Perpetuating the Gender Gap in Patents through Education Policy

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In conversation about workplace inequalities between the sexes, one issue that has been regularly addressed is wage disparity, generally phrased as "unequal pay for equal work." Though decades old, the subject remains relevant and important, perhaps more so because there has been no suitable solution. More recent feminist scholarship has raised a companion concern: whether or not the gender gap in patent assignments is problematic. Throughout the history of the United States, patents, which are an indicator of achievement or professional success in the field of engineering, have been a vehicle for generating wealth. Similar to gender wage disparity—women's earnings not being equal to men's for the same work—current data suggest that, although women make up more than half of the U.S. workforce, they constitute just 7.7 percent of U.S. patent holders.

On the one hand, some argue that this inequality is just the function of fewer women than men working in fields that provide an opportunity to file a patent application. From this perspective, a logical fix would be to increase the number of females employed in technology and innovation or engineering companies. On the other hand, however, some argue that contemporary corporate philosophy and workplace practices drive women away from careers in science, technology, engineering, and mathematics (STEM) industries. Workplace diversity scholars Yonghong Jade Xu and Cynthia Martin are proponents of this view, and believe "women feel that their freedom of expression is stifled. It may be…still a 'men's club.'"[1] According to the authors, non-inclusive work environments interfere with a woman's ability to collaborate with male peers on projects that could potentially lead to a

[1] Yonghong Jade Xu and Cynthia Martin, "Gender Differences in STEM Disciplines: From the Aspects of Informal Professional Networking and Faculty Career Development," *Gender Issues* 28, no. 3 (2011): 148.

patentable invention or improvement. In sum, then, discussion of the gender patent gap issue could be reduced down to whether women aren't in the right place, or the place isn't right for women. Institutional and legislative changes that might address the former argument would do nothing to address the latter. Cultural changes that might address the latter argument fall beyond the scope of legislation or institutional change. Addressing this part of the conversation is vital.

My own view is that correctly naming the cause of the gender gap in patenting is a critical detail in the conversation about how it best can be addressed. Though I concede that finding such a cause is unlikely because many other explanations are backed with good data as well, I maintain that enacting legislation, government policy, or institutional reforms to address such inequalities without an agreement about which "problem to solve" can be short-sighted at best, but economically irresponsible and, perhaps, ineffective at worst. For example, in an effort to draw more women and minorities into STEM fields, the United States government, along with various states and school districts, implemented a slate of science-, technology-, and engineering-specific educational programs. Although some might point out that such programs (even if they do not achieve all they are "supposed" to achieve), in the aggregate, will do more good than harm, I would reply that evidence suggests that such might not be the case. The issue is important because trying to "fix" the inequality without knowing its root cause appears to be perpetuating the imbalance. To begin, though, it might be helpful to consider why innovation is important, how patents encourage innovation, and how history has treated women innovators.

In his book *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It*, economic and public policy scholar Adam B. Jaffe writes that innovation leads to social benefits such as longer and healthier lives, rising incomes, and more numerous consumer choices for a population. Therefore, he says, "it is in our collective interests to create social, cultural, and legal institutions that foster technological innovation."[2] Jaffe notes that because technological innovation is capital-intensive, engineers and inventors are

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[2] Adam B. Jaffe, *Innovation and Its Discontents: How Our Broken Patent System Is Endangering Innovation and Progress, and What to Do About It* (Princeton, NJ: Princeton University Press, 2004), 42.

motivated to spend time and resources in the research and development process because they expect that they will be able to make “a bunch of money if the thing pans out.”[3] To that end, the government grants patents, which convert the innovator’s intangible creation into “property that can be bought and sold, or upon which a business can be founded.”[4] In the United States, the government uses its legal system to provide restitution to innovators whose proprietary ideas or products are made, used, or sold by others. Juries decide the penalty (usually a significant amount of money) that a patent “infringer” must pay to the patent awardee as compensation for the violation.

So patents protect the economic investments made in research and development, but they also protect the career interests of the researchers and inventors. Patents are the ultimate indicator of innovation and engineering success and, in the working world of invention, having no patents means not having the opportunity to qualify for career advancement.[5] As the United States Patent and Trademark Office (USPTO) numbers indicate, not many women have, or have had, this opportunity.

In the introduction to her essay “Examining Exclusion in Woman-Inventor Patenting: A Comparison of Educational Trends and Patent Data in the Era of Computer Engineer Barbie®,” Annette I. Kahler, former director of the Science and Technology Law Center at Albany Law School, includes a brief overview of the obstacles American women have encountered in the pursuit of patents. Many of the historical roadblocks she cites are understood also to be the basis for wage disparity between the sexes: no property rights, no educational opportunities, no or limited monetary resources, and societal condemnation if a woman left her “home.” Other obstacles included a lack of legal remedy in the event a woman *did* invent something. In such a case, her husband would secure the patent, then sell and keep any profits made from the invention and she would be unable to benefit.[6] Kahler also believes that women in 19th-century America were

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[3] Ibid., 43.
[4] Ibid., 41.
[5] Sue V. Rosser, “The Gender Gap in Patenting: Is Technology Transfer a Feminist Issue?” *NWSA Journal* 21 no. 2 (2009): Intro.
[6] Annette I. Kahler, “Examining Exclusion in Woman-Inventor Patenting: A Comparison of Educational Trends and Patent Data in the Era of Computer Engineer Barbie®,” *The American University Journal of Gender, Social Policy and the Law* 19, no. 3 (2011): 780.

discouraged from pursuing the higher education required to enter the fields of engineering and science. Further, she notes that women were dissuaded from embarking on labor-intensive innovation careers, primarily because of the societal attitude that workplace demands on their bodies might create reproductive difficulties.[7]

These historical influences are important to consider upon returning to the task of agreeing on which problem of causation to solve. Today, as in the 19th century, an obvious correlation can be made between a low number of patents granted to women and a low number of women in the fields of technology and engineering. But today, unlike in the 19th century, women seem to be pursuing the educational requirements that should lead to careers in STEM fields. The United States Bureau of Labor Statistics (USBLS) data indicate that in 2015 women made up approximately 15 percent of the engineering workforce, and just 8.3 percent of the patent-producing field of mechanical engineering.[8] Of course there are broad, traditionally male-dominated employment fields (i.e., in the construction industry, 2.7 percent of the workforce is female), but the percentage of engineering and technology jobs held by women is lower than the percentage of women leaving college with marketable STEM degrees.

American Society for Engineering Education (ASEE) data show that for the 2014–15 academic year, women earned 19.9 percent of all undergraduate engineering degrees,[9] 25.2 percent of all engineering master's degrees,[10] and 23.1 percent of all engineering doctorates.[11] The difference between the percentage of STEM degrees granted to women and the percentage of women finding employment in engineering or technology fields indicates that some obstacle other than the prerequisite education level keeps women from careers in fields of patentable innovation.

Some researchers today observe that there are numerous women embarking on careers in technology or engineering, but then exiting the field. Sue V. Rosser attributes this pattern to—drumroll, please—lack of patents. In her work, Rosser studies the impediments women face once they have moved from STEM

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[7] Ibid., 781.
[8] United States Bureau of Labor Statistics, Report 3, Washington, D.C., (2015) 3.
[9] American Society for Engineering Education, *Engineering College Profiles and Statistics* (Washington, D.C.: Author, 2015), 12.
[10] Ibid., 20.
[11] Ibid., 24.

education to STEM careers and how those roadblocks keep patents out of women's reach. Interviews conducted with industry professionals show that women encounter gender discrimination in at least two important phases of the patent quest: acquiring venture capital to fund projects that could culminate in a patent grant, and during the patent "review" process.

Gender bias exhibited by venture capitalists is thought to be a function of the prevailing societal attitude that commercialized innovation is a male domain, likely derived from the historical underrepresentation of women in fields of invention.[12] A case can also be made that women are stereotyped as deficient money handlers or investors. Therefore, they are thought to present a greater risk for the venture capitalist's outlay of funding for a project presented by a woman versus a project presented by a man.[13] In either case, Rosser's interview findings, referred to in the preceding paragraph, are consistent with data showing that 76 percent of venture capital investors take prior patent grants into account before deciding to fund.[14]

Rosser's interviews documented other barriers encountered by women seeking to patent an innovation—the most ominous of which is typically all-male patent review panels.[15] The perceptions of these review panels are gender-biased because their collective experience edifies that they themselves, privileged males, are responsible for the engineering of new technologies, as well as supplying the money to create them.[16] Such prejudiced views often result in the rejection of the patent application, and further undermine women's attitudes about the practicality of remaining in fields of invention.

Rosser points out that "few women obtaining patents hurts scientific innovations, technology, and competitiveness overall,"[17] but even more problematic, because patenting is integral to technology and science firms, women literally cannot succeed.[18]

[12] Fiona Murray and Leigh Graham, "Buying Science and Selling Science: Gender Differences in the Market for Commercial Science," *Journal of Industrial and Corporate Change* 16, no. 4, (2007): 679.
[13] Ibid., 676.
[14] Institute for Women's Policy Research, *Where Are the Women Patent Holders?* (Washington, DC: Author, 2016), 7.
[15] Rosser, 74.
[16] Ibid., 79.
[17] Ibid., 67.
[18] Ibid., 71.

This lack of success drives the downward spiral because the venture capitalists behind commercialized science, as discussed, might not back the projects of a non-patented female inventor.

Other researchers maintain that a sufficient number of women are employed as engineers, but that they are not in jobs that can lead to patentable projects. This contention seems plausible. ASEE data, again from the 2014–15 academic year, indicate that 38.9 percent of electrical and mechanical engineering master's degrees were awarded to women. Recall that presently 7.7 percent of all patents awarded go to women. If all women engineers—a total of 15 percent of the engineering workforce—earned their degrees in either electrical or mechanical engineering and entered the workforce, technological advances and the patent awards in STEM would likely increase from 7 percent to around 24 percent.[19]

The varied explanations for why or whether women are underrepresented in STEM workplaces, coupled with the possibility that the workplace itself is a deterrent, suggest that developing a strategy to provide more opportunities for women innovators should be undertaken carefully. However, against this backdrop, wholesale adoption of STEM education programs has taken place, and as inequitable as the gender patent gap might be, the situation might be going from bad to worse.

According to the United States Government Accountability Office (GAO), federal involvement in STEM educational programs began in 2003.[20] At that time, the government sought to increase the number of STEM field college graduates to help mitigate what was then viewed as a "STEM crisis"—that is, the lack of job growth in the United States in the late 1990s, combined with what was perceived to be a loss of technological superiority to foreign businesses. The "crisis" was introduced into political conversation at about the same time the No Child Left Behind Act became law in 2001, and STEM education discussion expanded to include K–12 as well as post-secondary institutions.[21] It is worth noting that in 2004, the U.S. government reported spending $2.8

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[19] Jennifer Hunt, Jean-Philippe Garant, Hannah Herman, and David J. Munroe, "Why Don't Women Patent." *Working Paper 17888. National Bureau of Economic Research* (Cambridge, MA: Author, 2012), 13.

[20] United States Government Accountability Office, *Federal Science, Technology, Engineering, and Mathematics Programs and Related Trends* (Washington, DC: Author, 2005), 18. Accessed September 15, 2016.

[21] Michael Anft, "The STEM-Crisis Myth," *Chronicle of Higher Education* 60, no. 11 (2013): A30,

billion on STEM education programs across 13 agencies.[22] GAO reporting of the budget for and progress made in these programs began in 2005 and included figures for the 2004 fiscal year. The mission of the lone gender-focused program, "Research on Gender in Science and Engineering," was to facilitate drawing more girls and women into STEM classes, majors, and careers by providing funds for research and extension services. The 2004 budget for this initiative was $10 million, or 0.4 percent of the original $2.8 billion.

GAO reported in 2010 that the agencies' budgets increased to more than $3 billion, and the Research on Gender in Science and Engineering received a proportional $11.5 million. More important, however, is the GAO's statement that "efforts to coordinate STEM education programs across the government remain limited."[23] The GAO also determined that the success of any of the prior initiatives could not be measured because of the inability of agencies to procure data from schools (primarily K–12). To address these shortcomings, oversight of the U.S. government's STEM education agencies was passed to the National Committee on Science, Technology, Engineering, and Math Education (CoSTEM).[24] At this point, the U.S. government had spent $15 billion for STEM education before analyzing the effectiveness and ancillary outcomes of the programs.

Based on these analyses, changes were made to address the shortcomings, but the budget expanded. In March 2016, the 2017 U.S Federal Budget that was presented included $7 billion for STEM education initiatives, but made little provision for female-specific programs ($500,000 for the Nancy Foster Scholarship granted through the National Oceanic and Atmospheric Administration). Surprisingly, a paltry $109 million (or 1.6 percent) will be targeted to increase the number of all undergraduate engineering majors. Included in the goal statement of this "Transforming Undergraduate Teaching and Learning" program is "the need to recruit more women…into majors in

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[22] GAO, (2005): 18.

[23] United State Government Accountability Office, *Science, Technology, Engineering, and Mathematics Education: Strategic Planning Needed to Better Manage Overlapping Programs Across Multiple Agencies* (Washington, DC: Author, 2012), 21. Accessed September 15, 2016.

[24] Ibid., 21.

computer science."[25] In 15 years, federal monetary investment in programs that could steer women into fields of patentable innovation, that is, engineering, has gone from very little—0.3 percent in 2004—to nearly none.

The bulk of the $7 billion STEM education budget is earmarked for the Obama Administration's mandated "Computer Science for All" program.[26] With a $4 billion allocation, the program's goal is to expose all students, beginning in pre-school, to computer science. The remainder of the budget, which is discretionary, is intended to help K–12 schools support STEM education through academic enrichment grants,[27] to train teachers in best STEM education practices,[28] and to provide research money for development of both formal and informal educational tools.[29] Discretionary spending on STEM programs in middle schools and high schools should, ostensibly, lead to an increase in the number of girls preparing for STEM college degrees, but the trend appears unchanged.

One such discretionary funded high school program, Project Lead the Way (PLTW), provides a pre-engineering curriculum for participant schools. For a school or school district to offer such introductory-level courses, investments must be made in the building(s) to accommodate updated computer systems, as well as specialized work stations. PLTW literature estimates $35,000 would be needed to create an adequate classroom if the room was not previously used for science classes. Once the infrastructure is updated, the school(s) incur additional costs to train teachers, purchase laptops capable of running engineering software, specialized printers, equipment, and setup fees, totaling about $30,000. PLTW's Principles of Engineering course requires $450 worth of consumables per student. As these figures show, the costs of such pre-engineering programs—intended to *interest* students in STEM fields—is significant and out of reach for many school districts.

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[25] Executive Office of the President of the United States, *Progress Report on Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education*. (Washington, DC: Government Printing Office, 2016), 6. Accessed September 3, 2016.
[26] Ibid., 1.
[27] Ibid., 3.
[28] Ibid., 5.
[29] Ibid., 9.

School districts likely to incorporate packaged programs such as PLTW in their curriculum are located in affluent suburban areas and receive state funding or grants to help implementation.[30] For many reasons, this disparity is disheartening, but it does provide a clear look at participation by gender: in schools where parental income levels are high, both boys and girls are offered the opportunity to participate in pre-engineering programs. Because of the socioeconomic profile of students taking advantage of programs such as PLTW, the costs of earning a STEM degree from a four-year institution are not prohibitive to the student, whether male or female. Yet across the United States, in schools offering the PLTW pre-engineering curriculum, girls account for only 17 percent of program enrollment. According to PLTW calculations, enrollment of females would have to triple for proportional representation to be attained.[31]

In studying this imbalance, IUPUI researchers Kenneth Reid and Charles Feldhaus also analyzed the preparedness of PLTW students from Indiana high schools for engineering coursework at the time they enter college.[32] Although Reid and Feldhaus believe PLTW does influence readiness for rigorous college-level work, they do not think the program, in and of itself, results in a student choosing to major in a STEM discipline. Rather, they say, success in and the choosing of a STEM major is the result of a challenging high school course load that was discussed and agreed upon by the student during meetings with counselors and parents. If girls are not advised at the beginning of high school to take STEM preparatory classes, they will not pursue STEM degrees as college undergraduates.[33]

The crucial role of parents in the girl's decision-making process is the influence they can exert over their daughters through their own gendered thinking. Lou Jean Beishline studied and collected via interviews data about female undergraduate

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[30] Douglas Walcerz, "Report on the Third Year of Implementation of Project Lead the Way," *Outcomes Assessment System Report,* (2009): 21.

[31] Ibid., 22.

[32] Reid, Kenneth, and Charles Feldhaus, "Issues for Universities Working With K-12 Institutions Implementing Prepackaged Pre-Engineering Curricula such as Project Lead the Way." *Journal of STEM Education: Innovations & Research* 8, no. 3/4, (2007): 5–14.

[33] Laura Horn and Xianglei Chen, For the National Institute on Postsecondary Education, Libraries, and Lifelong Learning, *Toward Resiliency: At-Risk Students Who Make It to College* (Washington, DC: Government Printing Office, 1998), 14.

engineering students' childhood home life. She found that stereotyped gendered thinking by a girl's parents discouraged the pursuit of an engineering career by conveying the expectations associated with engineering in a burdensome way. This might be expressed through parental concerns about the intense workload of the engineering profession or the limits such a career would place on a woman's ability to raise children and care for a home.[34]

Beishline's interviews also indicated that a high percentage of the young women experienced or recognized unintentional inequities. In their grade school and high school math and science classrooms, for example, they were not called on to solve problems or explain concepts. The young women said their teachers most often selected boys in the class to provide solutions and answers. Beishline believes these biases, absent parental encouragement to do so, discourage female students from entering college engineering or technology programs.[35]

So, considering that PLTW reports 17 percent of enrolled students are girls and comparing that figure with the 15 percent of engineering bachelor's degrees being earned by women, a case could be made that the money invested by local school districts is well-spent. Girls who are guided by their parents and/or counselors to participate in STEM classes in middle or high school generally earn a STEM degree in college. This argument, however, precludes the fact that, for a woman, earning the engineering degree likely will not result in the career success a patent would bring. As it stands, developing an interest in STEM and choosing a STEM major is only half the battle.

Between 2009 and 2015, the number of all mechanical engineering master's degrees awarded increased by 50.7 percent, so clearly the government STEM initiatives are producing more employable innovators. On the surface, such gains would look to be a boon for both the STEM industry and the STEM worker. Further analysis, however, suggests that perhaps these gains are creating detrimental (or, more accurately, one-sided) results.

According to Harvard University's Michael Teitelbaum, the United States' anxiety over the STEM "crisis," which paved the way for subsequent STEM education initiatives, is unwarranted.

[34] Lou Jean Beishline, *Perceptions of Women in Engineering Programs Regarding Parental Influence on Academic Choice: A Qualitative Study.* Dissertation, Marywood University, (2008): 32.

[35] Ibid., 32.

He believes that the worried discussion about unfilled engineering- and technology-sector jobs is started and maintained by industries that employ STEM workers as well as those industries' Washington lobbyists and trade associations. Teitelbaum is particularly incited by this ongoing, inaccurate portrayal of the STEM situation because "[s]uch claims have convinced some politicians and journalists, who echo them."[36] Government data indicate that Teitelbaum's stance is solid.

In the May 2015 *Monthly Labor Review*, the USBLS acknowledged that there is no nation-wide shortage of mechanical engineers,[37] so an increase in women's representation in the field, though possible, is not likely at this time. Further evidence suggests that the demand for mechanical engineers—even those with master's degrees—is stagnant, and those who presently are employed are vulnerable to layoffs.[38]

The expanding pool of degree-qualified mechanical engineers—both male and female—is now competing for scarce jobs. Rochester Institute of Technology professor Ron Hira thinks that there are only two possible outcomes for this problem of engineer oversupply: U.S. engineers will have to give up their demand for high wages and workplace and career security, or U.S. engineers will have to find a way to make themselves more marketable (productive) to stave off the hiring of lower-wage immigrant engineers.[39] In either scenario, the demand for engineers is not rising, as the stagnation of engineering wages demonstrates. According to research at the University of California–Davis, 25 percent of mechanical engineers who graduated from the Massachusetts Institute of Technology in 2012 took jobs on Wall Street rather than in technology sectors, ostensibly to earn a higher salary.[40]

While the natural market response to this over-supply of engineering labor will turn from wage stagnation to wage erosion, the harsher reality is that newly-minted female mechanical

[36] Anft, A30.

[37] United State Bureau of Labor and Statistics, *Employed Persons by Detailed Occupation, Sex, Race, and Hispanic or Latino Ethnicity* (Washington, DC: Author, 2015), 11.

[38] AFL-CIO, "Engineers," *DPEAFLCIO* (2014): 3.

[39] Ron Hira, "Not Enough U.S. Engineers?" *Issues in Science and Technology* 23, no. 4, (2007): 8.

[40]Norman Matloff and Jeff Flake, "Should Foreign STEM Graduates Get Green Cards?" *U.S. News and World Report* 4 no. 20, (2012): 2.

engineers will lose their shot at finding jobs that can lead to eventual patent applications. If the pool of employable innovators continues to expand as a result of federal STEM education policy, but the increase is not reflected in the employment of women, the opportunity for women to benefit through the patent system is diminished even further.

Theories and explanations about why the gender gap in patents persists run the gamut from deeply engrained biases against women in the traditionally male-dominated fields of innovation (the place isn't right for women), to women's unsuitability for handling the money involved in project funding (women aren't in the right place). In outlining a sample of scholarly thought on gender disparity in patent ownership, it becomes clear that the issue is not one that can be rectified by making changes through government policy or education reform. Gender inequality is part of STEM culture, whether in the classroom or in the workplace, perpetrated by societal and cultural attitudes that deem these locations as outside the domain of girls and women. Moreover, because the die has been cast by the adoption of and continued funding levels of STEM education initiatives through U.S. government policy—for a problem that might not even exist—the task of working toward gender equality in patent awards has been made exponentially more difficult as proportional representation of women in engineering and technology industries declines.