Spring 6-2022

The Effect of STEM Education on Women

Jasmine Gloden
Portland State University

The Effect of STEM Education on Women

by

Jasmine Gloden

An undergraduate honors thesis submitted in partial fulfillment of the

requirements for the degree of

Bachelor of Science

in

University Honors

and

Quantitative Economics

Thesis Adviser

Dr. Sarah Tinkler

Portland State University

2022

Abstract

This inquiry seeks to establish the effect of a STEM education on labor market outcomes for women. Gender differences in interest and performance in STEM fields begin at an early age, and remain steadfast through education and into the labor market. Due to factors like lack of female role models in STEM, gender stereotypes, and lack of growth mindset in terms of intellectual abilities, women can be discouraged throughout their education from continuing in a STEM education or pursuing a STEM occupation. Using data from the Education Longitudinal Study of 2002, I determined the effect of a STEM education for women on future wages. My findings indicate that having a bachelor's degree and being a man are the factors with the largest boost to future earnings. I found that there was not a significant difference in the returns from a STEM education for men and women. The effect of STEM education may not be different for men and women, but women face many obstacles that men may not that could deter them from pursuing a STEM education.

JEL Classification Codes: I24, I26, J71

Keywords: Education Economics, Feminist Economics, Labor Market Outcomes, STEM

Introduction

This inquiry seeks to establish the effect of a STEM[1] education on labor market outcomes for women. Female participation in STEM fields has increased over time, but still remains below that of other fields. Gender differences in math and science begin to emerge early in education, and continue throughout high school and college, eventually affecting labor market outcomes. Stereotypes, lack of female role models, and psychological factors can discourage young girls' interest in math and science. This can compound into a lack of confidence and disinterest in those areas, leading them to shy away from studying or joining STEM fields. Those who do enter into STEM occupations still face other issues like the wage gap, a cold work environment, difficulty balancing family life, and more. This paper will explore the impact of stereotypes, preferences, and psychological factors that contribute to lower female representation in STEM fields.

Background

In the United States (and much of the world), there has been a long standing stereotype that men are better at math and science while women are better at reading and writing. Historically this stereotype has been perpetuated through comparing test scores, but today girls have significantly narrowed the gender gap in math and science scores as well as improved their lead in reading scores (Blau Winkler, 257). The United States has made many improvements toward gender equality, so how can there still be a gender bias in education? Some believe that cultural roles, stereotyping, or preference could be the cause (Jia, 11). Girls and boys also show differences in believing that math ability can be learned and developed. This belief may affect a

[1] This paper uses the US Department of Education's definition of STEM- Science, Technology, Engineering and Math (including computer science)

student's confidence in succeeding in STEM courses. High school class choice and test scores may seem irrelevant to many people later in life, but in actuality these factors can influence decisions about college and eventually career.

Taking more math and science classes in high school could affect choice of college major. Gender differences in field specialization in college are even more persistent than in high school: women are underrepresented in almost all STEM fields. Taking more high school math has been shown to increase a woman's likelihood of entering a technical or non-traditional field and the wages of female college graduates (Blau Winkler, 200). Gender differences in fields of study negatively affect women's earnings and occupational attainment. Women hold about half of all jobs in the US economy, but even as educated women increase their share of the workforce, they hold less than 25% of STEM jobs (Beede 2011). STEM jobs are among some of the highest paying occupations, so entering a STEM field could benefit a woman's labor market outcomes.

Literature Review

Gender Differences in Early Years

Many of the issues and gender differences we see in education and even the labor market can be traced back to things we were taught as children. There are several common gender stereotypes in education– such as men are more likely to be labeled as genius or brilliant, and men are more suited for math and science than women. Girls learn this early on and are primed to maintain this belief throughout their lives. Through various studies with elementary school aged children, Lin Bian demonstrates that by the age of six, girls are less likely than boys to believe that members of their own gender are brilliant; and they begin to shy away from activities that they believe are for brilliant children (Bian 2017). She notes that the sooner children latch on to the idea that brilliance is a male quality, the stronger the effect it may have on their future aspirations (Bian 2017). Learning these stereotypes early on in their education could discourage young girls from interest in math and science, and ultimately steer them away from STEM career fields.

Carol Dweck believes that the effect of these stereotypes can be corrected with intervention. She reports that the gender difference in math is not due to lack of ability, but a difference in coping with setbacks and confusion (Dweck 2009). Her research found that, "viewing intellectual ability as a gift (a fixed entity) led students to question that ability and lose motivation when they encountered setbacks. In contrast, viewing intellectual ability as a quality that could be developed led them to seek active and effective remedies in the face of difficulty" (Dweck 2009). This is another common stereotype: you either have math ability or you do not. The binary of having ability or not leaves many students feeling defeated. Dweck found that students who believed that their intellectual abilities were something they could grow maintained interest in learning and earned higher grades than those who saw intellectual abilities as a gift (Dweck 2009). She notes that, "viewing intellectual or mathematical abilities as a gift can create vulnerability in females. It makes them susceptible to a lowered sense of belonging, to a loss of confidence, and to decrements in performance in the face of difficulty and in the presence of stereotypes" (Dweck 2009). Therefore, she argues that the messages sent in education are important, they have the potential of helping students reach their potential (Dweck 2009).

Gender Differences in High School

As discussed in the previous section, gender differences in math and science begin to emerge early, and typically persist throughout high school and college without intervention. One measure of how these differences persist in high school is the gender ratio in STEM AP classes.

Donna Ginther and Shulamit Kahn note that considerably fewer girls than boys take math-intensive AP courses (such as computer science or advanced math like calculus); however, more girls than boys take AP courses in biology and environmental science which are less math-intensive STEM courses (Kahn Ginther 2017). This is consistent with Kahn and Ginther's findings that the under-representation of women in STEM is the strongest in math-intensive science fields (engineering, computer science, geosciences, etc.). One possible explanation for this difference in course taking is that a correlation between having a math growth mindset (belief that math is not just a gift but an ability that can be developed) and math performance, math interest, and math course choice in middle and high school exists (Blackwell et al. 2007). As previously discussed, having a math growth mindset helped boost female students' interest in math as well as their math performance; it is reasonable to assume that developing this mindset earlier on (middle school or early high school) would help girls succeed in their math courses and feel confident and interested enough to continue progressing through more difficult math courses. This has a direct effect on women's future earnings, as Blau and Winkler note that taking more high school math has been linked to increases in female college graduates' wages and the likelihood of entering technical and nontraditional fields (Blau Winkler 2018). This math growth mindset is not only crucial for students to have, but it is also beneficial for their parents and teachers to possess it as well. Khan and Ginther note that mothers' beliefs about their child's difficulty in math strongly influenced their child's math anxiety; as well as parents' math growth mindset had a larger impact on girls' growth mindset compared to boys (Kahn Ginther 2017). This coincides with Dweck's research in emphasizing the importance of the math growth mindset. Parent's who also hold the belief that math is not a gift but an ability that can be learned, would likely pass that belief on to their children which would make them more confident in their math abilities. Kahn and Ginther indicate that having a parent who was employed in a STEM occupation increased a child's probability of majoring in and working in STEM, with a larger effect on girls rather than boys (Kahn Ginther 2017). As expected, teachers can also have an impact on girls' future in STEM– having female STEM teachers in high school increased the probability that female students majored in STEM in college (Bottia et al. 2015). Having strong STEM role models seems to increase the likelihood of maintaining interest in STEM for girls.

Another measure of gender differences in STEM often looked at is the gap between male and female student's math test scores. Some researchers believe that psychological factors could also play a role in gender differences in math scores— women respond worse to competitive pressure than men, so the competitive pressures for test-taking may be distorting gender differences in skill (Blau Winkler 2018). Math test scores could be biased downwards for girls in relation to their actual mathematical skills because of the competitive nature of math test-taking. Girls are "sensitive to the gender of their competitors, and since more boys pursue mathematics, this lowers girls' math scores" (Niederle and Vesterlund 2010). Girls may be sensitive to their competitors and their peers. Many women have the preference of not working in a male dominated field, so it is possible this preference emerges early on and girls may prefer to work with and compete against other girls.

Gender Differences in College

As seen in the last two sections, math ability and confidence builds as time goes on for students with a math growth mindset. For those who do not have this mindset, grades and scores in STEM encourage or discourage students to major or take courses in STEM, so it is possible that these students are comparing their performance in STEM courses to their performance in non-STEM courses. Therefore, “what matters may not be STEM ability, but STEM ability relative to other abilities” (Kahn Ginther 2017). Dweck also noted that high achieving female students did well when they did not face difficulty, but struggled to cope with experiences and material that called their ability into question (Dweck 2009). While Dweck’s research focused more on girls in middle school, the idea still holds true further on in education. STEM fields are often based in problem solving and attempting to answer difficult questions. If women feel that their intellectual abilities are being questioned by having difficulty in understanding or solving these problems, they will turn away from STEM fields in favor of fields that they feel more confident in. This is one possible explanation for why men are more likely to major in STEM fields. Majoring in a STEM field also translates to a higher likelihood of working in a STEM field. In a study from 2009, women account for almost half of all employed college graduates aged 25 and over; however, women only account for about 25% of employed STEM degree holders, and only about 20% of STEM degree holders that work in STEM jobs. (Beede 2011). This can also be seen in the breakdown of those with STEM degrees who work in STEM jobs: about 40% of men with STEM college degrees work in STEM jobs, only 26% of women with STEM college degrees work in STEM jobs (Beede 2011). If women with STEM degrees are not working in STEM occupations, where are they working? Female STEM majors are twice as likely as men to work in education or healthcare (Kahn Ginther 2017). Beede notes that “approximately 14 percent of female STEM majors end up in education occupations, compared with approximately 6 percent of men” (Beede 2011). This could have an impact on labor market outcomes for women with STEM degrees. Women with college degrees (regardless of undergraduate major) can earn 20% more in STEM jobs than other fields (Beede 2011). Women may not be reaching their full earning potential by working in non-STEM fields, the next section will explain some possible explanations for why women with STEM degrees may not want to work in STEM jobs.

Gender Differences in the Labor Market

While women are more likely to attend college and graduate than men, men tend to specialize in higher paying fields than women. While there has been some integration of women into male dominated fields, women are still missing in STEM fields, typically some of the highest paying careers. A possible explanation for this could be societal discrimination. Blau and Winkler define societal discrimination as “the multitude of social influences that cause women to make decisions that adversely influence their status in the labor market” (Blau Winkler 2018). Women with STEM degrees may choose to work in fields like education and healthcare due to possible societal discrimination or preference. Kahn and Ginther explain that on average women are more “people-oriented” and men are more “thing-oriented,” and this preference is seen in choice of college major and job preference (Kahn Ginther 2017). STEM fields tend to be more thing-oriented than people-oriented, which does not match womens’ average preference for altruistic people-oriented work. Some women avoid or leave STEM fields because they do not enjoy the work atmosphere. There is a higher exit rate for women in STEM positions compared to non-STEM positions, Kahn and Ginther note two possible explanations: one is that women feel less satisfied in jobs with lower shares of women (male dominated fields like STEM), and two is that some women feel there is a cold work climate in the sense of time flexibility and childcare accommodations (Kahn Ginther 2017). Discontinuous workers will not experience the same gross benefits from college as continuous workers since the benefits compound over time. This is why time flexibility and child care accommodations are important because typically the responsibility of leaving the labor market to raise children falls to mothers. Some women may not want to leave the labor market, so they would rather find a job in another field with the accommodations they require.

Another area worth exploring is how working in STEM affects the gender wage gap. There are many determinants of the wage gap in general. Occupational segregation shows us that women tend to work in lower paying occupations like teaching and nursing while men gravitate toward higher paying professions like working as a doctor, lawyer, or in the STEM field. Blau and Winkler argue that gender differences in occupation and industry (occupational segregation) can explain a substantial portion (32.9%) of the wage gap (Blau Winkler 2018). Other studies show that female dominated occupations pay less than male dominated occupations for both men and women. However, Blau and Winkler point out that even within predominantly female fields, men tend to be paid more and move up the career ladder faster than their female counterparts (Blau Winkler 2018). Occupational segregation not only hurts women financially, but perpetuates gender roles that continue to discourage men and women from working in their preferred field without judgment. The gender wage gap persists in many ways, but it has declined since 1980. Blau and Winkler also attribute a decline in discrimination to a decrease in the wage gap; as women have become more cemented in the labor force, discriminatory tastes and prejudices have become less socially acceptable (Blau Winkler 2018). Another factor contributing to the decline of the gender wage gap is the shift in the labor market demand. Since the 1980s, demand for manufacturing and blue collar jobs, occupations typically held by men, has decreased. This is contrasted by the technological change brought by computers, increasing jobs that don’t require physical strength. Blau and Winkler emphasize that this benefited women because women are more likely than men to use computers at work (Blau Winkler 2018).

The gender wage gap also impacts different women in different ways. In the overall labor market in the mid-2010s the female-to-male ratio of average hourly earnings for the US full-time workers was between 79-82%, but the ratio for men and women in STEM occupations is narrower (a 14% difference in pay for STEM a 21% difference for non-STEM), meaning that there is a smaller gender wage gap in STEM occupations (Kahn Ginther 2017). Although fewer women work in STEM fields (which are male dominated), they face less of a gender wage gap than those who work in a non-STEM field. While white women still experience the wage gap, on average women of color experience a harsher gap. Married women and single women also face different gender wage gaps. As shown by Kahn and Ginther (2017):

> By controlling for field, age, race, level of highest degree, Carnegie-rating of first bachelor's degree (a measure of university quality), marital status, and presence of children, we halved this gap to 14.6%. Field of study was an important control, particularly because of the paucity of women with engineering and computer science degrees, the highest-paying STEM fields. In a second regression, we included all of these controls but allowed family variables (marriage, children) to affect men and women differently. We found that among those never- married without children, the unexplained gender gap falls to 5.3% *ceteris paribus* but is still highly significant. However, among those currently married with children, even with all background controls, the gap is 28.2%. In other words, family characteristics have a huge effect on the gender earnings gap.

They indicate that there is a much smaller gender wage gap for single women without children than for married women with children. This labor market discrimination could be due to fears that married women with children may not be as invested in their work or fears that they may leave to raise children or take care of their family. It is clear that gender differences throughout education directly impact gender differences in the labor market. Having a STEM job can have many benefits (higher pay, less wage gap), but starting from a young age, girls are discouraged from pursuing STEM as a result of lingering stereotypes.

Methodology

Data

Data for the subsequent analysis was obtained from the Education Longitudinal Study of 2002. This was "a nationally representative longitudinal study of 10th graders in 2002 and 12th graders in 2004" (NCES). This study gathered data from students, their parents, and their teachers beginning in 2002 when students were in 10th grade, and followed students through college and joining the workforce. In the base year of this study (2002), 750 schools were chosen with over 15,000 students and parents randomly selected from those schools to be surveyed (NCES). The National Center for Education Statistics notes that non-public schools (Catholic and other private schools) and Asian students were sampled at a higher rate to ensure a large enough sample size to compare to their counterparts. While this data is available for public use, certain variables were restricted from the public; so some of the variables used in the regression analysis may have been more fruitful had the continuous variable version of them been available.

Results

Using the data from the Education Longitudinal Study of 2002, I ran linear regressions to determine the effect of STEM education on income.

$$\ln(income) = \beta_1 Male + \beta_2 STEM\ classes + \beta_3 STEM\ classes * Male + \beta_4 GPA + \beta_5 Bachelor's + \beta_6 Postbacc + \beta_7 exper1 + \beta_8 exper2 \tag{1}$$

Using equation (1), which is a modified version of the Mincer model, I determined the effect of educational attainment on earnings. Table 1 shows the results of the regression.

Table 1

Independent Variables	OLS Regression
Male	0.377*** (0.0866)
STEM Classes taken in College	-0.0056 (0.00403)
STEM Classes * Male	0.0021 (0.0054)
GPA of STEM classes in College	0.0507** (0.0244)
Bachelor's Degree	0.260*** (0.0955)
Higher than Bachelor's Degree	0.1687 (0.404)
Between One to Two years experience at current job	0.0833 (0.0667)
Two or more years experience at current job	-0.0639 (0.1030)
Constant	9.418*** (0.0531)
Observations	1,251
R-Squared	0.046

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Men earn on average 37.7% more than women, holding other factors fixed. This data is not a one-to-one comparison of men and women in the same field, but this finding is consistent with the gender wage gap– regardless of what field, on average women earn less than men. The results also suggest that there is a small premium for men that take additional STEM courses in undergraduate studies; however this coefficient is not statistically significant at most conventional significance levels. This indicates that the return to taking STEM classes in college is not different for men and women. Although the return to a STEM education may be the same for men and women, fewer women major in STEM fields and go into STEM occupations. Another variable that does have a sizable impact on future wages is having a bachelor's degree. Those with bachelor's degrees earn on average 26% more than those without bachelor's degrees. Only the coefficients for Male, Bachelor's, and STEM GPA are statistically significant at 5% and 10% significance levels. While employers may not actually be interested in GPA from STEM courses in college, it might be considered an approximation for a graduates ability in STEM fields. If STEM GPA is looked at as a stand in for ability, this may explain GPA's positive impact on future earnings; those with higher ability could be more likely to be paid more. Alternatively, years at current job may not be an accurate approximation of years of labor market experience. Years of labor market experience would encompass years at current job, but years at current job is a less accurate indicator of earnings.

A notable limitation of this model is that it does not contain an independent variable that accurately represents experience. Experience is a key component of the Mincer model and is often considered a valuable determinant of wage.

$$\log(y) = \log(y_0) + rS + X_1 + X_2^2 \qquad (2)$$

The Mincer model (Equation 2) is highly influential in labor economics, and models the natural logarithm of earnings as a function of years of education and years of labor market experience (Lemieux 2006). Not accurately capturing experience in the model is a missed opportunity to use the Mincer model as intended, but may not be as fatal since the Mincer model has limitations of its own. One such limitation is that the model does not include an interaction term between education and experience. This was fine when the model was conceived by Jacob Mincer in 1974, but today the experience-wage profile has become steeper for high school rather than college graduates (Lemieux 2006). This means that "the experience-wage profiles are no longer parallel for different education groups," so the college-high school wage gap is now much larger for workers with less experience (Lemieux 2006). This can be seen to some extent in the results above, as those with a bachelor's degree earned significantly more (on average) than those without a bachelor's degree.

Conclusion

Starting early in education, girls are conditioned to doubt themselves based on outdated stereotypes. They might grow up and realize this stereotype is not true, but that does not stop or reverse the damage of believing they are not gifted with math ability. Education (especially math and science) builds on itself, so the effect of crippling young girls' confidence in their intellectual abilities is long lasting. This effect continues through high school and college, which in turn impacts what kind of job they seek out; demonstrating a clear influence on labor market outcomes. While the return to a STEM education may be the same for men and women, this does not account for or represent that women are still less likely to pursue a STEM education to begin with. Of the numerous factors that dissuade girls from pursuing a STEM education, lack of growth mindset seems to be the most influential. If girls do not believe they have the ability to succeed in STEM, why struggle through trying to develop the skills that it requires? It seems some of the gender bias in STEM could be mitigated by encouraging young girls to grow their math and science skills and providing them with female role models who can prove that it can be done. The effect of STEM education on earnings may be the same for men and women, but the path of that STEM education is very different between genders.

Bibliography

Beede, David, et al. "Women in STEM: A Gender Gap to Innovation." U.S. Department of Commerce Economics and Statistics Administration Issue Brief, #04-11. Available at: http://www.esa.doc.gov/sites/default/files/womeninstemagaptoinnovation8311.pdf.

Bian, Lin, et al. "Gender Stereotypes about Intellectual Ability Emerge Early and Influence Children's Interests." *Science*, vol. 355, no. 6323, 2017, pp. 389–391., https://doi.org/10.1126/science.aah6524.

Black, Sandra E., et al. "The Importance of STEM: High School Knowledge, Skills and Occupations in an Era of Growing Inequality." Research Policy, vol. 50, no. 7, Sept. 2021. EBSCOhost, search-ebscohost-com.proxy.lib.pdx.edu/login.aspx?direct=true&AuthType=ip,url,uid&db=ecn&AN=1908136&site=ehost-live.

Blackwell, Lisa S., et al. "Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention." *Child Development*, vol. 78, no. 1, Jan. 2007, pp. 246–63. *EBSCOhost*, https://doi-org.proxy.lib.pdx.edu/10.1111/j.1467-8624.2007.00995.x.

Blau, Francine D., and Anne E. Winkler. The Economics of Women, Men, and Work. Oxford University Press, 2018.

Bottia, Martha Cecilia, et al. "Growing the roots of STEM majors: Female math and science high school faculty and the participation of students in STEM." *Economics of Education Review* 45:14– 27. doi:10.1016/j.econedurev.2015.01.002.

Dweck, C. S. (2007). Is Math a Gift? Beliefs That Put Females at Risk. In S. J. Ceci & W. M. Williams (Eds.), *Why aren't more women in science?: Top researchers debate the evidence* (pp. 47–55). American Psychological Association. https://doi.org/10.1037/11546-004

Jia, Ning. Do Stricter High School Math Requirements Raise College STEM Attainment? (n.d.). Economics of Education Review, 83. https://doi.org/10.1016/j.econedurev.2021.102140

Joensen, J. S., & Nielsen, H. S. (2009). Is there a Causal Effect of High School Math on Labor Market Outcomes? The Journal of Human Resources., 44(1), 171–198. https://doi.org/10.3368/jhr.44.1.171

Kahn, Shulamit, and Donna Ginther. Women and STEM. 2017. EBSCOhost, doi:www.nber.org.proxy.lib.pdx.edu/papers/w23525.pdf.

Lemieux, Thomas. “The “Mincer Equation” Thirty Years After Schooling, Experience, and Earnings.” (2006).

Niederle, Muriel, and Lise Vesterlund. 2010. "Explaining the Gender Gap in Math Test Scores: The Role of Competition." *Journal of Economic Perspectives*, 24 (2): 129-44.

DOI: 10.1257/jep.24.2.129

The National Center for Education Statistics. “Education Longitudinal Study of 2002.” *Education Longitudinal Study of 2002 (Els:2002) - Overview: Purpose*, 2013, https://nces.ed.gov/surveys/els2002/index.asp.