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A Data-driven Approach To Understanding Gender Disparities In Nuclear Engineering

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ABSTRACT

Nuclear engineering is an important educational and professional component of many key initiatives of the U.S., including energy and environmental security, and nuclear non-proliferation. While the gender and diversity gaps may appear to be lessening somewhat in the general nuclear policy sphere, the data on degrees conferred in recent years from major technical nuclear engineering programs shows that there is still a major gap. This puts many initiatives at a disadvantage, as cognitive diversity, plentiful where gender and ethnic diversity thrive, can help teams get to better solutions, with less interference from 'group think'. Many of the same gender gap issues seem to also exist in related STEM areas (electrical engineering, nuclear physics, applied mathematics, etc.) This project uses quantitative survey results to analyze potential contributing factors to this ongoing disparity.

INTRODUCTION

The impetus to undertake this project was manifold. First of all, and in a subjective manner, it has long been apparent to me that from the earliest days of kindergarten, grade school, and even before, that societal gender expectations are placed on children in a troubling, all-consuming fashion. This is something most of us have witnessed, whether we were troubled by it or not: color assignments of clothing and toys by gender, comments to children regarding what is expected and societally acceptable vis-à-vis their sex and gender from before they can talk; the list is lengthy, and hopefully well known to the lay person. Personal experience certainly lines up the data points for me: cis gendered female children are often praised for their beauty and manners, while cis gendered male children are often praised for their intelligence and bravery. Of course, these are generalizations, which do not apply to every situation, but I would (subjectively) argue that these trends do exist, and should be allowed into the discourse surrounding this issue.

On a more professional level, this project originated from an invitation to present at the Conference on Data Analysis (CODA) put on at Los Alamos National Laboratory in 2020. When asked to present on a topic of socio-cultural interest at national laboratories, and having a few years before finished a graduate degree in nuclear engineering, this topic immediately came to mind, and I jumped at the opportunity to look into issues of representation (not only gender) present broadly in STEM, and more specifically in nuclear engineering. While the originally scope was much broader, and the data collected sought to gain insight into other factors regarding entering nuclear engineering and STEM (such as parental careers, geographic origin, family income and education levels, and other

issues), the data were overwhelming, and since gender was the main impetus for taking on the work, this paper will focus specifically on that aspect of the research.

While national laboratories seem to have slightly greater gender representation than other industries, some troubling trends are noticeable: for example, while at the lower end of the career ladder, the disparity between male and female entrants is lower and apparently more welcoming to females. However, as the levels become higher and career advancement becomes more of the goal than career entrance, the disparity in favor of males grows greater. This is not even taking into account non-cis gendered individuals on the career path to nuclear engineering and related scientific fields, and is additionally not looking closely at the troubling racial disparities that are also prevalent. These issues are extremely important and urgently need to be addressed, but deserve their own platform, not to be a side note in this paper looking at traditionally discussed gender disparities. Suffice to say, while the cis male/cis female disparities seem to be addressed in some cases at the early stages of one's career, they tend to worsen over time, and the link between what happens, culturally, at a young age, and how that influences what happens later in people's careers, is of great interest, and impelled the research that led to this paper.

ASSUMPTIONS PRIOR TO RESEARCH

- Nuclear engineering is predominantly a white, cis male undertaking
- A disconnect along the way often occurs for women interested in STEM, leading them away from various types of advanced engineering
- Many women are scared off early in pursuing STEM, not by lack of ability, but by confidence issues encountered early in their education
- Teachers and role models leave a strong impression on young minds, particularly bad teachers
- Many women have been told that they are bad at math, and they believe it
- The latter experience closes many doors
- Many bad experiences occur at tough ages, when fitting in is very important

WHY IS THIS IMPORTANT?

The skeptic might ask: Why is this important? There are several reasons. First, let us examine the business/economic case for promoting a less gender skewed workforce in nuclear engineering and, more broadly, STEM. Several countries have done research leading to the conclusion that there is a projected lack of skilled engineering workforce in the coming years and decades.[i] National laboratories and the sponsors often undertake efforts to address the fading pipeline in all things nuclear, from diplomacy to science and engineering. If only a small portion of the population is being empowered to pursue engineering, and, of critical importance, nuclear engineering, there is a business risk of not having sufficient expertise to address urgent needs in the staffing of nuclear energy and nuclear security enterprises.

Another reason is the engineering case. Groupthink, as we refer to it, often occurs in situations with a lack of cognitive diversity present in a group. All other things being equal, cognitive diversity trumps like-mindedness, and lends itself to more innovative, creative solutions. Diverse perspectives and interpretations can be beneficial. The term

'diverse heuristics' (or, varied ways to reach solutions) are valuable when addressing engineering challenges. In short, diversity assists innovation. With the problem set facing the nuclear arena, ranging from nuclear security and nonproliferation concerns, to the urgent need for nuclear energy acceptance and implementation in the face of climate change, the importance of innovation and success cannot be overstated. We need a large and competent workforce, we need a diverse workforce, and we need flexible and creative problem-solvers.[ii] To get that workforce, women, minorities, and non cis people need to be empowered to enter and succeed in spaces into which they have traditionally not been welcomed.

Finally (for this paper; there are many more cases to be made), there is the security case for gender diversity in the nuclear realm. Feminist scholars argue that gender issues intersect with nuclear weapons issues in several ways.[iii] From a policy perspective, there is a significant body of work pointing to the gendered patterns of harm resulting from a weapons discourse that has traditionally favored the input of cis male, white individuals. Approaches to nuclear weapons and the policy pertaining to them need to recognize that traditional gender exclusion, the fact that for most of the history of the nuclear weapons programs of the world, women (and other minorities) were not present at the decision making table – the table at which, quite literally, the fate of all humankind might be determined. Additionally, when discussing arms control and nonproliferation decisions, the same cognitive diversity argument listed above is vibrantly applicable in the policy, decision-making case. Empowered and diverse expertise is urgently needed, whether among engineers, policy-makers, academics, or nuclear industry representatives.

THE PIPELINE

As previously noted, it is the contention of these authors that a troubling societal pressure is applied to young children from an early age, possibly affecting their future career choices and, by extension, options. When presenting on this topic at various forums, I often present the simplified argument of an image: The artwork of a South Korean photographer, called the Blue and Pink project, which illustrates how children are steered into certain interests from an early age. Further adding to the complexity of the issue, is the backlash of the blue versus pink argument. This backlash can be well described by a typical tee-shirt often seen on the female children of scientists or those interested in science, in which a female child wears a shirt that says something to the effect of, 'forget princess, I want to be an astrophysicist'. Both of these societal pressures are undue and unfair to children: first of all, they should not be pressured into traditional expectations for themselves based on their sex at birth. Secondly, they should not be pressured to dislike and disavow themselves from all things that are traditionally linked to their assigned or chosen gender. Children should be given the option to like or dislike the toys they choose to like or dislike; to follow or not follow certain academic and hobby paths; and ultimately, to pursue the career that gives them joy and fulfillment, as opposed to the career that societal actors (such as parents, friends, teachers, pastors, etc.) expect them to pursue. In particular, when it comes to sciences, a false dichotomy exists for many young girls – you can either be interested in 'girly' stuff, or in serious things like science.

PROJECT QUESTIONS AND METHODOLOGY

The research for this project involved an emailed survey, to which126 people responded. The intention was to obtain responses from both STEM and non-STEM students and professionals, which was achieved. The questions were formulated in order to obtain a snapshot of age, gender identification, geographical origin, parental professions, impact of various teachers, and current work/future work goals, etc.
Many rich data points could be obtained by cross-referencing one or two answers from within the survey. However, there was so much data, that in the end, the focus came down to gender disparities with a focus on cis female hurdles, and a secondary focus LGBTQI+ hurdles.[iv]

GENERAL RESULTS

Some of the overarching findings of the work included the following:

- Teachers matter slightly more than parents in career decisions, on average (with variation based on other factors)
- High school teachers matter significantly
- 42% of respondents identified seeing people 'like me' as a major catalyst for career choices*
- High variation existed between answer patterns for respondents identifying as cis female versus cis male

One of the important questions asked was, "Does seeing someone 'like me'" matter with regard to gender? The answers varied greatly based on the self-reported gender of the respondent. Among cis female respondents, 51% answered yes, and 29% answered that they had never observed someone whom they identified as being 'like them' in the field of their choice. That implies that there is still a hefty gap in the role model/pipeline department. Among cis male respondents, those answering 'yes to the initial question was only 34%, and on top of that, only 14% found that they had never observed someone whom they identified as being 'like [me]' in the field. The most troubling finding had to do with how those not identifying as cis male or female responded to this question. Sadly, 0% of respondents from this pool of self-reporting individuals reported having observed someone 'like me' in their field. 70% said it did matter to observe such a person; one can only begin to surmise what further detail would have been shared on the potential positive impact of such a role model, had it existed for these respondents. 30% reported that it did not matter. In this regard, the authors ruminate on the fact that perhaps one becomes accustomed to seeing no similar role models, and learns to make up the gap in other ways, which is enterprising and a cause for celebration. However, when compared with the cis male respondents, 86% of whom reported observing such similar role models, the massive disparity becomes achingly apparent.

OVERARCHING TAKE AWAYS

Cis female respondents, and non-cis respondents, placed a much higher value that cis male respondents on seeing someone with whom they could identify in positions to which they would likely aspire professionally. Non-cis respondents rarely saw role models like

themselves – and, perhaps relatedly, were poorly represented in the survey results. A few options came to mind as to what this might mean. Could it mean that we failed to reach diverse groups? Could it be that despite casting a wide net, we mostly reached populations more traditionally comfortable in formal scientific institutions?

When delving into cis male versus cis female questions in order to better understand both the generalized societal roots of the gap, and the results of the survey, an interesting fact appeared. According to *Scientista*, girl students taking a math test among a mixed gender population will average 55% correct answers. But girl students taking a math test only among other girls will average 70% correct answers.[v] What could account for this, and why does it matter in terms of the nuclear engineering pipeline? Could it be that the importance placed on likeability, and the importance of being perceived as attractive, are so ingrained in young girls that it can impede their comfort in the early years of learning the building blocks of STEM? Likeability, in this case, may be related to a perception of fitting in. The authors of this paper believe that there is evidence to suggest that the following social formula may be at play, and may impact career choices.

Femininity + Likeability* = Professional Social Relationship SUCCESS

A common message that young girls and women perceive is that their appearance, and their likeability, is crucial to their success. Likeability and appearance should not be something that is required for success, nor is the eschewing of these things something that should indicate that women or girls are serious in their academic, intellectual, and professional pursuits.

Starting at a very early age, marketing to children diverges greatly based on a dichotomous formulation of gender. For example, Lego and similar toys marketed to girls are often made up of fewer pieces, with simpler instructions, that Lego toys marketed to boys. How is this supposed to set girls up for success within STEM? And furthermore, what is it telling young boys that they are permitted to be interested in? Additionally, at an early age colors (as mentioned previously) are assigned to genders, in such a way that children know and experience the social cues of what is for them, and what is not for them, at a troublingly early age. This is not to imply that girls should not be allowed to like pink, nor that boys should not be allowed to like blue. That is entirely a false message. Similarly, telling girls that they should not like dolls is not the point. Nor is telling boys that they should not like traditional gendered male things, like trucks. But having young girls (or anyone!) infer that "pink is bad" is an overly simplistic path forward – and only reinforces negative stereotypes girls might have developed about themselves.

The correlation between liking fashion/appearance/etc. to being less of a "math person" is false, created by the society in which children grow up, and can be addressed by having more inclusive toys/environments for all children (among other efforts.)

CONCLUSIONS

This project, while aiming at assessing a variety of factors, quickly became mostly about how our society teaches cis female success to young girls. Many additional areas of

research were addressed: impact of geographic origin, impact of parental input and background, and vicinity/access to STEM programs/internships/laboratories. These areas are rich with data, and already are generating additional questions, which will be further pursued.

The results, versus the preliminary assumptions of the project, are as follows. Assumption 1: Nuclear engineering is predominantly a white, cis male undertaking. This assumption was confirmed. Assumption 2: A disconnect along the way often occurs for women interested in STEM, leading them away from various types of advanced engineering. Unfortunately, this was also confirmed. Assumption 3: Many women are scared off early in pursuing STEM, not by lack of ability, but by confidence issues encountered early in their education. This was thoroughly confirmed, through the responses received from survey takers who identified as not being on a path to a career in STEM. Assumption 4: Teachers and role models leave a strong impression on young minds. This was also confirmed, especially in the case of bad teachers. The final assumption was also confirmed: Many women have been told that they are bad at math, and they believe it. The latter experience closes many doors.

The final, and most important conclusions were as follows. The socialization of the importance of likeability to women raised to be traditionally successful cis-females can have a massive impact on career choices, particularly if coupled with subpar, or less thoughtful, teachers. Ceasing to make certain subconscious, gendered, dichotomous inferences and actions towards girls and boys about what success needs to look like 'for them' may pave the way and allow for greater inclusivity – and greater cognitive diversity in engineering and science. In the case of nuclear engineering, the need for a successful and creative, successful workforce going forward is without a doubt a matter of life and death – whether in terms of the future of nuclear weapons arsenals, or in terms of meeting rising energy needs in a fashion with a far lower environmental footprint than humans are currently producing. We need all the good minds we can get. Those minds need to be diverse in order to solve the huge problems, both that we inherited, and that we are creating today.

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[iii] *Ray Acheson, "Sex, Gender, and Nuclear Weapons", Reaching Critical Will Reachingcriticalwill.org/images/documents/Publications/sex-gender-nuclear-weapons.pdf*

[iv] The reason for the 'secondary' is that unfortunately, there was very little data, possibly due to a traditional gender bias in favor of cis males in the field.
[v] scientistafoundation.com/women-in-science-news/the-gender-gap-in-engineering