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Gender Inequality in STEM Academia: An Investigation of Factors that Influence the Decision to Remain in the Pipeline

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Abstract

In our modern day and age most countries, especially the United States, have recognized the importance of gender equality. National statistics show that although women earn 42% of science and engineering doctorates, they hold less than 25% of STEM jobs. On top of that, women only occupy 21% of full science professor positions and 5% of full engineering professor positions. According to a recent study on faculty retention and survival rates at research institutions, women have comparable success to men once in a tenure track faculty position. This provides evidence that women are somehow lost from the pipeline between earning a PhD and accepting a tenure track academic position. This investigation aims to answer the predicament of why women that are talented and dedicated enough to earn a STEM PhD elect to pursue career paths other than the research academic track. Statistical data have been collected from several high-activity research institutions as well as from top primarily undergraduate institutions to identify trends in faculty demographics by institution and by discipline. One key observation thus far is that the field of chemistry has an average proportion of women in comparison with other STEM departments, and the United States Naval Academy (USNA) has a higher percentage of females in chemistry compared to the other institutions. Thus, USNA was chosen as a case study to examine potential reasons for its success. Faculty in the Chemistry Department and other departments were surveyed to investigate decisions and choices that influenced their career paths. The results of this analysis are presented with the hope that trends identified at USNA might contribute to the implementation of policies at other institutions to attract and retain more women.

Keywords: Gender Inequality, STEM Academia, Retention of Females

1. Introduction

In our modern day and age most countries, especially the United States, have recognized the importance of gender equality. However, in 2014 the United States was only ranked 20th of 142 countries for job equality and was behind many third world countries. As our country strives to promote economic participation and opportunity domestically, many sectors have been under evaluation which includes the participation of females in higher positions of STEM.[1] In the overall labor force, 21.4 million women (48%) and 22.2 million men (52%) make up the work force which is nearly equal, yet women currently hold less than a quarter of STEM jobs.[2] Furthermore, women are earning 42% of the STEM PhDs,[3] but only occupy 21% of full science professor positions and 5% of full engineering positions.[4] In the field of chemistry, women earned 37% of chemistry PhDs in 2012, but for the 2012-13 academic year women held only 18% of tenure track positions in the top 50 schools in terms of R&D spending.[5] According to a recent study on faculty retention and survival rates at research institutions, women have comparable success to men once in a tenure track faculty position.[6] This provides evidence that women are somehow lost from the pipeline between earning a PhD and accepting a tenure track academic position.

Although much research has been done (see Background section that follows), the reasons gender disparity exist are still not fully understood. Of particular note is that much of the research focuses on the lack of female representation at research institutions and the reasons women are lost from the pipeline. Less is known about which alternate career paths women choose and what attracts women to institutions with a higher female representation. This study investigated gender representation at a variety of institutions and in a variety of departments. Based on those findings, the choices men and women make as they navigate their career paths were investigated with a focus on faculty in the fields of chemistry and mathematics. The expectation is to contribute to the literature base by identifying factors that promote higher female representation where it exists rather than focus on lower representation. The results of this analysis can hopefully be useful to develop innovative ways to close the gender gap.

1.1. Objectives

This investigation consisted of two related objectives:

- What are the trends in female representation for different academic institutions and departments? (Statistical)
- What factors contribute to a more diverse population for some academic institutions and/or departments? (Survey Instrument)

2. Background

In a recent inquiry on research about gender inequality in the STEM fields, several factors have commonly emerged such as affirmation and environment, family and parenthood, and work and policies.

2.1. Affirmation & Environment (Sense Of Belonging/Relationships)

Research has found that most women find affirmation externally through the relationships they possess in their friends, family and coworkers. Females' dependence on intimate social interactions creates a ground for their behavior and identity.[7] This identity is used to build the needed confidence to allow them to succeed in male–dominated domains such as STEM fields.[8] On-the-job socialization combats the stigma of male privileges that commonly induce a segregated climate that is unaccommodating to women.[9]

Group membership was found to be beneficial to women because it provides social experiences with like-minded colleagues.[8] Gender socialization literature suggests that from a young age, females are attuned to the emotions emitted from others and that it comes more naturally to females than it does to males. From this, female faculty members may place a greater importance on department climate because it fuels the positive emotional interactions that they need. Departments should work towards creating a department climate that allows for these interactions to improve the retention of female faculty. This is beneficial for the department because it would reduce the expense of searches and investments in new start up packages.[8]

Men, on the other hand, rely on achievement based success to make their career decisions in the field of science. Although men did talk about their relationships in terms of academic and career influences, they were not perceived as crucial social supports. Men develop their identity and confidence from their own mastery experiences and view the significant people in their lives as providing mere reinforcement to that.[8]

2.2. Family/Parenthood

Women have two choices in regards to the timing of having children: they may have children either before or after their STEM career kicks off. Women's optimal fertility is between ages 18 and 31, and by age 37, many women will have difficulty conceiving. The pre-tenure years might be off-putting for women who do not wish to delay having children until her late thirties. She would have to deal with pregnancy, childbirth, and child care at the same time as she is attempting to compile a tenurable portfolio of research. This is daunting for some women, and therefore they may either leave the tenure-track pipeline or give up having children. The tenure track that has been in place for decades was created at a time when few women worked outside the home and child rearing was assumed to be a woman's sole work. Thus the tenure track was premeditated for people without significant responsibilities in household work or child care.[10]

Despite all of this, many women rarely make one decisive choice to leave the workforce. Instead, women consciously deselect themselves from long term career prospects in STEM before they are even in a position to have children

because they are preparing for the likelihood of it. Overall, young women placed more value than young men on the importance of making occupational sacrifices for one's family[11] whereas male participants did not list family/ work balance as a challenge.[7]

2.3. Work/Policies

The changing expectations at home show that more women want a career which means that the traditional home life needs to be split between the man and the woman. However, what has been commonly observed is that as couples begin their careers, it becomes more difficult to uphold equal home responsibilities because of inadequate policies at work. Women are more likely to use offered benefits than men because men are more concerned with damage to their career.[12] In a study done at Stanford to improve the retention of doctors by providing them with a credit to be used for miscellaneous outside-of-work tasks (housework, errands, groceries, etc.), they hoped to prevent burnout and allow their research professors more time outside of work to actually enjoy their families and life. With this new program, the share of female faculty members who felt Stanford supported their career development rose from 29 to 57%.[13]

The research cited above has identified several areas of focus for ways to help retain a more diverse workforce. This study seeks to contribute to this literature by identifying institutions and departments where females have a higher representation and the possible contributing factors to this greater gender diversity.

3. Statistical Methods & Results

The first research objective was to identify trends in female representation for different academic institutions and departments. To address this, faculty demographics were tabulated for a variety of institutions and departments to compile the percent ratios of females for both STEM and NON-STEM fields. Data were collected from the faculty information on department webpages found on the corresponding public university websites. This methodology was based on that of the Kaminski work on faculty retention.[6] The departments under investigation include (STEM): Aeronautical/Aerospace Engineering, Astronomy, Biology, Biological Engineering, Chemical Engineering, Chemistry, Civil Engineering, Computer Science, Engineering Systems, Earth and Environmental Engineering, Electrical/ Computer Engineering, Mathematics, Material Science/Engineering, Mechanical Engineering, and Physics; and (NON-STEM): Economics, English, History, Philosophy, Political Science, and Sociology. In each of these departments the number of males and females in each position of full professor, associate professor, and assistant professor were tabulated. STEM and NON-STEM fields were both analyzed to determine whether there were consistent trends between STEM and NON-STEM in relation to specific institutions. Much attention has been given to female representation in STEM fields, but it was important to determine if STEM was uniquely problematic in its gender representation.

Data were tabulated for both research universities and Primarily Undergraduate Institutions (PUIs). As mentioned in the Introduction, most of the gender disparity research in academia has been related to research institutions. If gender representation is more equitable at other types of competitive institutions, then lessons might be learned from those populations. The research universities that were studied came from those used in the Kaminski investigation on Survival Analysis of Faculty Retention.[6] This list was cross referenced with the top 50 schools identified by the National Science Foundation as having spent the most on chemistry research in 2010.[5] The final list of research universities included Boston University, Columbia University, Cornell University, Massachusetts Institute of Technology (MIT), Princeton, University of Massachusetts Amherst (UMA), and Virginia Tech (VTech). Next, the same data were collected to analyze PUIs from the top ten National Liberal Arts Colleges as identified by US News and World Report[14] which included Williams College, Amherst College, Swarthmore College, Bowdoin College, Middlebury College, Pomona College, Wellesley College, Carleton College, Davidson College, and United States Naval Academy (USNA).

3.1. Results

Figure 1 shows the percentage of women in STEM fields (shown in the darker shade) and in NON-STEM fields (shown in the lighter shade) for the institutions investigated. Research institutions are shown in blue, PUIs (with the exception of USNA) are shown in red, and USNA is shown in yellow in the middle. Several observations can be made from these data. As might be expected, there is a distinct lack of female representation in the STEM field compared to NON-STEM. This trend is consistent across institution type, but is less pronounced for the PUIs. PUIs have a higher

representation of females than research institutions overall and in STEM. On average for the institutions included here, women represented 18% of STEM faculty and 37% of NON-STEM faculty at research institutions and 38% of STEM faculty and 42% of STEM faculty at liberal arts institutions. USNA was included as one of the ten PUIs in the analysis and is shown in yellow in the middle of Figure 1. USNA's faculty gender representation is between the average for research institutions and PUIs, but with a smaller gap between STEM and NON-STEM than for research institutions.

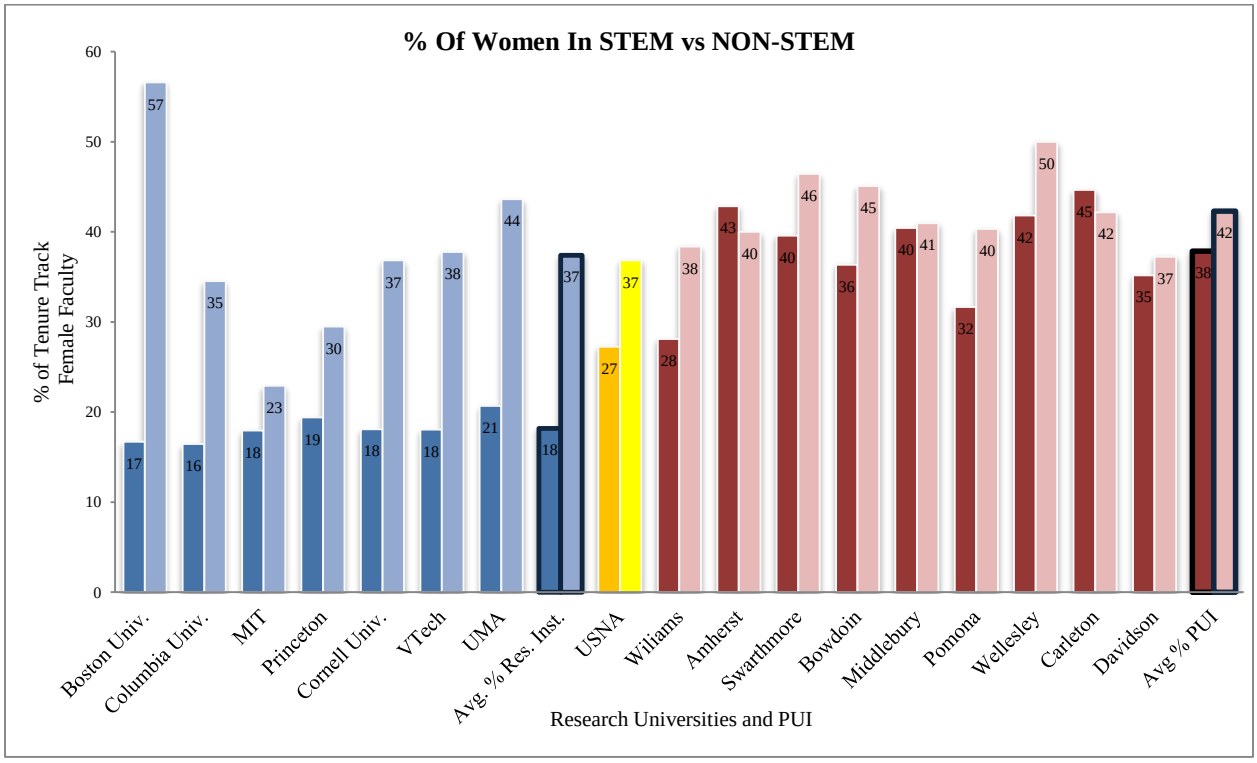

Figure 1. The percentage of women in STEM (darker shade) vs. NON-STEM (lighter shade) fields for a variety of institutions.

Figure 2 isolates chemistry faculty from the data presented in Figure 1 and shows the percentage of female faculty for the chemistry departments of the institutions in this analysis. Chemistry is generally representative of the other STEM fields in terms of percentage of women for both research universities and PUIs, although there is some variability. PUIs not only have a higher representation of females than research institutions overall, but also in chemistry specifically. One notable difference between Figures 1 and 2 is that USNA has a relatively high percentage of women in chemistry (46%) relative to the overall STEM faculty (27%). This female representation is much higher than for any research university in this analysis and is just above average compared to the PUIs.

Figure 2 shows a much higher percentage of women at PUIs than at research institutions. However, it is important to consider the size of the faculty in this comparison because for smaller faculties a change in gender for one faculty member can yield a larger swing in percentage than for larger faculty. For that reason, Figure 3 shows the total number of faculty (and of women) for each institution. The research institutions have larger faculties but still have low numbers for females in their chemistry departments. PUIs have smaller departments (<15 in all cases) but manage to recruit and retain a higher proportion of women into their departments. USNA is representative of the PUI percentage of females despite the fact that the chemistry department is one of the largest with 35 tenure track faculty members.

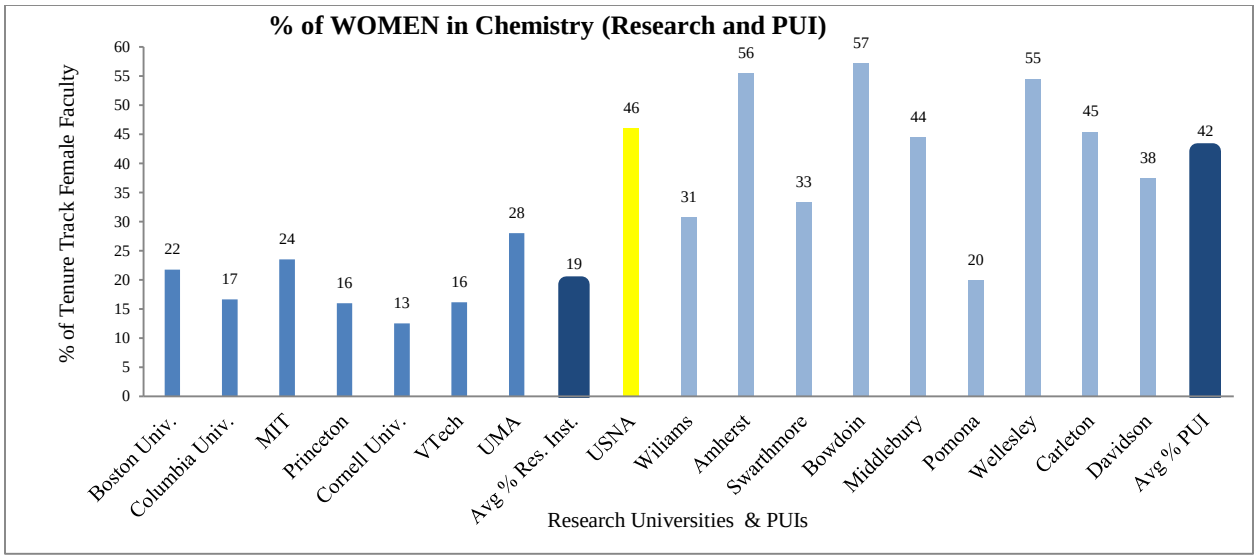

Figure 2. The percentage of females in chemistry departments at each institution.

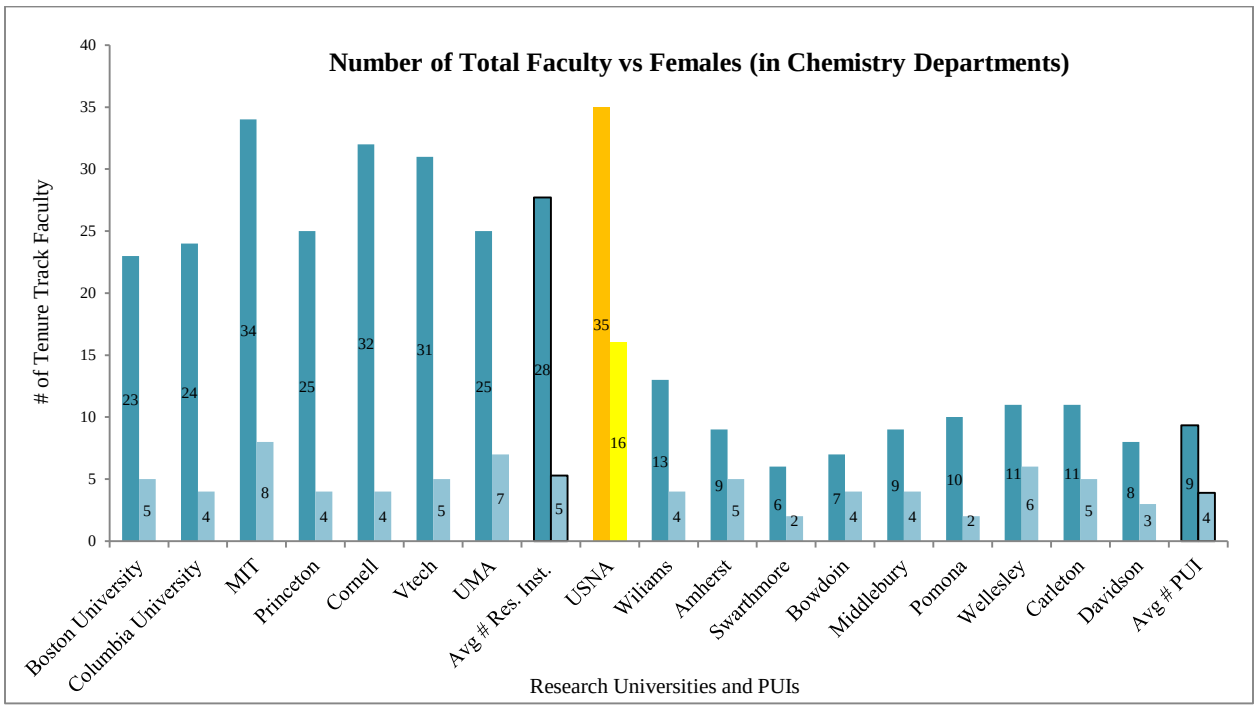

Figure 3. The number of total faculty (darker shade) and of females (lighter shade) in the chemistry departments at the institutions under investigation.

4. Survey Instrument & Analysis

The results shown above in Figures 1-3 indicate that USNA has a high percentage of female faculty in the Chemistry Department (46%) relative to similar institutions. Thus, USNA was chosen as a case study to examine possible reasons for its success in recruiting and retaining female faculty. Specifically, a survey was designed to investigate the decisions and choices that influence those faculty members' career paths.

The survey was developed using the common themes from the background research (affirmation & environment, family & parenthood, work/policies), and USNA's Chemistry Department was chosen as a target population. Although not shown in the statistical results above, the USNA Mathematics Department also showed a higher proportion of females (39%) than similar institutions and was included in the survey analysis for a wider range of respondents. Approval was obtained from the USNA Human Research Protection Program Office - IRB USNA.2016.0018-IR-EP7-A to conduct and analyze the survey.

4.1. Survey Participants

The voluntary online survey was disseminated by email to all faculty in the Chemistry and Mathematics departments at USNA. Surveys were only analyzed for civilian, tenure track faculty. Both departments also included military faculty and adjunct instructors that were not included in the analysis presented here because those career paths are different from the tenure track academic path. Demographic information for the survey participants is shown in Figure 4. The categories listed (male, female, chemistry, mathematics, <45, >45) were statistically tabulated for each question in the survey. Representation was similar for male/female and chemistry/mathematics, but more respondents were full professors (19/31) and correspondingly older in age. Results were not broken down by rank because of small numbers in some categories. Of the <45 group, 9 of the 12 were female such that this category was not a fair representation of the group at large. For that reason, results were not broken out for that category here. Tabulations for the survey were deemed important if the group had higher than 35% for an answer.

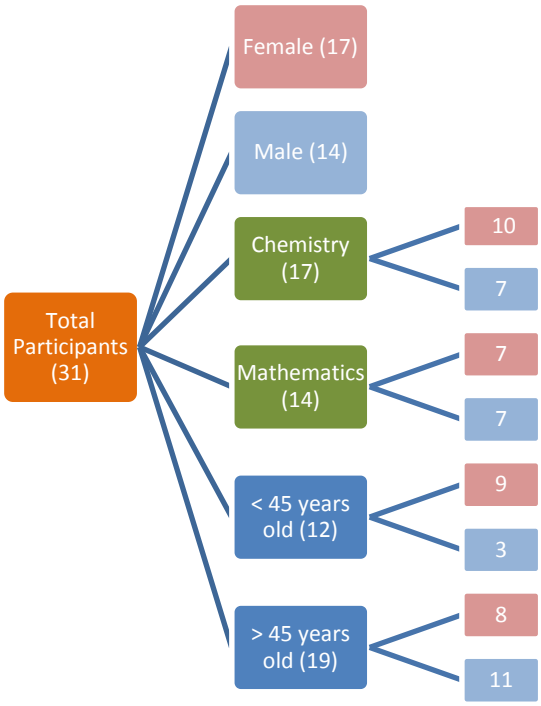

Figure 4. Breakdown of survey participant demographic information.

Of the 31 survey participants, 19 were Full Professors. From the responses, it became evident that many Full Professors responded to the survey because they had witnessed the department's trend towards female diversity during their time at the United States Naval Academy. Many of the newer faculty (assistant and associate) had answers that were very general (i.e. not specific to USNA), whereas the full faculty gave responses more specific to their experiences at USNA. At this point in their careers, many provided detailed responses because they showed a large desire to be a part of the solution and to continue to make positive contributions to the USNA environment. This trend can be seen by this response in the survey: "At one point there was definitely an institutional drive to secure female faculty. After that time, the presence of successful female faculty probably increased acceptance, and certainly increased the comfort level of women in the interview process."

4.2. Results

The online survey consisted of several questions relating to the common themes from the background research. It allowed respondents to describe their personal career trajectory and decisions about why they chose to pursue a career at USNA. Due to space considerations, the specific questions are not included here, but relevant questions will be explained as the results are presented. The survey produced a wealth of rich responses that are still being analyzed using qualitative methods. Relevant preliminary highlights and trends are presented below.

4.2.1 mentoring

Previous research indicated that women value mentoring more than men. With departments that have a high representation of females, it was inferred that mentoring between male and female would also be more equal. The survey presented here asked questions about whether respondents had been mentored or had been a mentor in the past or currently and whether that mentoring was in an official or informal capacity. Respondents were also asked to specify whether that mentoring experience was with a male or female. The USNA survey data show that the female respondents have been equally mentored by males and females in an official and informal setting, whereas males were commonly mentored by other males with a few instances of female mentorship. For past mentorship, half of the male respondents have officially mentored a woman. This could be due to official matching of a male mentor with a female mentee; however, half of the males have also informally mentored a female which shows that without official assignment, they still have a female mentee. Those over the age of 45 informally mentor men and women equally as well.

Currently in the chemistry and mathematics departments, the majority of females are being informally mentored by a male. The reasons for this are not clear from the survey data. It is possible that more women choose to be mentored by a male, or it may be that the departments attract males that are interested in mentoring and are more open to mentoring a fellow faculty member that is just beginning their tenure process. The females in the department currently seem to place a larger importance on mentorship than the men do since they have a higher percentage of participants that are actively seeking out mentorship. Exploring why more women than men proactively seek mentoring, predominantly from male mentors, is an important area for future inquiry.

Respondents were also asked at what points in their career they were mentored and at what points mentoring was most important. Men and women both agreed that the mentoring was important during the time they receive their Bachelors and PhD, and during their time as an Assistant Professor. Women, in addition to those three, thought that mentoring during the time of the Post Doctorate was important. One key difference was that more women than men were mentored as Assistant Professors, 87% of women vs. 43% of men. Women valued and sought mentorship during the beginning of their tenure portfolio in order to set themselves up for success, whereas most men did not prioritize mentoring in the same way.

In summary, mentoring was important and valued for a majority of survey respondents and females were comfortable with male and female mentors. It appears that women may place more importance on proactively seeking mentorship during the probationary pre-tenure years and that the institution provides that support.

4.2.2. institutional climate

The survey included several questions about USNA's institutional and department climates and respondents were asked to rank the importance of various factors on their choice to pursue a career at USNA. The results of this analysis, broken down by gender, are shown in Figure 5. These results indicate that all faculty were influenced strongly by supportive colleagues, the teaching/research/service balance of the institution, and department climates. Although past research has shown the importance of an affirming environment for women, these results indicate that the perception of a supporting environment seems to both attract men and women. Many of the male faculty also found USNA to have great collegiality and a supportive institutional climate. Faculty care very much about having a greater focus on teaching than most research universities: "It is not a 'publish or perish' institution. They do not have a huge amount of research infrastructure (though what they have is nice), so they have to provide something others do not. And what they provide is a mission and a life. The students provide a reason to be here, and one is allowed to think longer term than the next grant cycle." Similarly, another survey respondent stated: "After visiting and learning about the institution, I felt it was the best fit for me. The focus on teaching with the feel of a larger institution in terms of department size, and support and facilities for research provided a unique environment. I wanted to be at a place that

valued teaching more than grant-writing or supporting graduate students but still allowed time for research or scholarly development."

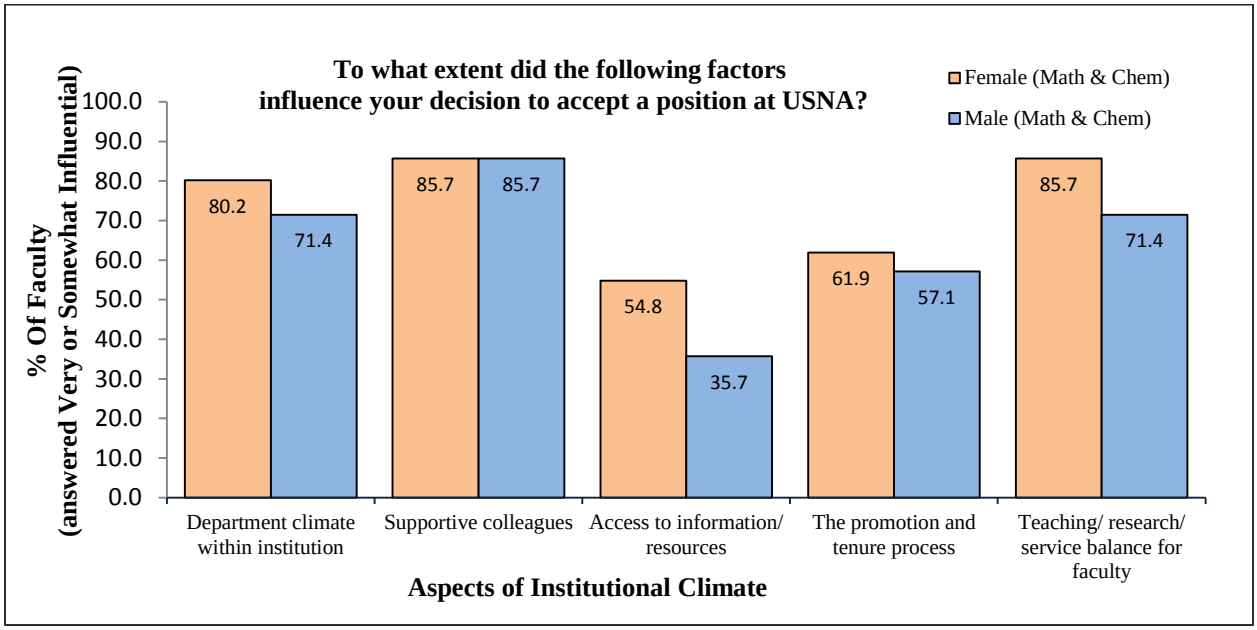

Figure 5. Institutional climate factors that influence the decision to accept a position at USNA. The males that accept a position with the USNA Chem or Math departments value supportive colleagues at the same level that women do.

4.2.3. family, marriage, and children

The survey also asked respondents questions about family life and the role of work/family balance and policies on the decision to accept a position at USNA. Figure 6 shows the responses broken down by gender. Both men and women prioritize their families, but more women cited the work/family balance culture as more influential in their decisions (see Figure 6). The vast majority of the faculty are currently married (87% of female and 93% of male respondents). Women primarily got married earlier, before graduate school or during graduate school, whereas males got married at various times over the course of their career. Over half of the faculty have full-time working spouses (65% of female faculty and 57% of male faculty). This could be related to the fact that most of the survey participants were Full Professors and their children are now raised, because Annapolis is an expensive area to live in and necessitates dual income, or simply because of the general trend towards more dual income families. Most spouses work outside the home; 73% of women had a spouse that had a STEM related career vs. 38% for males. Thus for this survey population, more women marry someone in the STEM discipline. More men, on the other hand, have a spouse employed in an education NON-STEM career.

USNA is located in a very convenient area that is in between DC and Baltimore. "We are near DC and Baltimore, so this is a good area for a husband and wife to find a job together without a bad commute from home." This allows a spouse to also find work in the area. However, since the area is more expensive, both spouses may have to work. The survey did not specifically ask what factors contributed to decisions for both spouses to maintain employment (or not), but some respondents did volunteer information that cost of living necessitated dual income or that they had hired help to do work for household/childcare responsibilities.

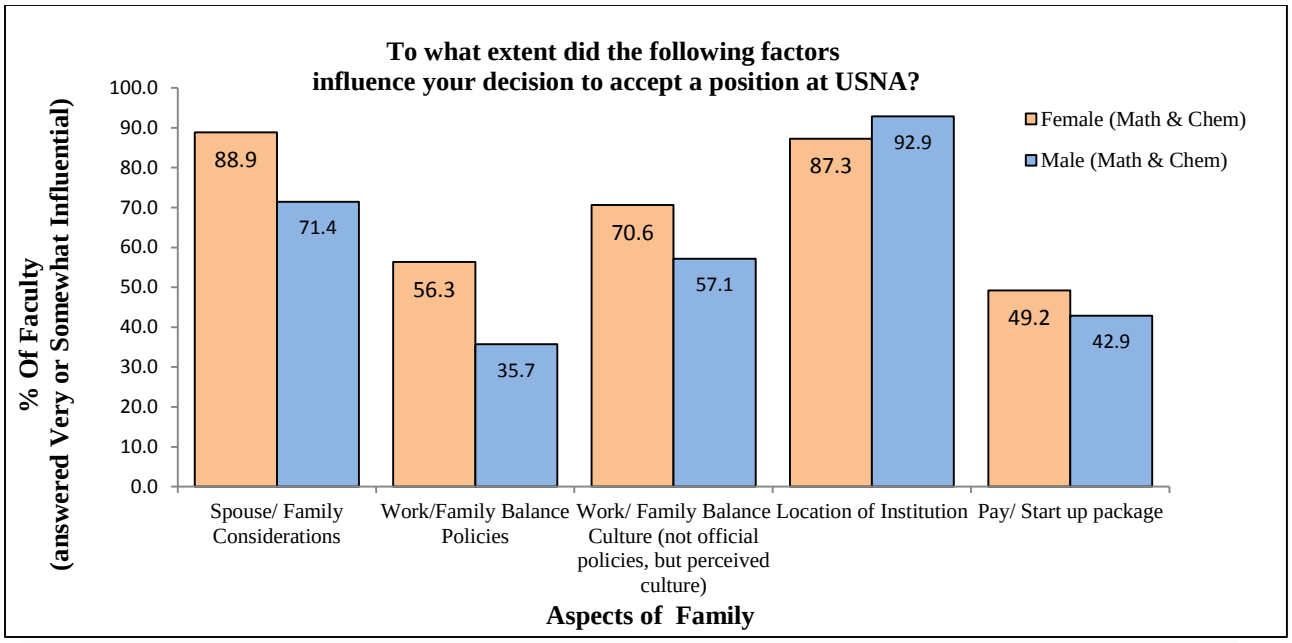

Figure 6. Family factors that influence the decision to accept a position at USNA. The majority of the respondents found each category to have a significant value in regards to family. Females considered their spouse and/or family more when making their decision then men.

A majority, 68%, of the faculty that responded have children, but more women than men do not have children (38% vs. 21%). Of those with children, half of the respondents indicated they equally shared child-rearing responsibilities. Over a quarter of the females with children indicate that they are the lead parent at home vs. none of the males. As prior research also shows, women (unlike men) often maintain a primary role in household/child-rearing responsibilities and seek a work/family balance that aligns with their choices. "USNA is attractive to many female faculty since there is not as much of an emphasis on the stress cycle of graduating students and getting postdocs jobs, publishing papers, and getting grants. The faculty work very hard but the hours are flexible and the environment is supportive of people having families…I asked the department chair when I interviewed here what the policies were for maternity leave and unlike the other schools where I interviewed, I was offered a position."

The majority of the faculty were unaware of any official work/family balance policies and diversity programs. Nevertheless the informal work/family culture and supportive climate seem to be factors in recruiting and retaining both men and women that value that balance. The responses indicate that both departments have a more family friendly culture, and they hire/attract both males and females who value a more relational environment. Some faculty explicitly stated that this supportive environment contributes to higher numbers of females in the department. "USNA is a unique institution and because our department is diverse and has many female role models, I think that attracts others females to this institution. I believe new candidates to the department feel the support and camaraderie within the department. In general, women tend to be more welcoming to new faculty and are generally more collaborative rather than competitive."

5. Discussion and Conclusion

The research presented here shows that overall, and especially at research institutions, there is a distinct lack of female representation in the STEM field compared to NON-STEM. PUIs have a higher representation of females than research institutions overall, in STEM, and in Chemistry, but tend to have smaller department sizes. Chemistry is generally representative of the other STEM fields in terms of percentage of women for both research universities and PUIs. USNA has a high representation of females and is representative of the average PUI percentage despite the fact that its chemistry department is one of the largest with 35 tenure track faculty. USNA was thus chosen as a case study to examine possible factors that contribute to recruiting and retaining a more diverse faculty.

Although the survey sample is small (N=31), preliminary analyses have indicated interesting trends that may contribute to the gender diversity in USNA's chemistry and mathematics departments. Survey responses indicate that

the perceived family-friendly culture and supportive institutional and department climates attract both men and women. Faculty also indicated that the institutional emphasis on teaching as well as research was a major factor in their choice of USNA as their place of employment. Continued and more detailed survey analysis as well as follow on interviews with respondents will likely elucidate further trends.

6. Acknowledgements

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