Female Scholars in Computer Science: The Role of Family and Other Factors in Achieving Academic Success

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***Abstract*—Computer Science continues to experience underrepresentation of women at all levels. In recent years, much emphasis has been placed on attracting and retaining women to enter the discipline and, as a result, there has been an increase in the percentage of bachelor's, master's, and doctoral degrees awarded to women. These gains are a critical step in achieving the ultimate goal of gender representation in computing that is reflective of society at large. This goal is not focused on the end of the educational pipeline, however, but on the industry as a whole. If women do not persist and thrive in academic and industrial careers, the positive impacts of diversity will not be realized in the most influential sectors of the discipline. Our research focuses on faculty in the assistant professor rank, specifically with respect to the research outputs of journal publication and conference presentation, which are highly influential in achieving promotion to associate professor and securing tenure. Our results indicate that research productivity of women is on par with that of men at this career stage. However, we find significant gender differences relative to factors that impact the overall experience during these years, most notably in the realm of parental responsibility. These results may provide insight into why women leave academic positions at a higher rate than men.**

Keywords—women, computer science, productivity, publication, conference presentation, academic.

I. Introduction

As in many academic disciplines, women are under-represented in computer science departments. Two recent studies show women account for 20-24% of computer science faculty [1,2]. A variety of factors may account for this low representation. While some women may choose industry over academia, others may attempt to succeed in academia but ultimately fall short of expectations for tenure. Research productivity is a key factor in determining whether Assistant Professors are promoted and tenured. This often highly stressful period can be complicated by having young children or an unsupportive work environment with no or limited research funding, for example. With this in mind, we explored three research questions:

- Are there gender differences in the research productivity of faculty at the Assistant Professor level?
- Are institutional policies and support consistent for women and men relative to research during the Assistant Professor years?
- How do personal circumstances, particularly spousal support and childcare responsibilities, impact research productivity at the Assistant Professor rank? Are there gender differences?

II. Related Work

The representation of women in the professoriate has long been recognized as an issue of concern that spans a variety of disciplines [3, 4, 5, 6, 7]. Within the STEM fields, challenges in attracting women undergraduates [8] and small numbers of women going on to pursue doctoral degrees [1] contribute to the lower percentages of women in academic positions. In computer science, there is an additional challenge given that only 9.2% of Ph.D. recipients were reported to have entered tenure-track positions in North America [1]. Those who enter the academic ranks face challenges related to retention and career progression. Several studies provide evidence of a "leaky pipeline", in which the percentage of women in academic ranks falls off with promotion to higher levels [5, 9, 10, 11]. Additional research points to concerns about disproportionate numbers of women in lower-ranking positions, slower progress toward promotion, small numbers of women receiving the most prestigious awards, and women working in marginalized subdisciplines that receive less funding and lower recognition [12, 13, 14, 15, 16]. Research suggests these issues are not a result of discriminatory practices in interviewing, hiring, awarding of grant funding or institutional support, however, but are instead attributable to factors such as gender stereotypes, lifestyle and career choices, and family responsibilities, inter alia [12, 17, 18].

Scholarly productivity is a large part of progress toward promotion and tenure in academia. Understanding the role of gender in research productivity has been the focus of many studies that have produced varying results [12, 19, 20, 21, 22, 23, 24]. Two primary approaches to this research have been taken. The first approach analyzes bibliographic references to determine if there are gender differences in scholarly productivity of women [23, 25, 26, 27]. This approach is challenging because it can be difficult or even impossible to

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determine gender from names as they appear in citations, particularly when publications use reference styles that include only the initials for authors' first names. Additionally, the results of this type of analysis give no insight into factors that contribute to an individual's scholarly production or research environment.

Alternative approaches use surveys and case studies to enable greater exploration of the research experience of academic professionals. Studies that use these methods suggest a variety of factors that impact women's scholarly productivity and recognition within their field. These factors include gender differences in family responsibilities [22, 28, 29]; variation in time use patterns as women dedicate more time to serve on committees, teaching and mentoring students [30]; differences in institutional support [21, 24]; and different patterns of academic collaboration and networking [12, 31].

There is evidence that the annual productivity of men and women on the individual level is comparable [21, 32] and that the percentage of publications in computer science authored by women is growing [25, 27]. In spite of these encouraging results, concerns remain; total research productivity over one's career is higher for men than women [32, 33]; women publish less than men in outlets considered to be most important for career advancement and peer recognition [22, 23, 34]; there is evidence that women are segregated into research fields considered less influential and result in lower citation rates [16, 35].

Our work adds to the understanding of research productivity in computer science by focusing on the Assistant Professor rank. Given the critical importance of research to advancement in the academic ranks, it is important to understand whether there are gender differences in individual research productivity and/or the institutional and personal circumstances that may impact productivity and affect one's success in securing promotion and tenure. Insight into what gender differences may exist is important to reversing the trend of women leaving the discipline at a higher rate than men.

III. METHODOLOGY

A. Survey Construction and Dissemination

The goal of this research was to explore gender differences in research productivity and the research experience of Assistant Professors in Computer Science within U.S. institutions. Our survey methodology was influenced by a previous study in the field of International Studies [3]. That survey, which was sent to the 5,000+ members of the major professional organization for international studies scholars, queried basic demographics, graduate school research experience, production of research during the assistant professor years, and a variety of professional and personal circumstances whose combined impact can positively or negatively impact productivity. Our survey was modified to take into account particular aspects of computer science, such as shifting measures of research productivity from journal articles and solo-authored books to journal articles and conference presentations. (The complete survey instrument can be made available upon request.)

Dissemination of the survey was challenging given that there is no single professional organization that encompasses the breadth of journals and conferences for all subdisciplines of computing or claims membership of all research active professors. As a result, an invitation to participate in the survey was sent to members of five organizations - the Association for Computing Machinery (ACM), ACM's women in computing committee (ACM-W), Computing Research Association (CRA), CRA's committee on widening participation in computing (CRA-WP), and the National Center for Women in Information Technology (NCWIT). Collectively communications from these organizations reach over 100,000 individuals and more than 1400 universities, companies, and non-profit and governance organizations worldwide. Responses were collected over a period of six weeks in August and September 2017, during which time several reminders of the survey were sent. While it is not possible to know the exact number of people that received or viewed the invitation to participate, the result of 357 responses was disappointingly low. Response rates to online surveys have been noted to be a challenge [3] and other survey-based studies in computer science have noted such challenges. [2, 24].

Among the total respondents, there were 42 that indicated they had never held an assistant professor position in the United States or had held the position too long ago to effectively participate. These responses were excluded from the data analysis as were an additional 55 incomplete responses, giving an analysis base of 260 responses.

Approximately 30% of the survey respondents identified as female. This percentage is higher than that of computing professionals in the US at large, which is reported as 26% by NCWIT [36]. The source of the NCWIT data was an unpublished report of the Department of Labor Bureau of Labor Statistics. As such, it would include professionals outside of those in the academy. To better compare our respondents to the academic community, we restricted our response set to those individuals who currently hold a rank of Assistant, Associate, or Full Professor. Table I summarizes a comparison with the data reported in two annually conducted surveys – the Taulbee survey of Ph.D. granting universities, and the annually conducted ACM Survey of Non-Doctoral-Granting Departments in Computing (NDC). [1,2]. The proportion of female respondents in the current study is slightly higher than that of the Taulbee study but is statistically indistinguishable from that of the NDC survey. In Table II, we break out the women within the academic respondents by rank. The current study had a smaller percentage of Assistant and Associate Professors and a larger percentage of Full Professors than either of the other two sources. Once again, the differences are not statistically significant.

TABLE I. FEMALE REPRESENTATION OF ACADEMIC RESPONDENTS

	Male	***Female***	***Total***	***% Female***
Current study	181	79	260	30%
Taulbee survey	4176	1020	5196	20%
NDC survey	688	223	911	24%

TABLE II. FEMALE REPRESENTATION BY RANK

	Current Study	*Taulbee Survey*	*NDC Survey*
Assistant Professor	32%	33%	34%
Associate Professor	28%	29%	37%
Full Professor	39%	38%	29%

B. Data Analysis

The data analysis phase of our work was influenced by another survey-based study from the field of Political Science [4]. In this work, several regression models were constructed using clusters of related explanatory variables that allow exploration of variables such as family-related factors and the working environment on the total number of articles published in refereed academic or professional journals over the respondents' career. We developed similar models, further described below, but focused on research output during the assistant professor years.

When developing models for research productivity, a primary difficulty of this work was the determination of an appropriate dependent variable meant to capture the true research productivity of faculty members in computing during their time as assistant professors. Our basic measure of research productivity was the ratio of publications during assistant professorship to the number of years spent as an assistant professor. Computing differs from many other academic disciplines in that conference presentations rival journal publications in selectivity and professional importance [37]. In order to account for the variety of ways to publish in computing-related fields, we developed a metric that assigned 2 points for peer-reviewed publications of any type (whether in traditional journals, conferences with proceedings of significant length, or conferences with no proceedings or proceedings of abstracts only) and 0.1 points for non-peer-reviewed publications of any type. In accordance with the recommendation by Fox and Milbourne [38], we transformed this score by applying a logarithm of one plus the aforementioned score to both reduce the influence of outliers and to ameliorate a cluster of scores at or near zero. When choosing the weights of peer-reviewed and non-peer-reviewed publications, we were unable to find existing literature on which to form a basis for their relative value. We attempted to balance the tension between the conventional wisdom that peer-reviewed publications are valued more highly by scholars and institutions [39] against the fact that 41% of our respondents had published in at least one non-peer-reviewed venue, suggesting that such activity should not be entirely discounted as unimportant (see Table IV). We experimented with ratios other than 20:1 and did not find that it resulted in any changes to the overall conclusions. We specifically chose to score peer-reviewed and non-peer-reviewed works at 2 and 0.1 respectively instead of 20 and 1 (e.g.) in order to replicate the work of [4] while maintaining an acceptable fit of the models.

Each of our various models explored a particular theme of proposed explanatory variables relating to the aforementioned response variable. In the "Work Environment" model, we explored concepts related to a faculty member's work environment. In the "Graduate Mentor" and "Assistant Professor Mentor" models, we considered the gender of the faculty member's mentor during graduate school and during their time as an assistant professor (when applicable). In the "Children" and "Partner" models, we explored the question of whether the respondent had children under 18 years or a partner (respectively) by treating both as binary variables. In the "Family" model, we explored the number of children (realized as a quantitative variable) and the identity of caregivers for the children. Finally, in the "Career Length" model, we explored the length of a faculty member's career in the discipline of computing. Each model included both gender as a separate variable and interaction coefficients between gender and other variables.

IV. FINDINGS

We divide our findings into two sections: descriptive statistics and regression analysis. In brief, we found the most statistical significance in the first section and much less in the regression analysis. In several areas, our findings differ from previous research with other disciplines.

A. Desccriptive Statistics

Consistent with other studies, we find that productivity is not significantly different between men and women during their Assistant Professor years. While one might speculate that women produce research at lower rates, accounting for differences in retention of men and women in academia, we found that the average number of peer-reviewed publications and presentations for the men in our study was 9.2 and for women 11.2. The rates of publication were not significantly different for men and women ($p = 0.14$). Table III and IV summarize the gender breakdown of the respondents' publications by ranges of productivity (e.g., 3-5) and type of publication venue for peer-reviewed and non-peer reviewed venues, respectively. There was no significant difference between the productivity of women and men within a publication type. There also was no significant difference between genders in the types of venues utilized.

We next considered a number of other factors that might show different outcomes for women compared to men. Of these factors, we found answers on several childcare questions to be significantly different between the two genders as well as the role of spouses. On childcare, women report spending more hours taking care of their children than men (highly significant; $p<0.001$) and are much more likely to report being the primary caregivers for their children. We defined primary caregiver as the person who was most likely to get up with children in the night, go to doctor's appointments, etc. (highly significant; $p<0.001$).

TABLE III. SUMMARY OF PEER-REVIEWED PUBLICATION VENUES

	Journal Publications		***Conferences with Proceedings***		***Conferences without Proceedings***	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**
None	26	64	12	33	48	137
1-2	18	46	16	37	12	25
3-5	20	35	17	47	10	12
6-9	9	20	19	34	3	6
10+	6	16	15	30	6	1
Totals (> 1)	53	117	67	148	31	44

TABLE IV. SUMMARY OF NON-PEER-REVIEWED PUBLICATION VENUES

	Journal Publications		*Conferences with Proceedings*		*Conferences without Proceedings*	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**
None	48	131	65	156	63	161
1-2	13	28	8	15	11	11
3-5	12	13	5	3	4	7
6-9	3	5	0	5	0	1
10+	3	4	1	2	1	1
Totals (> 1)	31	50	14	25	16	20

Related to this finding, women reported being much more likely to use paid childcare while men are more likely to use family to take care of children when they are not available (significant, p=0.001). This finding is potentially important to explaining why women leave academia at higher rates. If not because of productivity, it is possible that the burden of caring for children while trying to meet academic requirements for promotion and tenure results in women choosing to work in less demanding workplaces or to decide not to work outside the home. However, this finding is inconsistent with another finding: women did not report higher interruption of work due to childcare responsibilities (p=0.78).

We explored a number of questions about the university work environment related to children. One of the ways women can theoretically manage their additional childcare responsibilities while also meeting academic standards for promotion is to extend the tenure clock. Of the 48 who reported they know their university allows parents to request an extension, only 9 (6 women and 3 men) received or planned to request an extension. This raises the question of why more people do not take advantage of this opportunity. Anecdotally, some authors of this paper have heard there is a fear of being looked down on if they take this option or be judged as if they had an extra year to do research.

Another way to offset the additional challenges of parenting is a reduced teaching load. While we found no significant difference between women and men in whether they report knowing about the policy (p=0.19), it is notable that around half of all respondents were not aware of the policy regarding reduced teaching load. This suggests universities need to do a much better job of informing faculty about their policies and that faculty might be making family decisions based on incomplete information about policies that could affect whether, when, and how many children they decide to have.

Finally, regarding children, we found supporting evidence for Hancock, et al.'s finding that, compared to the general population of professionals, academics are more likely to have no children during their 20's and 30's, the age range of most Assistant Professors. We found that 37/77 women (48%) and 99/176 men (56%) have children. This raises quality of life concerns for women since delaying pregnancy might make it harder to have biological children or as many children as they might want.

We also explored the role of academic spouses. We hypothesized that academics with spouses who are also academics in the same discipline would benefit from discussing their research, co-authoring, and a greater understanding of what is required to succeed in earning promotion and tenure.

We found significantly more women than men report having a spouse who is also a professor. Of these, there were also more women reporting a spouse in the same profession of computer science (p<0.001). These women were more likely to report a positive effect on productivity while men were more likely to report negative or no effect (p=0.007). The survey does not provide a basis for understanding this surprising difference but we note that when we measured productivity, we did not find a significant difference between men and women suggesting this may be an impression that is not born out in reality.

In other areas of institutional support, such as research funding and conference funding, we found no significant difference in support levels between women and men (p=0.28 and p=0.77 respectively). In general, this is a positive result as it suggests universities are not discriminating based on gender when providing financial support.

B. Regression Models

Table V summarizes the variables used in the regression models, our expectation of how each would relate to publication rates, and a qualitative summary of our finding on each case. Table VI illustrates the regression models used in our analysis. Within the table, many of the models appear twice (Versions A and B). Version A of each model includes the listed variables as standalone coefficients in the regression model. Version B includes the same standalone coefficients along with the interaction effects from the gender of the respondent.

Table VI adopts the common convention of displaying the statistical significance of coefficients using asterisks. The main takeaway of this table is the relatively comprehensive lack of asterisks (aside from the "Work Environment" model and the unimportant constant coefficients within each model). This weak relationship between the explanatory variables in many of the models and the research output variable was confirmed by the low values of R^2. In short, our findings from the regression models largely failed to replicate those from research in other academic fields.

In the "Work Environment" model, the factors that we found to be important aligned with our expectations; higher publication rates were associated with straightforward institutional factors such as being employed at a PhD-granting institution, having a lower teaching load, or having dedicated time in the summer to spend on research. (We note that the apparent shift in prevalence between some of these factors in versions A and B of the model may be due to their interrelated nature and ought not be overinterpreted.) It is natural to expect such factors to correlate generally both to a higher expectation of research and to higher research output. The affirmative findings of significance for these variables serve to highlight the fact that so many of the other variables did not show an expected significance.

We did not anticipate our finding that having support in the form of a research assistant or teaching assistant would yield a benefit to scholarly productivity for women but not for men. We speculate that women may mentor and utilize TAs and RAs differently than men, which could result in benefits such as

TABLE V. QUALITATIVE SUMMARY OF FINDINGS

Variable	Expectation Higher publication rates expected to be a function of:	Findings
Highest degree granted in department	Employment at PhD-granting institution	Supported for both men and women
Research leave	More leave time	Insignificant
Teaching load	Lower teaching load	Supported for men and women
TA / RA support	Having RA/TA support as an assistant professor	Supported for women, but not for men
Summer research	More summer months dedicated to research	Supported for men and women
Sex of mentor during graduate school	Having a female advisor Having an advisor of same sex as respondent	Insignificant
Sex of mentor during assistant professorship	Having a female advisor; having an advisor of same sex as respondent	Insignificant
School-aged children	Not having school-aged children at home	Insignificant
Primary caregiver identity	Having a paid caregiver, or having a family member (as opposed to self) as caregiver	Insignificant
Hours with alternate caregiver	More hours with alternate caregiver	Insignificant
Number of pre-K children	Lower number of pre-K children	Insignificant
Number of K-12 children	Lower number of K-12 children	Insignificant
Partner status	Having a partner	Insignificant
Years since assistant professor	Being an assistant professor more recently	Insignificant

higher productivity by the TAs/RAs themselves, mitigation of the higher demands of child care experienced by women, and more opportunity to produce co-authored publications.

We had anticipated that various mentoring-related factors might correlate to research productivity, such as the gender of the mentor or whether the gender of the mentor matched that of the faculty member receiving the mentoring; however, this effect simply did not appear in our data.

The lack of significant results for family-related variables also stood in stark contrast to the work environment explorations. For instance, previous studies [3, 4] have found the number of children to be important predictors of research productivity, but this consideration did not yield a significant result in our study. Reference [4] also found that the marital status of the respondent was a predictor of research productivity, but we did not detect an effect in our survey on the closely-related partner status variable. None of our models concerning family-related variables showed any reasonable overall explanatory power or had coefficients that even bordered on significance.

We had also hypothesized that expectations for publication in computing have increased over time. However, we did not see a significant difference in publication rates during recent or long-past assistant professorships.

We offer two possible reasons for the replication failure. First, the data sample may simply have been underpowered due to the aforementioned challenges in survey data collection and anecdotal evidence of survey fatigue (faculty receiving so many surveys, they stop responding). Second, it is possible that there are simply genuine differences between computer science and other academic fields relative to the factors explored.

V. CONCLUSIONS

This research investigated issues related to research productivity of faculty at the Assistant Professor rank in computer science. Through an analysis of our survey data, we explored whether there were gender differences evident in individual research productivity, institutional support for research, and personal circumstances (e.g., spousal support, childcare responsibility) at this critical stage of the academic career. We found that women and men appear to be equally productive, publishing and presenting at similar rates and in comparable venues. We found institutional policies and support for research to be gender equitable. Our study was not designed to investigate the effectiveness of particular policies related to family leave, reduced teaching loads, and stopping the tenure clock.

TABLE VI. REGRESSION MODELS WITH RESEARCH PRODUCTIVITY AS DEPENDENT VARIABLE

		Version A	Version B (w/ interaction coefficients)	
Model	**Variable Name**	**Coefficient (SE)**	**Coefficient (SE)**	**Male interaction coefficient (SE)**
Work Environment	Constant	1.43*** (0.27)	0.50 (0.52)	
N = 260	Male†	-0.12 (0.09)	1.13 (0.60)	
	PhD-granting institution†	0.38** (0.11)	0.67** (0.22)	-0.37 (0.26)
	Research leave taken†	-0.03 (0.09)	0.04 (0.16)	-0.11 (0.19)
	Teaching load (# credits / semester eq.)	-0.17** (0.06)	0.03 (0.12)	-0.26 (0.14)
	TA/RA support as assistant professor†	0.16 (0.10)	0.47** (0.18)	-0.44* (0.21)
	Summer research (# months)	0.15** (0.04)	0.18* (0.08)	-0.03 (0.09)
	R^2	0.294	0.312	
Graduate Mentor	Constant	1.18*** (0.14)	1.30*** (0.20)	
N = 248	Male†	-0.04 (-0.11)	-0.22 (0.25)	
	Male graduate mentor†	0.19 (0.13)	0.06 (0.22)	0.21 (0.28)
	R^2	0.009	0.011	
AsstProf Mentor	Constant	1.35*** (0.13)	1.22*** (0.16)	
N = 168	Male†	0.05 (0.12)	0.29 (0.23)	
	Male assistant professor mentor†	0.06 (0.13)	0.25 (0.20)	-0.33 (0.27)
	R^2	0.003	0.012	
Children	Constant	1.36*** (0.10)	1.30*** (0.12)	
N = 253	Male†	-0.02 (0.10)	0.07 (0.15)	
	Children†	-0.01 (0.09)	0.11 (0.17)	-0.17 (0.20)
	R^2	0.000	0.003	
Partner	Constant	1.23*** (0.14)	1.06*** (0.22)	
N = 260	Male†	-0.04 (0.10)	0.20 (0.27)	
	Partner†	0.16 (0.13)	0.35 (0.24)	-0.28 (0.29)
	R^2	0.006	0.010	
Family	Constant	1.74*** (0.24)	2.14*** (0.42)	
N = 134	Male†	-0.02 (0.17)	-0.59 (0.53)	
	Hours w/ alt. caregiver (quant.)	-0.007 (0.005)	-0.01 (0.01)	0.01 (0.01)
	Alt. caregiver for children is paid†	0.06 (0.15)	0.29 (0.26)	-0.30 (0.33)
	Pre-K aged children (# of children)	-0.07 (0.09)	-0.25 (0.21)	0.24 (0.23)
	K-12 aged children (# of children)	-0.09 (0.06)	-0.25 (0.16)	0.18 (0.17)
	R^2	0.039	0.064	
Career Length	Constant	1.37*** (0.11)	1.31*** (0.16)	
N = 260	Male†	-0.04 (0.10)	0.04 (0.18)	
	Was assistant professor 1-15 years ago†	-0.05 (0.10)	0.12 (0.20)	-0.24 (0.23)
	Was assistant professor 15+ years ago†	0.10 (0.13)	-0.02 (0.24)	0.18 (0.29)
	R^2	0.006	0.017	

Note: **** indicates p < 0.001; ** indicates p < 0.01; * indicates p < 0.05.*

Variables marked with (**†**) are binary; for these, the listed coefficient corresponds to the presence of the variable. Further discussion of all variables (other than the Constant and Male variables) can be found in Table V.

However, a substantial proportion of men and women reported being unaware of these policies. This suggests that universities should review how they inform their faculty about these policies. As we had hypothesized, higher publication rates for both women and men result when employed at PhD granting institutions, when teaching loads are lower, and when the summer months are dedicated to research. For women, the availability of TA/RA support has a positive impact on productivity. We also found statistically significant gender differences related to family circumstances, specifically regarding child care demands (higher for women) and the perceived value of having a spouse who is a professor in the same discipline (positive for women; negative or neutral for men). The lack of support for other hypotheses stands in contrast to previous scholarship and may be explained by our small sample size.

VI. FUTURE WORK

Our survey experience and findings suggest a number of pathways for future research. Given the challenges and limitations of surveys of computer scientists in universities, research should now focus on other methods, notably case studies and interviews. In particular, scholars should explore the surprising finding about differing perceptions on the impact of spouses in the same field. Through interviews and reviews of policy making and dissemination, researchers can help universities better educate their faculty on these policies and encourage their use when appropriate. In particular, we need to understand why so few Assistant Professors opted to use policies that might have helped them better balance work and family. Productivity was apparently not affected by having children but that does not mean quality of life was not negatively affected, particularly for women who are more likely to be the primary caregivers.

Additional research should be done on some data we collected but did not further explore due to low response rates. These include the type of institution where the respondent's highest degree was earned, subdiscipline of focus, experience prior to the assistant professor position, total hours worked per week, and expectations of time dedicated to research and experience of actual time spent on research.

One of our key findings is that women are more likely to be primary caregivers but remain as productive as men. Further research should explore how this affects women's quality of life and if it might account for some women leaving academia.

We also found that women received more benefit than men toward scholarly productivity as a result of having TA/RA support. Additional research is warranted to validate this finding and explore what differs in how women and men interact with and utilize TA/RA support that might lead to this result.

Finally, a seemingly positive finding in computer science is that there is not the "leaky pipeline," (in which women leave academia in increasing numbers as they progress to higher levels) as observed in other fields, at least not to the same extent. The percentage of women in Assistant Professor, Associate Professor and full Professor positions are fairly static (although the two main sources differ), accounting for 33%, 29%, and 38% (Taulbee) and 34%, 37%, and 28% (NDC), respectively. Even in the NDC numbers, which show a substantial drop off from Associate to full Professor, it is notable that the fall off is not from Assistant to Associate Professor, suggesting women get tenured but either remain at the Associate level or choose to leave academia. The difference in these two sources also suggests the need for further research to verify percentages in each category.

Overall, there remains much research to be done on women in computer science as well as other academic disciplines. While women have made considerable strides in terms of rising numbers in the field, they remain underrepresented and are potentially leading more challenging lives when parents and Assistant Professors than their male counterparts, and that universities can potentially improve the lives of their faculty, and thus retention and professional enthusiasm, through policy promotion.

REFERENCES

[1] S. Zweben and B. Bizot, "2019 CRA Taulbee Survey", *Computing Research* News, vol. 31, no. 5, pp. 3-74, April 2020.

[2] S. Zweben, J. Tims, and Y. Timanovsky, "ACM-NDC Study 2019-2020: Eighth Annual Study of Non-Doctoral-Granting Departments in Computing", *ACM Inroads*, vol. 11, no. 3, pp. 26-37, September 2020, doi: 10.1145/3410475.

[3] K. Hancock, M. Baum, and M. Breuning, "Women and Pre-Tenure Scholarly Productivity in International Studies: An Investigation into the Leaky Career Pipeline", *International Studies Perspective*, vol. 14, pp. 507-527, 2013, doi: 10.1111/insp.12002.

[4] V. Hesli and J.M. Lee, "Faculty Research Productivity: Why Do Some of Our Colleagues Publish More Than Others?", *PS: Political Science and Politics*, vol. 44, no. 2, pp. 393-408, April 2011, doi:10.1017/S1049096511000242.

[5] V. L. Golich, "Measuring 'Success' for Women in International Studiesin Academic Settings" *Oxford Research Encylopedia of International Studies, International Studies Encyclooedia*, Dec. 2011, doi: 10.1093/acrefore/9870190846626.013.258.

[6] G. Abramo, C. A. D'Angelo, and F. Rosati, "Gender bias in academic recruitment," *Scientometrics*, vol. 106, no. 1, pp. 119–141, Nov. 2015, doi: 10.1007/s11192-015-1783-3.

[7] A. Scott Metcalfe, and L. Padilla González, (2013). "Underrepresentation of Women in the Academic Profession: A Comparative Analysis of the North American Region", *NASPA Journal About Women in Higher* Education, vol. 6, no. 1, pp. 1–21, 2013, doi: 10.1515/njawhe-2013-0002.

[8] L. Jensen and E. Deemer, "Identity, Campus Climate, and Burnout Among Undergraduate Women in STEM Fields", *The Career Development Quarterly*, June 2019, doi: 10.1002/cdq.12174.

[9] P. A. Stout, J. Staiger, and N. A. Jennings, "Affective Stories: Understanding the Lack of Porgress of Women Faculty", *NWSA Journal*, vol. 19, no. 3, pp. 124-154, 2007, doi: 10.1353/nwsa.2007.0050.

[10] T. Camp, "The Incredible Shrinking Pipeline", *ACM SIGCSE Bulletin*, vol. 34, no. 2, pp. 129-134, June 2002, doi:10.1145/543812.543846.

[11] C. Silander, U. Haake, and L. Lindberg, "The different worlds of academia: a horizontal analysis of gender equality in Swedish higher education," *High Education*, vol. 66, no. 2, pp. 173–188, Dec. 2012, doi: 10.1007/s10734-012-9597-1.

[12] M. Jadidi, F. Karimi, H. Lietz, and C. Wagner, "Gender Disparities in Science? Dropout, Productivity, Collaborations and success of male and female computer scientists," *Advances in Complex Systems*, vol. 21, no. 03n04, p. 1750011, May 2018, doi: 10.1142/s0219525917500114.

[13] K. Weisshaar, "Publish and Perish? An Assessment of Gender Gaps in Promotion to Tenure in Academia," *Social Forces*, vol. 96, no. 2, pp. 529–560, Jun. 2017, doi: 10.1093/sf/sox052.

[14] G. Santos, G. and S. Dang Van Phu, "Gender and Academic Rank in the UK", *Sustainability*, vol. 11, no. 11, June 2019, pp. 3171-3216, doi: 10.3390/su11113171.

[15] C. Sá , S. Cowley, M. Martinez, N. Kachynska, E. Sabzalieva, "Gender gaps in research productivity and recognition among elite scientists in the U.S., Canada, and South Africa", *PLoS ONE*, October 2020, doi: 10.1371/journal.pone.0240903.

[16] S. Campero, "Hiring and Intra-occupational Gender Segregation in Software Engineering", *American Sociological Review*, Nov. 2020, doi: 10.1177/0003122420971805.

[17] G. Abramo, C. A. D'Angelo, and F. Di Costa, "The effects of gender, age and academic rank on research diversification," *Scientometrics*, vol. 114, no. 2, pp. 373–387, Sep. 2017, doi: 10.1007/s11192-017-2529-1.

[18] S. Ceci and W. Williams, "Understanding current causes of women's underrepresentation in science", *Proceedings of the National Academy of Sciences*, vol. 8, no. 8, Dec. 2010, pp. 3157-3162, doi: 10.1073/pnas.1014871108

[19] H. Sotudeh and N. Khoshian, "Gender differences in science: the case of scientific productivity in Nano Science & Technology during 2005–2007," *Scientometrics*, vol. 98, no. 1, pp. 457–472, May 2013, doi: 10.1007/s11192-013-1031-7.

[20] M. W. Nielsen, "Gender and citation impact in management research," *Journal of Informetrics*, vol. 11, no. 4, pp. 1213–1228, Nov. 2017, doi: 10.1016/j.joi.2017.09.005.

[21] P. van Arensbergen, I. van der Weijden, and P. van den Besselaar, "Gender differences in scientific productivity: a persisting phenomenon?", *Scientometrics*, vol. 93, no. 3, pp. 857–868, Apr. 2012, doi: 10.1007/s11192-012-0712-y.

[22] P. van den Besselaar and U. Sandström, "Gender differences in research performance and its impact on careers: a longitudinal case study", *Scientometric*s, vol. 106, no. 1, pp. 143–162., 2015, doi: 10.1007/s11192-015-1775-3.

[23] M. J. Gallivan, R. Benbunan-Fich, "Examining the Relationship between Gender and the Research Productivity of IS Faculty", *SIGMIS CPR '06: Proceedings of the 2006 ACM SIGMIS CPR Conference on Computer Personnel Research: Forty Four Years of Computer Personnel Research: Achievements, Challenges & the Future*, pp. 103-113 Apr. 2006, doi: 10.1145/1125170.1125201.

[24] M. McGill and A. Settle, "Institutional support for computing faculty research productivity: does gender matter?", *ACM-SE '12: Proceedings of the 50th Annual Southeast Regional Conference*, pp. 36-41, March 2012, doi: 10.1145/2184512.2184522.

[25] L. L. Wang, G. Stanovsky, L. Weihs, and O. Etzioni. 2021. "Gender Trends in Computer Science Authorship", arXiv.1906.07883, January 2021), doi: 10.1145/3430803.

[26] M-F Roy, et al, A *Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences: How to Measure It, How to Reduce It?*, International Science Council, June 2020, doi: 10.5281/zenodo.3882609

[27] J. McGrath Cahoon, S. Nigai, J. Kaye, "Gender and Computing Conference Papers", *Communications of the ACM*, vol. 54, no. 8, pp. 72-80, Aug. 2011, doi: 10.1145/1978542.1978561.

[28] Amerian Political Science Association (APSA), Women's Advancement in Political Science: A Report on the APSA Workshop on the Advancement of Women in Academic Political Science in the United States, American Political Science Association, Washington, D.C., 2005.

[29] L. Padilla-Gonzalez, A. S. Metcalfe, J. F. Galaz-Fontes, D. Fisher, and I. Snee, "Gender Gaps in North American Research Productivity: Examining Faculty Publication Rates in Mexico, Canada, and the U.S.," *Compare: A Journal of Comparative and International Education*, vol. 41, no. 5, pp. 649–668, Sep. 2011, doi: 10.1080/03057925.2011.564799.

[30] D. Kamerāsde, "Shaping women or changing the system: accounts of gender inequality in science," *Equal Opportunities International*, vol. 26, no. 2, pp. 162–170, Feb. 2007, doi: 10.1108/02610150710732221.

[31] G. Abramo, C. A. D'Angelo, and G. Murgia, "Gender differences in research collaboration", *Journal of Informetrics*, vol. y, no. 4, pp. 811-822, Oct. 2013, doi: 10.1016/j.joi.2013.07.002.

[32] J. Huang, A. J. Gates, R. Sinatra, and A. Barabási, "Historical comparison of gender inequality in scientific careers across countries and disciplines", *Proceedings of the National Academy of Sciences*, vol. 117, no. 9, March 2020, pp. 4609-4616, doi: 10.1073/pnas.1914221117.

[33] R. S. Connaway, M. Morelock, and M. E. Gentry, "Research Productivity of Women and Men in Selected Social Work Positions," *Administration in Social Work*, vol. 9, no. 1, pp. 81–91, Feb. 1985, doi: 10.1300/j147v09n01_08.

[34] S. J. Mayer and J. M. K. Rathmann, "How does research productivity relate to gender? Analyzing gender differences for multiple publication dimensions," *Scientometrics*, vol. 117, no. 3, pp. 1663–1693, Nov. 2018, doi: 10.1007/s11192-018-2933-1.

[35] M. Potthoff and F. Zimmermann, "Is there a gender-based fragmentation of communication science? An investigation of the reasons for the apparent gender homophily in citations," *Scientometrics*, vol. 112, no. 2, pp. 1047–1063, Apr. 2017, doi: 10.1007/s11192-017-2392-0.

[36] W. DuBow and J. J. Gonzalez, *NCWIT Scorecard: The Status of Women in Techology*, Boulder, CO, NCWIT, 2020.

[37] Computing Research Association. "Best Practices Memo: Evaluating Computer Scientists and Engineers for Promotion and Tenure", *Computing Research News*, September 1999.

[38] K. J. Fox and R. Milbourne, "What Determines Research Output of Academic Economists?," *Economic Record*, vol. 75, no. 3, pp. 256-267, September 1999, doi: 10.1111/j.1475-4932.1999.tb02454.x.

[39] M. McGill and A. Settle, "Computing Faculty Tenure and Promotion Requirements at U.S. and Canadian Post-Secondary Insitutions", SIGITE' 11 ACM Special Interest Group for Information Technology Education Conference, pp. 133-138, Oct. 2011, doi: 10.1145/2047594.20476322.