Empathy as a Barrier to Women's Entry into STEM Majors: An Empirical Study

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Background

A growing body of literature has examined the underrepresentation of women in science, technology, engineering, and mathematics (STEM) education and related work force. A myriad of factors, ranging from individual, cultural, to structural/organizational, have been found to contribute to the lack of gender balance in STEM fields (Griffith, 2010; Zhang, 2008; Xu, 2015). Recently, many researchers (e.g., Thomson et al., 2015) have been paying attention to a psychology factor, the lacking in empathy, as possibly explaining the disparity between men and women's choices in science-related majors at university (Billington, Baron-Cohen, & Wheelwright, 2007; Lai et al., 2012; Wakabayashi, 2013).

In general women are measured much higher than men on emphasizing profiles and empathy-biased minds (e.g. Baron-Cohen 2003, Andrew et al., 2008 Rasoal et al., 2011; Willer, et a., 2015). In other words, women have a stronger tendency to identify another person's thoughts and emotions and to respond to this with appropriate emotions. Empirical findings support the notion that women have higher empathic response than men.

Empathy has also been examined as an important element in women's profession identities. Professional identity can be described as the values, knowledge, skills, attitudes, and beliefs that are shared with others in the same professional group (Adams et al., 2006; Hall 1987; Watts 1987; McGowen & Hart, 1990). Professional identity is a matter of subjective self-conceptualization associated with the work and professional role being undertaken by an individual. In other words, professional identity is an integral part of an individual's personal

identity (Carlsen et al., 1984), and the existence of a personal identity is a prerequisite for the development of a professional identity (Ohlen, 1998). As such, individuals' occupational choices are strongly related to their personal values and beliefs (Adams et al., 2006; Myyry & Helkama, 2001). Studies found that women have lower connection between their own identity and the values of STEM professions (Heyman et al., 2002). Empathy is an important part of women' identity, whereas STEM disciplines are perceived as lacking empathy as a core element and having little concern for the welfare of others (Jacobs et al., 2016).

Conceptual Framework

The original concept of empathy was initiated in ancient Greek. A few decades ago, psychologists had growing interest in this concept and empathy became a topic in academic research. The definition of empathy has been evolving. Some researchers argue that empathy involves both a cognitive and an affective component (Hoffman,1977, 1981; see also Myyry & Helkama, 2001), nonetheless both emotional and cognitive components of empathy are rooted in one's awareness of other's experiences and the ability to see and experience from other's perspective (Sheldon, 1996; Rasoal et al., 2011). That is, empathic persons are more likely to pay attention to subjective experience, as viewed from the perspective of the experiencer.

Approaching empathy from a more analytical perspective, Baron-Cohen (2002, 2003) suggests that there are actually two psychological dimensions contributing to sex differences; in addition to empathizing (E), the opposite but complementary dimension is systemizing (S). Empathizing is defined as "the drive to identify another person's emotions and thoughts, and to respond to these with an appropriate emotion" (Baron-Cohen, 2002). Systemizing is the complementary cognitive style of empathizing, and it drives individuals to analyze the variables in a system, to understand the rules that govern the behavior of a system, and to be able to

construct systems (Baron-Cohen 2002). Empathizing and systemizing are perceived as two fundamental ways in which people interact with the world, and the literature provides consistent supports that females "adopt on average a more empathizing style, while males adopt on average a more systemizing style of information processing" (Groen et al., 2015; Rasoal et al., 2011).

STEM disciplines are often perceived as focusing on systematic study, based on observation, experimentation, and quantitative manipulation (Manson & Winterbottom, 2012). To better understand the role of empathy in women's low presence in STEM, in this study, the quantification of empathy is based on Baron-Cohen's (2009) empathizing–systemizing theory (E–S theory) of sex differences. The Empathy Quotient (EQ) measure the level of an individual identifying with the thoughts, emotions, and feelings of others. The Systemizing Quotient (SQ) measure a person's tendency to analyzing, exploring, and constructing systems (Baron-Cohen et al. 2003).

Research Objectives

This study is designed to explore how empathy and human-centered perspective may influence women's decision about entering STEM programs and professions. We will use empirical data to answer the following research questions:

1. Are male and female college students different in their EQ-SQ traits?
2. How male and female college students perceive the empathy level of academic majors in STEM and non-STEM differently?
3. How do male and female college students differ in their preference to academic majors? Is empathy a factor related to their preference?

4. How do male and female college students perceive faculty support differently in their academic programs, where academic programs are groups as STEM vs. non-STEM? Is this perception related to personal EQ-SQ scores?
5. What can be done to increase female presence in STEM majors?

Methods

Instrument

A survey was developed and ministered online to measure empathetic factors and student perception of related academic issues on the campus of public 4-year institution in the midsouth area. The survey included eight questions about EQ (Cronbach $\alpha = 0.88$) and four questions about SQ (Cronbach $\alpha = .70$) to measure empathizing (EQ) and systemizing (SQ) traits in individual respondents. The 12 items were extracted from the EQ-SQ instrument developed by Simon Baron-Cohen (2006; this subset of questions was chosen based on factor analysis of the original instrument and content check to match the goal of the present study while keeping the total number of questions on a survey at a reasonable length. Additionally the online survey included items measuring 1) the level of empathy perceived by the student for a list of twenty-one academic majors and 2) their self-reported likelihood of pursuing one of the majors. There were also a series of statements inquiring respondents about the level of empathy they perceived among faculty and other students within their major. Finally, the survey captured basic demographic information such as gender, age, current or planned major and status in undergraduate education (Freshman, Sophomore, Junior, Senior). A complete survey is provided in Appendix A.

Sampling and Participants

Data was collected using stratified sampling at an urban university in the mid-south area in the spring of 2017. In 2017, the university had an enrollment size of over 20,000. For non-STEM students, a random sample of 3,000 students was randomly selected and contacted. In order to have sufficient representation of STEM students, greater effort was given to recruit in STEM majors; in particular, all undergraduate students in the College of Engineering was contacted by email and encouraged to respond to the online survey. A total of 639 responses were recorded by the end of May, 2017. The final sample of respondents, after data cleaning and preparation that removed incomplete and invalid responses, included 517 undergraduate students. The sample comprised of STEM (n = 257) vs. non-STEM (n = 260) majors. Respondents were also identified as 46% female and 54% male.

Analytical Procedures

The focal point of this study was how empathy play in college students' academic experience. Based on the review of literature, empathizing (EQ) and systemizing (SQ) are two fundamentally related, but practically opposite ways that individuals interact with their surroundings, in this study the two measures were combined by taking their ratio (i.e., EQ/SQ scores). The questions were weighted in a way such that EQ/SQ = 1 indicates a balance between the two traits (Type B); EQ/SQ > 1 indicates a stronger trait of empathizing (Type E); and EQ/SQ < 1 indicates a stronger trait of systemizing (Type S). Descriptive statistics and preliminary comparisons were used to examine gender differences in the EQ/SQ ratio and how the differences are related to their evaluation of academic majors and faculty support. Mean comparisons (e.g., t test, 2-way ANOVA, and ANCOVA) and correlational analyses are used to answer the research questions. Missing data were handled using listwise deletion.

Results

Based on the sample of 517 students, the descriptive analysis indicated that female students had an average of 1.37 on the EQ/SQ ratio, which was significantly higher ($p < .001$) than the average of male students ($\bar{X}_{EQ/SQ}$= 1.05). As shown in Table 1, female students in non-STEM majors had the highest EQ/SQ ratio ($\bar{X}_{EQ/SQ}$= 1.49), significantly higher than their counterparts in STEM majors as well as male students in on-STEM majors. Gender difference in EQ/SQ ratio was smaller in STEM majors (1.16 for females vs. 1.02 for males) than in non-STEM majors (1.49 for females vs. 1.12 for males).

To answer the second research question whether male and female college students perceive the empathy level of academic majors differently, ANCOVA analysis was conducted. To begin, all the 21 majors listed in the survey were separated into STEM vs. non-STEM categories. Student evaluations of the level of empathy associated with those professions were totaled within the two categories. Because students' EQ/SQ ratio was positively related to the empathy evaluations of non-STEM majors (r = .22, p .001) but negatively related to that of the STEM majors (r = -.15, $p < .01$), the EQ/SQ ratio was controlled for as covariate after the assumptions of homogeneity of regression and homogeneity of variance were verified. The results (Table 2) indicated that male and female students did not differ significantly in the perceived levels of empathy associated with STEM professions, rather students majored in STEM reported empathy levels of STEM professions ($\bar{X}$ = 35.20) significantly higher than their counterparts in non-STEM major ($\bar{X}$ = 29.71). With regards to non-STEM majors, the opposite patterns were found. Students in both STEM and non-STEM majors offered very similar ratings of the empathy level of non-STEM professions, but female students ($\bar{X}$ = 34.72) perceived the non-STEM profession as having higher empathy level than male students ($\bar{X}$ =32.45).

In order to obtain reliable answer to research question 3 about gender differences in major choice, separate analysis was completed for each of the 21 majors using models of identical structure. Specifically, the likelihood of choosing a given academic major was the dependent variable, the level of empathy of that major perceived by and the EQ/SQ ratio of students were entered as covariates, before, gender was finally entered as the independent variable. The results are summarized in Table 3. As shown, the most consistent finding is that there was a strong significant relationship between the perceived level of empathy and the likelihood of choosing that major. With no exception, the higher empathy level perceived by students, the more likely students would major in the discipline. After the variance related to perceived was removed from the model, a second outstanding pattern was found with the majors in group 1 (Civil Engineering, Mechanical Engineering, Electrical Engineering, Computer Engineering, Computer Sciences, Physics, Mathematic, and Statistics): Students' EQ-SQ disposition was negatively related to the likelihood of choosing those majors, meaning that students with stronger systemizing trends had a higher likelihood of choosing them. In addition, even after the EQ/SQ ratio was controlled for, female students still reported significantly lower likelihood of choosing them as an academic major in comparison to male students. As a contrast to group 1, in group 3 it is found that student EQ/SQ ratio was positively related to the likelihood of choosing the following majors: Psychology, Nursing, and Elementary Education. Moreover, female students had a significantly higher likelihood of majoring in them than males after the effects of perceived empathy level and EQ/SQ ratio were controlled in the models.

It is interesting that gender differences in the likelihood of choosing biomedical engineering and chemistry (group 4) disappeared after the strong influence of their ratings of the empathy level and EQ/SQ ratio were accounted for. These findings reveal two more clear

patterns: 1) the higher the EQ/SQ ratio was, the lower a student's likelihood of choosing a hard science major, including Mathematics, Computer Science, Mechanical Engineering, Electrical Engineering, Computer Engineering, and Physics. And 2) Even after perceived empathy level and EQ/SQ ratio were controlled for, girls still had significant higher likelihood of choosing disciplines that are traditionally considered as catering toward women (including language arts, nursing, elementary education, biology and arts), while had lower likelihood of choosing most of the scientific and quantitative orientated majors than their male counterparts.

Finally, it is also important to find out, do students feel the environment of their academic program empathic, especially for girls who had already chosen a STEM major? Support by faculty was used to indicate the empathy level within the program. Controlling for their EQ/SQ ratio, the ANCOVA results suggested that there was no significant difference between genders or between STEM/non-STEM majors. Student rating of faculty support was not related to their EQ/SQ ratio either. However, with a possible score ranged 4-20, the average rating of faculty support was only 10.58. Note that the satisfaction with faculty support by female students in non-STEM majors (11.51) was higher than their male counterparts, whereas the satisfaction of female students in STEM majors (9.99) was lower than their male counterparts, and the interaction effect was significant at $p = .002$.

Discussion and Conclusions

In general, sample used in this study suggests that there was slight emphasis on systemizing over emphasizing for male college students, whereas female students reported a much stronger tendency for emphasizing over systemizing. Overall, our study found that higher scores in empathy (i.e., higher EQ/SQ ratio) negatively predicted individuals' likelihood of choosing STEM majors. Further, the perceived level of empathy associated with practitioners in

various disciplines was highly related to students' likelihood of choosing engineering majors. The results suggest that the lower likelihood of female students choosing STEM is very likely a consequence of their perception of STEM professions as having lower empathy levels, especially given the observation that likelihood of choosing biomedical engineering as a major was similar between male and female students when comparable levels of perceived empathy were reported by the two gender groups.

The findings of this study provide evidence concerning the (lack of) congruency between women's personal and professional identity traits and the values espoused by different fields in engineering (NSB, 2018). In order to reduce the gender imbalance in STEM fields that has lasted for decades, it is important to take greater efforts to intentionally connect the stated values and missions of STEM professions and the broader welfare of society and human kind. All students could benefit from an increased emphasis on, exposure to, and experience with empathetic endeavors.

References

Baron-Cohen, S. (2002). The extreme male brain theory of autism. *Trends in Cognitive Sciences, 6*(6), 248–254.

Baron-Cohen, S. (2009). Autism: The Empathizing–Systemizing (E–S) theory. *Year in Cognitive Neuroscience,* 1156, 68–80.

Baron-Cohen, S., Richler, J., Bisarya, D., Gurunathan, N., & Wheelwright, S. (2003). The systemizing quotient: an investigation of adults with Asperger syndrome or high-functioning autism, and normal sex differences. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences, 358*(1430), 361–374.

Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., Goldenfeld, N., Delaney, J., Fine, D., Smith, R., and Weil, L. (2006). Development of short forms of the Empathy Quotient (EQ-Short) and the Systemizing Quotient (SQ-Short). *Personality and Individual Differences, 41*(5), 929–940,

Carlsen L.B., Hermansen M.V. & VraÊle G.B. (1984). Sykepleiefaglig Veiledning (Professional Nursing Supervision). Gyldendal, Oslo.

Dizikes, P. (2016) *Why do women leave engineering? Study: Group dynamics of teamwork and internships deter many women in the profession*. MIT New Office. Retrieved on May 2, 2018 from http://news.mit.edu/2016/why-do-women-leave-engineering-0615.

Fox, M. F., Sonnert, G., & Nikiforova, I. (2011). Programs for undergraduate women in science and engineering: Issues, problems, and solutions," *Gender & Society, 25,* 589–615.

Griffith, A. L. (2010). Persistent of women and minorities in the STEM field majors: Is it the school that matters. *Economics of Education Review, 29,* 911-922.

Groen,Y., Fuermaier, A. B. M., Den Heijer,A. E., Tucha, O., & Althaus, M. (2015). The empathy and systemizing quotient: The psychometric properties of the dutch version and a review of the cross-cultural stability. *Journal of Autism Development Disorder, 45*(9), 2848–2864.

IEEE. (2018). *Mission statement.* Retrieved on May 2, 2018 from http://www.ieee.org/about/vision_mission.html?WT.mc_id=lp_ab_mav.

Manson, C., & Winterbottom, M. (2012). Examining the association between empathising, systemising, degree subject and gender. *Educational Studies, 38*(1), 73-88.

Matusovicha, H. M., Streveler, R. & Miller, R. L. (2010). Why do students choose engineering? A qualitative , longitudinal investigation of students' motivational values. *Journal of Engineering Education, 99*(4), 289–303.

McGowen K.R. & Hart L.E. (1990) Still different after all these years: gender differences in professional identity formation. *Professional Psychology: Research and Practice* **21**, 118–123.

National Society of Professional Engineers (NSPE). *Engineers creed.* Retrieved on May 2, 2018 from http://www.nspe.org/resources/ethics/code-ethics/engineers-creed .

Penprase, B., Oakley, B., Ternes, R., and Driscoll, D. (2015). Do higher dispositions for empathy predispose males toward careers in nursing? A descriptive correlational design. *Nursing Forum 50*(1), 1–8, Jan. 2015.

Levenson, R.W., and A.M. Ruef (1992). Empathy: A physiological substrate. *Journal of Personality and Social Psychology, 63*(2): p. 234-246.

Rasoal, C., Danielsson, H., and Jungert, T. (2012). Empathy among students in engineering Programmes. *European Journal of Engineering Education 37*(5), 427–435.

Strobel, J., Hess, J., Pan, R., Wachter, C., & Morris, A. (2013). Empathy and care within engineering: Qualitative perspectives from engineering faculty and practicing engineers. *Engineering Studies, 5*(2) , 137–159.

Watts, R. (1987) Development of professional identity in black clinical psychology students. *Professional Psychology: Research and Practice, 18,* 28–35.

Willer, R., Wimer, C., & Owens, L. A. (2015). What drives the gender gap in charitable giving? Lower empathy leads men to give less to poverty relief. Social Science Research.

Xu, Y. J. (2015). Gender-based earning gap of college graduates: Modeling ten-year progress for STEM and Non-STEM comparisons. *The Journal of Higher Education, 86*(4), 489-523.

Xu, Y. J. (2016). Aspiration and application for graduate education: Gender differences in Low-Participation STEM disciplines. *Research in Higher Education, 57*(8), 913-942.

Zhang, L. (2008). Gender and racial gaps in earnings among recent college graduates. *The Review of Higher Education, 32,* 51-72.

NSF. https://www.nsf.gov/statistics/seind14/index.cfm/chapter-3/c3h.htm.

Table 1.

Descriptive comparison of EQ/SQ between groups.

				STEM majors	
EQ/SQ				No	Yes
Gender	Male	EQ/SQ	Mean	1.12	1.02
			Count	94	172
	Female	EQ/SQ	Mean	1.49	1.16
			Count	144	85

Table 2.

Tests of perceived empathy of academic majors.

Tests of Between-Subjects Effects

Dependent Variable: Q33STEM

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ESRATIO	27.319	1	27.319	.407	.524
Q2	71.037	1	71.037	1.059	.304
STEM1	1994.660	1	1994.660	29.724	.000
Q2 * STEM1	18.971	1	18.971	.283	.595
Error	25433.512	379	67.107		
Total	28161.477	383			

Dependent Variable: Q33NS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ESRATIO	51.425	1	51.425	1.122	.290
Q2	396.415	1	396.415	8.647	.003
STEM1	2.166	1	2.166	.047	.828
Q2 * STEM1	5.236	1	5.236	.114	.736
Error	21410.075	467	45.846		
Total	22026.780	471			

Table 3. Likelihood of Choosing a major by Gender.

	Academic Major	Perceived Empathy Level	EQ/SQ Ratio	Gender (Means of Female Vs. Male)
Group 1	Civil Engineering (4)	80.159***	11.906**	46.329 *** (2.04 vs. 2.70)
	Mechanical Engineering (7)	109.584***	56.694***	73.955*** (2.41 vs. 3.25)
	Electrical Engineering (9)	63.521***	40.278***	63.676 *** (2.18 vs. 2.96)
	Computer Engineering (17)	63.960***	54.622***	42.311*** (2.32 vs. 2.96)
	Computer Science (14)	30.176***	36.889***	23.963 *** (2.38 vs. 2.85)
	Physics (21)	41.829***	29.873***	50.422 *** (2.17 vs. 2.94)
	Mathematics (5)	52.526***	42.293***	7.005 * (2.44 vs. 2.69)
	Statistics (2)	28.104***	4.842*	5.701* (1.88 vs. 2.11)
Group 2	Biomedical Engineering (13)	103.613***	18.322**	.564 (2.70 vs. 2.78)
	Chemistry (8)	48.010***	6.975*	.555 (2.29 vs. 2.36)
Group 3	Psychology (3)	84.272***	33.333***	17.015 *** (2.80 vs. 2.40)
	Nursing (10)	20.115***	18.582***	48.860 *** (2.76 vs. 2.09)
	Elementary Education (12)	6.960*	14.206***	57.473 *** (2.56 vs. 1.82)
Group 4	Biology (1)	57.222***	.037	15.999 ** (2.55 vs. 2.17)
	Art (15)	96.330***	1.008	23.607 *** (2.65 vs. 2.18)
	English (20)	76.538***	3.823	29.085*** (2.45 vs. 1.93)
	Accounting (6)	71.192***	4.857	18.467 *** (2.07 vs. 2.49)
	Economics (11)	68.348***	.137	13.374 ** (2.09 vs. 2.45)
Group 5	Business Administration (18)	158.874***	.472	5.882 (2.56 vs. 2.79)
	Music (16)	99.646***	.470	.024 (2.34 vs. 2.33)
	History (19)	94.336***	.004	2.026 (2.22 vs. 2.36)