https://doi.org/10.7494/human.2019.18.4.31

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MEN AND WOMEN ON THE STEM TRACK. SIMILAR OR DIVERSE?[1]

Much attention has been directed towards explaining and overcoming the low representation of women in STEM (Science, Technology, Engineering, Math) fields. In this study, we aimed to test gender differences among men and women on the STEM track: female and male students enrolled in STEM majors. We found that women (versus men) feel less competent in STEM, value work in STEM less, and have a lower expectancy of succeeding in STEM. When it comes to career goals, women were equally agentic but more communal. We failed to find any gender differences regarding a sense of belonging to STEM, or in general behavioral intentions to engage in STEM. To conclude, although we replicated some of the hypothesis about gender differences, we found preliminary evidence that there may be indeed fewer gender differences among those already engaged in STEM than we might have expected based on the previous research.

Keywords: STEM, gender, self-efficacy, goal congruence, gender differences

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[1] The study was conducted with the use of funding awarded by the Faculty of Humanities, AGH University of Science and Technology.

INTRODUCTION

A considerable body of research has focused on internal barriers towards women entering STEM (Science, Technology, Engineering, Math) education and careers (Cheryan et al. 2009; Corbett and Hill 2015; Diekman 2007; Diekman et al. 2010). The shortage of female representatives in this domain remains a significant concern for policymakers, educators and the general public (Corbett and Hill 2015; Hill, Corbett and Rose 2010). It is a valid empirical and practical issue, as studies show that retention of women in STEM jobs is still not satisfactory (Hill et al. 2010). Previous studies suggest that women are almost twice as likely as men to leave a science major (Margolis and Fisher 2002). There is evidence that women who graduate with degrees in STEM majors are less likely than their male counterparts to enter STEM occupations, or remain in them (Beede et al. 2011; Glass et al. 2013; Ma and Savas 2014; Mann and DiPrete 2013; Sassler et al. 2017). At the same time, women with STEM degrees are less likely than men to work in STEM fields (Beede et al. 2011).

Previous research has focused on the following factors influencing gender differences in STEM engagement, among others: value-expectancy (Eccles 2009; Wang and Degol 2013), sense of belonging (Good, Rattan and Dweck 2012; Geisinger and Raman 2013), goal congruence (Diekman et al. 2010; Diekman et al. 2013; Brown, Thoman and Diekman 2015), and self-efficacy (Correll 2001; Nagy et al. 2008; Ehrlinger and Dunning 2003; Else-Quest, Hyde and Linn 2010; Spelke 2005; Steffens and Jelenec 2011). These four factors provide useful insights into mechanisms influencing men's and women's attitudes towards pursuing a STEM educational and career path (Eccles 2009; Wang and Degol 2013).

Not much attention, however, has been directed to women on the STEM track (some examples can be found here: Smith et al. 2013; Lewis et al. 2017; Sonnert and Fox 2012). The aim of the present study was to focus on intrinsic factors influencing academic and vocational decisions among men and women on the STEM track. The majority of studies have been conducted among either students of mixed majors (e.g. Xu 2013, 2017) or prospective students (e.g. Fuesting, Diekman and Hudiburgh 2017). Adding to the previous research, we aimed to gather data on actual STEM students. We planned to examine factors most commonly perceived as attributing to low female representation in STEM fields.

SELF-EFFICACY IN STEM

Despite the lack of gender differences in STEM competencies (National Center for Education Statistics 2012; Sonnert and Fox 2012; Hill et al. 2010; Hargittai and Shafer 2006) women tend not to recognize their achievements accurately and continue to underestimate their competencies in math and science (Ehrlinger and Dunning 2003; Else-Quest, Hyde and Linn 2010; Spelke 2005; Steffens and Jelenec 2011; Correll 2001; Nagy et al. 2008; Hargittai and Shafer 2018). For example, over 20% of MIT (Massachusetts Institute of Technology) female students (as opposed to 9% of male) declared not feeling as capable as their peers (Chin and Tekiela 2016), and this number is higher among seniors than among freshmen (Pajares 2005).

Self–efficacy is a crucial factor affecting one's motivation (Master et al. 2017), goals formation (Eccles 1994, 2005; Wigfield and Eccles 2000), and performance. For example, Pajares and Kranzler (1995) found mathematical self-efficacy to be a stronger predictor of performance than gender. In the light of those results, we wanted to investigate whether men and women on the STEM track perceive their competences differently.

H1: Women on the STEM track would have lower self-efficacy compared to male peers.

VALUE AND EXPECTANCY OF WORKING IN STEM

According to value-expectancy theory (Eccles 2009), people make decisions about goal engagement based on their own evaluations of the probability of attaining a goal and of the value assigned to the goal. Value-related beliefs are strong premises when predicting academic achievement and engagement (Schiefele 2001). Some research suggests (Wang and Degol 2013) that women may be more likely to assign a lower value to STEM domains because of the social assumption that a career in STEM is incompatible with female aspirations and interests. At the same time, since women tend to underestimate their capabilities in STEM domains (Durik, Vida and Eccles 2006; Eccles et al. 1998) it may influence their success expectancy. It is well-established that lack of confidence in one's competences weakens motivation to engage in education and a career (Eccles 1994, 2005). There are also significant gender differences regarding prospective salary: women anticipate earning less both at the beginning and at the peak of their careers (Heckert et al. 2002). Therefore, we wanted to test perception of STEM value and expectancy of succeeding in STEM among men and women on the STEM track.

H2: Women on the STEM track will attribute lower (than men) value to a career in STEM.

H3: Women on the STEM track will declare lower (than men) expectancy in terms of succeeding in the field.

SENSE OF BELONGING TO A UNIVERSITY

Sense of belonging is considered to be an important factor in the formation of academic motivation (Baumeister and Leary 1995). The greater the mismatch between oneself and a given domain one perceives, the lower the sense of belonging (Cheryan et al. 2009; Stephens et al. 2012) and the higher the probability of leaving the domain (Marra et al. 2013, Geisinger and Raman 2013). Since the STEM fields are stereotypically perceived as masculine rather than feminine (Cheryan 2012), it can be assumed that women's sense of belonging to STEM will be lower.

Indeed, research consistently shows that women tend to report a lower sense of belonging to STEM domains (Ayre, Mills and Gill 2013; Faulkner 2009; Margolis and Fisher 2002;

Cech et al. 2011) and universities with high-tech profiles (Chin and Tekiela 2016). This is important, as sense of belonging is a strong predictor of women's interest in STEM (Good, Rattan and Dweck 2013; Smith et al. 2013; Cheryan et al. 2009). Additionally, intervention aimed at increasing students' sense of belonging was found to positively affect achievements (Walton and Cohen 2011).

We presume that male and female students will differ in the sense of belonging to a STEM university.

H4: Women on the STEM track will declare lower (than men) sense of belonging to their university.

GOAL CONGRUENCE

According to the goal congruence theory (Diekman et al. 2010) women lean towards occupations that allow them to work with others and/or to help others (communal goals), whereas men tend to choose professions that are perceived as profitable and admirable (agentic goals). Orientation towards others versus orientation towards status provides a partial explanation of gender segregation in education and career. The commonly shared stereotype is that STEM fields do not satisfy communal goals (Diekman et al. 2010). Even people in STEM majors tend to believe that STEM careers provide fewer chances to pursue communal goals (e.g. affiliation and altruism) than other professions (Diekman et al. 2010, 2011). Also, college students recognize fewer other-oriented role models in STEM than in other fields (Fuesting and Diekman 2017). This is important, as research suggests that highlighting goal congruence among women in STEM would provide a benefit, in higher retention rates (Diekman et al. 2011). In alignment with previous findings, we expect to find gender differences in terms of men and women's goals.

H5: Women on the STEM track would have more communal goals than men.

H6: Women on the STEM track would have less agentic goals than men.

ENGAGEMENT INTENTIONS

There is some evidence suggesting that several factors might influence engagement intentions in STEM fields. Some of these factors are already described in this paper, such as sense of belonging, self-efficacy and goal congruence. Not much, however, is known about generic gender differences in engagement intentions of people already on the STEM track. The question that remains unanswered is: do men and women already involved in STEM training and education differ in terms of their engagement intentions? The main premise in the literature is that women are less engaged in STEM than men (Diekman et al. 2011; Wang and Degol 2013).

Taking into account all the aforementioned arguments, we presume that there will be gender differences in engagement intentions among men and women already on the STEM track.

H7: Women on the STEM track would declare lower intentions to engage in STEM than men.

METHOD PARTICIPANTS AND PROCEDURE

364 students of universities of science and technology in Poland participated in the study. 48 of them did not finish the questionnaire, so we took a sample of 316 to analyze (157 female, 49.7%; M_{age} = 20.88, *SD* = 1.61). Most of them were from STEM majors (computer sciences 53.8%, bioengineering 22.8%, mathematics 18%, physics 3.8%, other STEM 1.6%).

A list of all students in the STEM fields was obtained from the registrar on each campus. An email with an invitation to participate in the study was sent to students from four majors: Physics, Mathematics, Computer Science and Bioengineering. The email gave a brief description of the research project and provided a link to our survey published on the research portal *surveymonkey.com*. Participants were offered chance to win (by a draw) a gift of university-branded gadgets (flash drive, elegant pen etc.).

MEASURES

If not mentioned otherwise, all variables were measured on a scale ranging from 1 (definitely disagree) to 7 (definitely agree).

Self-efficacy. The scale consists of two items: "I consider myself a competent person in the field I study" and "Compared with other students I'm equally competent" (α = .75).

Value. This item was designed to capture a participant's assigned value to working in STEM: "After graduation, it is important for me to work in my profession".

Expectancy. This item was designed to capture a participant's expectancy of succeeding in STEM after graduation: "After graduation, I have a good chance to get a job in my profession".

Another way of measuring expectancy was to ask about expected earnings. Participants had to choose how much money they wanted to earn per month after studies (gross). The scale consists of 11 categories, ranked from "1500 PLN" per month (a minimal salary in Poland) to "more than 6000 PLN". The mean salary in Poland is approximately 3000 PLN per month.

Belonging to the STEM university. The scale consisted of three items: "I feel that I belong to this university", "I feel good at my university", and "My studies suit me" (α = .87).

Career goals. This scale was designed to differentiate between agentic and communal career goals. Participants rated the extent to which each of the ten factors (e.g. "Compatibility of work with qualifications", "Ability to help others through my work") are important for them in choosing a job on a 7 – point Likert scale (1 – least important, 7 – most important).

We decided to run factor analysis (MLE method) with Varimax rotation. KMO measure of sampling adequacy was sufficient (.796) and Bartlett's test of sphericity was significant ($p < .001$), which allowed us to run analysis. It showed two factors: communal goals ("Awareness that my work is socially useful", "Awareness that my work contributes to the quality of life of others", "Ability to help others by my work") and agentic ("Reputation of the company", "Vocational interests", "Possibility of personal development", "Organizational Culture"). The items "The amount of earnings" and "compatibility of work with qualifications" were dropped from the scale because they were not related to either of the two main factors, and "Work in a team" was dropped because it loads both factors equally. Both the final agentic and communality career goals scales were relatively homogenic (α = .90, and α = .59, respectively).

Engagement in STEM. Participants were presented with a list of ten activities (e.g., "Gain practical competences through participation in extra-curricular practices, internships, projects", "Participate in the students' scientific association", "Ask a researcher about the opportunity to join in additional activities at the university", "Contact senior students who already work in companies to obtain contacts / build a social network", "Be systematically active during classes"). Participants rated the extent to which they were likely to engage in each of those activities on a scale from 1 (definitely not) to 7 (definitely yes) (α = .80). This measure was used in a previous study (Jasko, Dukala and Szastok 2019).

Datasets and analyses are available as Online Supplemental Materials at https://osf.io/3y48j/?view_only=a7c1f84a07ff414a83420f77b48be783.

RESULTS

All correlations between main variables are shown in Table 1.

Table 1. Correlations between main variables

	Self-efficacy	**Value**	**Expectancy**	**Belonging to university**	**Engagement in STEM**	***M* [95%CI]**
Self-efficacy		.32**	.39**	.46**	.32**	5.08 [4.94, 5.22]
Value	.32**		.42**	.31**	.20**	5.69 [5.53, 5.85]
Expectancy	.39**	.42**		.36**	.16**	5.57 [5.39, 5.75]
Belonging to university	.46**	.31**	.36**		.48**	5.23 [5.08,5.36]
Engagement in STEM	.32**	.20**	.16**	.48**		4.33 [4.22, 4.44]

*$p < .05$. **$p < .01$.

SELF-EFFICACY

There was significant difference between genders on self-efficacy, $F(1, 315) = 9.97$, $p = .002$, $\eta^2 = .031$. Female students' felt less competent ($M = 4.86$, $SD = 1.25$) than males ($M = 5.30$, $SD = 1.23$). H1 was confirmed.

VALUE

Because value was non-normally distributed, with skewness of −1.10 ($SE = 0.14$) and kurtosis of 0.51 ($SE = 0.27$) we decided to use a non-parametric test. The Kruskal-Wallis H test showed that there was a statistically significant difference in value between gender, $\chi^2(1) = 6.472$, $p = .011$, with a mean rank value of 145.93 for female, and 170.91 for male. H2 was confirmed.

EXPECTANCY

Expectancy was also non-normally distributed, with skewness of −1.20 ($SE = 0.14$) and kurtosis of 0.62 ($SE = 0.24$). The Kruskal-Wallis H test showed that there was a statistically significant difference in value between gender, $\chi^2(1) = 33.39$, $p < .001$, with a mean rank value of 129.81 for female, and 186.83 for male. H3 was confirmed.

EXPECTED EARNINGS

The U Mann-Whitney test indicated that the predicted earnings were lower for female ($Mdn = 5$) than for male students ($Mdn = 6$), $U = 8963.5$, $p < .001$, $r = .247$; female students aspire to earn about 500 PLN per month (1/6 of the mean salary in Poland) less than male students. H3 was confirmed.

BELONGING TO THE STEM UNIVERSITY

A one-way between subjects ANOVA showed no statistically significant differences between female ($M = 5.29$, $SD = 1.29$) and male students ($M = 5.17$, $SD = 1.41$, $F(1, 315) = 0.63$, $p = .428$, $\eta^2 = .002$. H4 was not confirmed.

CAREER GOALS

Two one-way ANOVAs were conducted to reveal the impact of gender on communal and agentic goals. There were no significant effects on agentic career goals, $F(1,314) = .98$, $p = .321$, $\eta^2 = .003$. Female students were not different from male students on agentic career goals ($M = 5.45$, $SD = 0.76$ and $M = 5.36$, $SD = 0.89$, respectively). However, there was a significant effect on communal goals, $F(1, 314) = 7.53$, $p = .006$, $\eta^2 = .023$. Women have higher priority for communal goals than men ($M = 4.35$, $SD = 1.54$ and $M = 3.84$, $SD = 1.42$, respectively). H5 was confirmed and H6 was not.

ENGAGEMENT IN STEM

There were no differences between female (M = 4.33, SD = .91) and male (M = 4.33, SD = 1.05) students in mean engagement in STEM domains, $F(1, 315) = .98$, $p = .958$, $\eta^2 < .001$. We decided to run a series of ANOVAs to check if there are any gender differences in single items. In two items out of ten, female students were less engaged than males: "Gain practical competences through participation in extra-curricular practices, internships, projects", $F(1, 313) = 4.80$, $p = .029$, $\eta^2 = .015$, (M = 5.33, SD = 1.31 and M = 5.66, SD = 1.36, respectively); and "Apply with my own project (business or scientific) to a researcher", $F(1, 312) = 7.76$, $p = .006$, $\eta^2 = .024$, (M = 2.53, SD = 1.49 and M = 3.02, SD = 1.64, respectively).

In case of two items females were more engaged than males: "Take part in additional training to raise my professional qualifications", $F(1,315) = 4.99$, $p = .026$, $\eta^2 = .016$, (M = 5.37, SD = 1.27 and M = 5.02, SD = 1.51, respectively), and "Study hard the subjects included in the program of my studies", $F(1, 314) = 5.96$, $p = .015$, $\eta^2 = .019$, (M = 5.17, SD = 1.60 and M = 4.72, SD = 1.66, respectively). Thus, H7 was partially confirmed.

DISCUSSION

It is well-documented (see introduction) that the factors contributing to low female representation in STEM are, among others, low self-efficacy, goal incongruence, perception of STEM domain, and low sense of belonging. These factors are said to contribute to lower eagerness of women to pursue STEM. Yet less attention has thus far been directed towards women already on the STEM track. There are studies regarding gender differences in dropout from STEM (Mavriplis et al. 2010; Geisingerand and Raman 2013) focusing on finding indicators of possible renouncement both in intrinsic (psychological) and extrinsic (societal) factors. Even though much of the focus in current literature is on finding differences among men and women, in fact more and more studies show that there actually might be fewer differences and more similarities than we might expect.

In the present study, we aimed to analyze differences among men and women on the STEM track (male and female students of STEM majors) in areas that, according to the literature, contribute to gender inequality in STEM. In line with our hypotheses, women (compared to men) expressed lower self-efficacy in STEM, lower expectancy to succeed in STEM, declared lower expected earnings, and value STEM less. These results are of high practical importance because they present a potential crucial barrier to female activity in STEM: high self-doubt. Although this argument calls for further analysis, it may be the case that when predicting, accurately or not, a more difficult and less profitable future in STEM, women may transfer commitment outside this domain. This results in highly educated individuals signing off from a valid career path due to unaddressed apprehensions. On the other hand, this strategy might be in fact reasonable, and based on actual observations of career trajectories of women in STEM. As mentioned before, this issue requires further research attention.

This study also focused on goal congruency as an important factor in education and career planning. Activities and environments not perceived as congruent with one's values and desires are more likely to be abandoned. Since STEM is perceived as more agentic (focus on earnings, success, position, etc.) than communal (focus on cooperation and helping others) the incongruence experienced by women may discourage them from pursuing STEM jobs. Yet this assumption is mostly valid among those who are yet to choose a career path. We wanted to explore how goal congruence theory applies to men and women already on the STEM track. We predicted, based on the available literature, that women would value communal goals more, and agentic goals less, than men do. Indeed, female students expressed stronger priority for meeting communal goals in their future career (e.g. social usefulness) than men. This was consistent with previous results (Diekman et al. 2010). We were unable, however, to find any gender differences in the importance of agentic goals (e.g.: "Possibility of personal development") in a future career. This is an important discovery, as it is contrary to lay beliefs that women tend to care less about their careers than men. In fact, we found women to value success, position and earnings to a similar degree as men. This is also congruent with the following findings referring to engagement intentions in STEM tasks and actions.

In general, we did not find any gender differences in behavioral intentions to engage in STEM. Women in our sample were as equally determined as men to engage in further investment in STEM careers. We did find, however, that men and women differ in terms of manners of engagement. Women were more willing to focus on formal forms of education, like studying hard and taking part in additional workshops. Indeed, studies are showing that there is an increasing number of female over male students in higher education (Bae et al. 2000; Diprete and Buchmann 2006). On the other hand, men declared stronger intentions to engage in practical and bold actions, like "applying with my own project (business or scientific) to a researcher". These results may help to explain the gender gap in employment and wages: although female students seem to put more effort into studying, male students focus more on gaining practical skills which may be particularly important for prospective employers. This result might be also interpreted in context of previously discussed self-efficacy. While men feel confident to put their competences into practice, women tend to pursue strategies based on their estimated low readiness and continuous preparation, i.e. educational activities. This may posit as an explanation of lower representation of women in STEM, despite their sufficient academic background.

And lastly, men and women presented similar feelings of belonging to a STEM university, which is an interesting and important finding for numerous reasons. First, the aforementioned (see introduction) concepts indicated that women show a lower sense of belonging to STEM than men. This constitutes a valid argument for low representation in STEM – since women feel they do not belong to STEM they may be more reluctant to both choose this path and to stick to it. Second, a sense of belonging can influence other significant factors like engagement intention, which is crucial for pursuing a STEM career. In our sample women and men in STEM declared a similar sense of belonging, which is on the one hand a positive signal indicating that this mechanism is not at play here, yet on the other hand, forces us to look for other indicators of low female representation in STEM.

The presented study is novel because we tested effects known from the literature addressing a very specific sample of women and men who are already engaged in STEM: male and female students in STEM majors. Some of our results are in line with previous studies conducted in the same context but with different samples (e.g. Smith et al. 2013; Lewis et al. 2017; Sonnert and Fox 2012). Albeit, not all the literature-based hypotheses derived from previous research regarding gender differences were confirmed in our study. Although more studies are needed, we discuss the lack of gender differences results as a preliminary indication that women and men on the STEM track may be in fact quite similar to each other. Nevertheless, our data is too limited to lead to strong conclusions, still, the results suggest a possible need to transfer attention from intrinsic to extrinsic factors that keep women away from STEM domains.

It needs to be especially highlighted that despite some differences, women and men expressed equal levels of behavioral intentions to engage in STEM. This result suggests that women may not be less motivated to put effort into their work in STEM. That said, we did find women to value STEM less than their male peers. Further research in terms of different forms of engagement would be in our opinion interesting and important.

To conclude, our findings suggest that there may be indeed fewer gender differences among students already on the STEM track than we might have expected based on the previous research. However, we have shown that some aforementioned gender differences persist, and they may contribute to the existing underrepresentation of women in STEM.

The practical implications of this line of research are very broad. For example, we showed that despite many societal changes, women still put less trust in their own competence than men, which in turn may influence their future career decisions, especially since STEM is a domain considered as highly relying on outstanding competences (Dweck 2006). There is as well the issue of the incoherence of goals and values of women in STEM, which needs to be addressed in order to make women equally engaged in STEM. Our study shows areas and issues that should be addressed by policymakers to increase female representation in STEM.

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MĘŻCZYŹNI I KOBIETY W NAUKACH ŚCISŁYCH – PODOBNI CZY RÓŻNI?

Obecnie dużo uwagi w literaturze tematu poświęca się na szukanie wyjaśnienia niskiej reprezentacji kobiet w naukach ścisłych i zawodach technicznych. W niniejszym badaniu podjęto próbę określenia różnic między kobietami i mężczyznami, którzy już podjęli ten kierunek specjalizacji (studenci i studentki uczelni technicznej). Wykazano, że kobiety czują się mniej kompetentne niż mężczyźni, przypisują mniejszą wartość pracy w naukach ścisłych oraz mają mniejsze oczekiwanie sukcesu w tej dziedzinie. Jeśli chodzi o cele zawodowe, kobiety i mężczyźni nie różnią się pod względem celów sprawczych, natomiast kobiety wyżej cenią cele wspólnotowe. Nie stwierdzono różnic płciowych w zakresie poczucia przynależności do dziedziny nauk ścisłych. Podsumowując, udało się zweryfikować część hipotez dotyczących różnic międzypłciowych w zakresie udziału kobiet i mężczyzn w naukach ścisłych. Jednak wydaje się, że wśród osób, które już wybrały tę ścieżkę kariery, różnic tych może być mniej, niż sądzono.

Słowa kluczowe: płeć, nauki ścisłe, STEM, poczucie skuteczności, zgodność celów