)	3.30 (.65)	3.10 (.59)	3.84 (.49)	3.35 (.60)	

Note. Intercorrelations for male participants (n = 316) are presented above the diagonal, and intercorrelations for female participants (n = 96) are presented below the diagonal. Means and standard deviations for male participants are presented in the vertical column, and means and standard deviations for female participants are presented in the horizontal row. ATT = Attitude towards teamwork; FSAB_SC = belief that engineering is solo/competitive; FSAB = belief that engineering requires brilliance; APPLES_SG = belief that engineering is a helping profession; MICC = helping career motivation; AFCSP = belonging/academic fit; SDQ = math self-concept; EECC = effort comparison concerns; EC_SELF = self-rating of having engineering "come easily and naturally"; EC_OTHERS = rating of teammates as having engineering "come easily and naturally"; EC_SELF – EC_OTHERS = individual EC_SELF score minus individual EC_OTHERS score; HEX_H = Hexaco honesty/humility scale; HEX_E = Hexaco emotionality scale; HEX_X = Hexaco extraversion scale; HEX_A = Hexaco agreeableness scale; HEX_C = Hexaco conscientiousness scale, HEX_O = Hexaco openness to experience scale.
* $p < .01$, ** $p < .001$.

Table 2

Descriptive Statistics for the HEXACO Personality Scale

Measure	Male *M (SD)*	Female *M (SD)*	*D* (Male-Female)	Male college sample *M (SD)*	Female college sample *M (SD)*	*D* (Female college sample - Female)
HEX_H	3.24 (.67)	3.34 (.55)	-.10	3.04 (.71)	3.30 (.66)	-.14
HEX_E	2.89 (.56)	3.46 (.72)	-.57	2.93 (.61)	3.64 (.55)	.18
HEX_X	3.47 (.63)	3.30 (.65)	.17	3.47 (.63)	3.49 (.62)	.19
HEX_A	3.27 (.58)	3.10 (.59)	.17	3.19 (.65)	3.10 (.58)	0
HEX_C	3.69 (.52)	3.84 (.49)	-.15	3.31 (.62)	3.58 (.59)	-.26
HEX_O	3.24 (.61)	3.35 (.60)	-.11	3.51 (.68)	3.54 (.64)	.19

Note. HEX_H = HEXACO Honesty/Humility scale; HEX_E = HEXACO Emotionality scale; HEX_X = HEXACO Extraversion scale; HEX_A = HEXACO Agreeableness scale; HEX_C = HEXACO Conscientiousness scale, HEX_O = HEXACO Openness to experience scale. College sample is from Ashton & Lee (2009), The HEXACO-60: A short measure of the major dimensions of personality. *Journal of Personality Assessment*, *91*, 340-345.

Appendix A

Letter of Information and Consent Form

Letter of Information

Understanding Engineering Project Teams

Principal Investigator: Dr. Natalie Allen, PhD, Psychology

Western University, [redacted]

You are being invited to participate in this research study about teamwork, because you will be working as part of a project team during the ES 1050 course. The purpose of this letter is to provide you with information required for you to make an informed decision regarding participation in this research. The purpose of this study is to obtain a better understanding about the psychological processes underlying teamwork. The approximately 500 Engineering students enrolled in this year's "Introductory Engineering Design and Innovation Studio" (ES1050) are eligible to participate in this study**.** If you agree to participate in the present study, you will be asked to complete a series of questionnaires that include survey questions about your ES 1050 project team and your opinions about teams and group work in general in three different sessions throughout the school year. You will also be given instructions on how to complete the questionnaires, and it is anticipated that questionnaires in each session will take approximately 20-30 minutes. We will also be putting you into your groups today. These will be the teams you will work in on your design projects for the course.

There are no known or anticipated risks or discomforts associated with participating in this study. You may not directly benefit from participating in this study but information gathered may provide benefits to society as a whole which include a contribution to knowledge about what factors are important for successful teamwork, the importance of selecting individuals with certain characteristics when forming teams in organizations, and how best to manage teams, reduce conflict, and enhance team performance. As per an agreement between The TeamWork Lab and the ES 1050 professors, you can receive a total of 2.0% bonus marks added to your final ES 1050 course grade for participating in every phase of this research. If you participate in today's study session, you will receive a total of .5% toward your grade. We will also be back two more times in which you will also receive .5% for each time point you participate in a research study component. You will also receive .5% bonus grade for participating in all three sessions (for a total of 2% in bonus marks added to your final grade in the course).

Your participation in this study is voluntary. You may decide not to be in this study. Even if you consent to participate you have the right to not answer individual questions or to withdraw from the study at any time. If you choose not to participate or to leave the study at any time it will have no effect on your academic standing. You can do an alternative assignment and obtain the .5% bonus added to your grade for each portion of the study you chose not to participate in, which involves writing a short summary and answering reflection questions about an article related to the topic of teamwork. You can alternate between completing questionnaires and alternative assignments as you wish. We will give you new information that is learned during the study that might affect your decision to stay in the study. You do not waive any legal right by signing this consent form. Note: Your course instructor and teaching assistants WILL NOT be aware of your decision to participate, as surveys will be collected directly by members of the TeamWork Lab, and your participation is recorded solely by the ES 1050 marks manager, not any individual professor. Further, as part of this project, the TeamWork Lab will be accessing team grades with a view to examining whether particular variables might be linked to group performance. Once we have completed data analysis, these names will be removed from our data file. All the data collected will be confidential and accessed only by the principal investigator (Dr. Natalie Allen) and members of the TeamWork Lab in the Psychology Department at Western. If the results are published, your name will not be used. Any data on paper will be stored in a locked cabinet in a locked institutional office, and electronic data will be stored on a password protected computer on a secure network behind institutional firewalls. If you chose to withdraw from this study, your data will be destroyed and removed from our database. The researcher will keep any personal information about you in a secure and confidential location for a minimum of 10 years. A list linking your study number with your name will be kept by the researcher in a secure place, separate from your study file. While we will do our best to protect your information there is no guarantee that we will be able to do so. The inclusion of your first name and partial student number may allow someone to link the data and identify you. If data is collected during the project which may be required to report by law we have a duty to report. Representatives from the University of Western Ontario Non-Medical Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of research.

If you do not wish to participate in the study but would still like the opportunity to obtain extra credits toward your final grade in the course, you have the option to complete an alternative assignment as previously mentioned for which we will provide you with instructions.

If you have any questions or concerns about the research, or if you would like to receive a copy of any potential study results, you are encouraged to contact Dr. Natalie Allen, the principal investigator [redacted] If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Research Ethics [redacted]

This letter is yours to keep for future reference.

Consent Form

Understanding Engineering Project Teams

Principal Investigator: Dr. Natalie Allen, PhD, Psychology

Western University, [redacted]

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant's name (please print): ____

Signature: ______________________________ Date:_____________

Person Obtaining Informed Consent (please print): ___________________________

Signature: ______________________________ Date: _____________

Appendix B

Survey Measures

Field-Specific Ability Belief Scale (Meyer, Cimpian & Leslie, 2015)

Please circle the number that best represents your agreement with each statement about the field of engineering.

	Strongly Disagree	**Disagree**	**Slightly Disagree**	**Neither Disagree nor Agree**	**Slightly Agree**	**Agree**	**Strongly Agree**
Engineering is a field in which you spend a lot of time working by yourself rather than being around other people.	1	2	3	4	5	6	7
Engineering is a field in which competition with others is much more common than collaboration.	1	2	3	4	5	6	7
Being a top scholar of engineering requires a special aptitude that just can’t be taught.	1	2	3	4	5	6	7
If you want to succeed in engineering, hard work alone just won’t cut it; you need to have an innate gift or talent.	1	2	3	4	5	6	7

With the right amount of effort and dedication, anyone can become a top scholar in engineering.	1	2	3	4	5	6	7
When it comes to engineering, the most important factors for success are motivation and sustained effort; raw ability is secondary.	1	2	3	4	5	6	7
To succeed in engineering you have to be a special kind of person; not just anyone can be successful in it.	1	2	3	4	5	6	7
People who are successful in engineering are very different from ordinary people.	1	2	3	4	5	6	7

Academic Pathway of People Learning Engineering Survey (Sheppard et al., 2010)

Please indicate below the extent to which the following reasons for choosing to study engineering apply to you:

	Not a reason	Minimal reason	Moderate reason	Major Reason
Technology plays an important role in solving society's problems	1	2	3	4
Engineers have contributed greatly to fixing problems in the world	1	2	3	4
Engineering skills can be used for the good of society	1	2	3	4

Motivations Influencing Course Choice (Skatova & Ferguson, 2014)

On the scale provided, please circle the number that best corresponds with your level of agreement with the following statements:

I chose to study engineering because….

MICC (Skatova & Ferguson, 2014)	**Not at all**					**Very much so**
I want to help other people.	1	2	3	4	5	6
I want to serve society	1	2	3	4	5	6
I am interested in people.	1	2	3	4	5	6
I want to make the world a better place.	1	2	3	4	5	6
I am interested in understanding other people's perspectives.	1	2	3	4	5	6

Effort Expenditure Comparison Scale (Smith et al., 2013)

Please indicate on the scale provided how you believe you compare with other engineering students in general.

	A lot less				**A lot more**
Compared with other engineering students, how much effort do you expend in your field of study?	1	2	3	4	5
Compared with other engineering students, to what extent to do you find the material and work in your field challenging?	1	2	3	4	5
Compared with other engineering students, to what extent does your field come easily and naturally to you?	1	2	3	4	5
Compared with other engineering students, how much energy does it take you to succeed in your field?	1	2	3	4	5

Academic Fit (Walton and Cohen, 2007) /College Satisfaction and Persistence (Cabrera et al., 1992)

Please circle the number that best represents your agreement with each statement.

	Strongly Disagree	**Disagree**	**Slightly Disagree**	**Neither Disagree nor Agree**	**Slightly Agree**	**Agree**	**Strongly Agree**
I feel I belong within the Engineering department at Western	1	2	3	4	5	6	7
I am confident I made the right decision in choosing the Engineering program at Western	1	2	3	4	5	6	7
I am satisfied with my academic experience	1	2	3	4	5	6	7
It is likely that I will re-enroll at Western University next fall	1	2	3	4	5	6	7
I feel comfortable at Western University	1	2	3	4	5	6	7
People at Western University accept me	1	2	3	4	5	6	7

Self-Description Questionnaire- Short (Math Subscale; Ellis, Marsh, & Richards, 2015)

Please indicate the degree to which the following statements about you are true or false.

	False					**True**
Mathematics is one of my best subjects	1	2	3	4	5	6
I get good marks in mathematics	1	2	3	4	5	6
I have always done well in mathematics	1	2	3	4	5	6

Attitude Towards Teamwork Scale (Bremner & Woodley, 2013)

Please **circle** the number that best represents your agreement with each statement.

	Completely Disagree	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Completely Agree**
I enjoy working in a team.	1	2	3	4	5	6	7
Working alone is more enjoyable than working in a team.	1	2	3	4	5	6	7
I perform best when working in a team.	1	2	3	4	5	6	7
When I have the choice, I tend to choose working alone over working in a team.	1	2	3	4	5	6	7
When working in a team, I tend to experience positive feelings.	1	2	3	4	5	6	7
I dislike having to work in a team environment.	1	2	3	4	5	6	7
I am more effective as a team member compared to when I work by myself.	1	2	3	4	5	6	7

(Continued from previous page)	**Completely Disagree**	**Disagree**	**Somewhat Disagree**	**Neither Agree nor Disagree**	**Somewhat Agree**	**Agree**	**Completely Agree**
Working alone is better because there are too many distractions when working in a team.	1	2	3	4	5	6	7
Teams are more productive because they combine team members' knowledge, skills, and abilities.	1	2	3	4	5	6	7

Individual effort in relation to the effort perceived to be expended by peers (adapted from Smith et al., 2013)

Please write the first name and last initial of one of your team-members in the space below.

____

Please indicate your level of agreement with the following statement:

Engineering comes easily and naturally to this student.

Strongly Disagree	**Somewhat Disagree**	**Neither Disagree nor Agree**	**Somewhat Disagree**	**Strongly Agree**
1	2	3	4	5

Please indicate your level of agreement with the following statement:

Engineering comes easily and naturally to YOU:

Strongly Disagree	**Somewhat Disagree**	**Neither Disagree nor Agree**	**Somewhat Disagree**	**Strongly Agree**
1	2	3	4	5

Careless Responding

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
To ensure quality data, please select "Strongly Disagree"	1	2	3	4	5	6	7
To ensure quality data, please select "Neither Agree Nor Disagree"	1	2	3	4	5	6	7

Appendix C

Ethics Approval Form

Western Research | Research Ethics

Western University Non-Medical Research Ethics Board
NMREB Amendment Approval Notice

Principal Investigator: Prof. Natalie Allen
Department & Institution: Social Science\Psychology,Western University

NMREB File Number: 108317
Study Title: Understanding Engineering Project Teams (2016-2017)
Sponsor: Social Sciences and Humanities Research Council

NMREB Revision Approval Date: February 14, 2017
NMREB Expiry Date: September 12, 2017

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Revised Western University Protocol		2017/02/01
Instruments	Questionnaire 4	2017/02/01

The Western University Non-Medical Science Research Ethics Board (NMREB) has reviewed and approved the amendment to the above named study, as of the NMREB Amendment Approval Date noted above.

NMREB approval for this study remains valid until the NMREB Expiry Date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario.

Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

[redacted]

Ethics Officer, on behalf of Dr. Riley Hinson, NMREB Chair
EO: Erika Basile ___ Nicole Kaniki ___ Grace Kelly ___ Katelyn Harris___ Nicola Morphet ___ Karen Gopaul ___

[redacted]

Curriculum Vitae

Name:	Julia McMenamin
Post-secondary Education and Degrees:	University of Waterloo Waterloo, Ontario, Canada 2010 B.A., General Psychology
	The University of Western Ontario London, Ontario, Canada 2014 B.A., Honors Psychology
	The University of Western Ontario London, Ontario, Canada 2017 (in progress) M.Sc.
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