

The Graduate Research Field Choice of Women in Academic Physics and Astronomy: A Pilot Study

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Abstract. The low representation of women in physics is apparent at the undergraduate level through faculty positions. However, when looking at the percentage of PhD women graduates in the closely related field astronomy (40%) and women PhDs in physics education research (30%), it is found that those areas have higher representations of women compared to women physics PhD graduates (18%). This study seeks to understand the research subfield choice of women in academic physics and astronomy at large US research universities through in-depth interviews and a grounded theory analytical approach. Though preliminary results have not shown why women chose their graduate research field, they have shown that positive pre-college experiences are bringing these women to physics, while supportive advisors and collaboration amongst students are encouraging these women to persist.

Keywords: Women in Physics, Gender, Grounded Theory, Feminism, Gender Gap

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INTRODUCTION

The dearth of women in academic physics is obvious through both anecdotal and statistical data. The field, at the undergraduate level, is around 78% male and 22% female [1]. The discrepancy of men and women majoring in physics is even more staggering when considering that women earn around 57% of US bachelor's degrees [1,2]. At the graduate level women have almost equal representation as at the undergraduate level in physics programs [1].

The distribution of women amongst graduate programs is significantly different in the areas of astronomy and physics education as compared to physics overall. The most recent numbers show that women earn about 18% of all doctorates in physics, 40% of all doctorates in astronomy, and currently comprise around 30% of all physics education PhDs [1,3]. Though few women go into physics, those who do have a higher representation in astronomy and physics education graduate research programs. The requirements to get into these programs are often very similar and many institutions offer all three programs, such as The Ohio State University and the University of Washington. It is interesting to note that the higher representation of women in astronomy versus physics also holds at the undergraduate and faculty levels [1]. Women comprise 37% of astronomy bachelor degrees and are 17% of faculty compared to 12% physics faculty and 30% of PER faculty [1,2].

RESEARCH QUESTIONS AND GOALS

- I. *Why do women choose to study astronomy, physics education research, and physics in graduate level programs?*
- II. *What are the experiences of women in astronomy, physics education and physics overall?*

This paper presents the results from a pilot study for a larger initiative that seeks to understand the experiences and research choices of women prepared for graduate work in physics and the closely related field of astronomy. The interviews in this phase of the study were used to populate a range of potential responses in further data collection. This information will be used to design stronger interview and participant recruitment techniques.

METHODOLOGY

Theoretical Framework

The theoretical framework used in this study was feminist standpoint theory (FSPT)[4]. FSPT starts its knowledge discovery from the perspectives of women in an effort to facilitate social change. In this case, this project began by collecting data from the stories of the lives of women in physics and astronomy. These

stories will be used to uncover women’s social realities in physics, which can be used in support of institutional and policy changes that will help women in the field.

Participants and Data Collection

The participants recruited for the pilot study were identified from universities that offer research areas in the three above mentioned fields, through graduate list-servs and by e-mailing relevant research group leaders for student lists. Recruitment e-mails were sent to students requesting that they fill out and return a demographics screening form. Study participants were required to fit the following requirements: 1) Gender identified as woman; 2) Seeking a PhD in physics, astronomy, or astrophysics at a large US research institution; and 3) Have passed their qualifying examinations. Through this process 27 participants were recruited. At the time this article is being written all 27 interviews have been conducted. This article will focus on three of these interviews that were conducted as the pilot study. These three participants represent each field targeted for inclusion in this project and are at the later stages of their graduate careers, thus they have gone through almost every major stepping stone in the graduate experience. All three participants were heterosexual white females who completed their qualifying examinations within a department of physics. Their information is presented in Table 1 below, with the participants identified by pseudonyms.

TABLE 1. Participants

Name	Degree Program	Degree Stage
Stevie	Nuclear Physics	Dissertation Defense
Janis	Astronomy	Dissertation Writing
Grace	Physics Education	Dissertation Research

Data were collected in the form of individual in-depth unstructured interviews that were conducted in person. Intensive interviewing techniques were employed to elicit participant interpretations of their experiences [4][5]. For example, all interviews began with the prompt ‘Tell me about the pathway that led you to physics.’ This allowed participants to share the individual experiences that were important to them. The researcher carefully listened to their stories and encouraged further thoughts and responses [5].

Analysis

Constructivist grounded theory processes were utilized to analyze the interviews [5]. Transcripts of the interviews were coded for themes, cross-compared

between participants, written into biographical narratives, further cross-compared for narrative relationships, and then synthesized into preliminary results. During this process the researcher continually wrote memos to capture and limit his own bias while developing an understanding of the data. This process is meant to develop a theory grounded in data, however, in this pilot study a theory had not yet emerged [5]. All data analysis was conducted by the lead author.

RESULTS

The results of this pilot study traced out the paths these women followed in their educational processes until the interviews occurred. The stories presented below arose spontaneously following open-ended prompts such as ‘Tell me about your experiences in the classroom’ and ‘Tell me about your relationship with your advisor.’

Stevie

Stevie’s primary goal from high school and throughout college was to get a career so she could ‘eat every day.’ In high school she really enjoyed math but could never really see how the sciences led to a career. She felt that she didn’t know what a physicist did because ‘we spent physics classes building bridges out of popsicle sticks.’ These experiences led to Stevie’s choice of math as her first undergraduate major.

As an undergraduate, Stevie found math’s career tracks uninteresting and wanted a science as a second major. Concurrent with her search for a second degree, Stevie had been placed in a research group doing nuclear physics through a merit scholars program. They put her in a physics research group because no math groups were available. After taking modern physics, Stevie felt this was the hardest possible path and a challenge she wanted to conquer. After completing her undergraduate degree she felt it wasn’t enough to get a career. This led Stevie to apply and go to graduate school.

The classes in graduate school were easy for Stevie and she primarily worked on homework sets alone. She continued doing nuclear physics research because it was ‘safe’ and what she ‘knew.’ She felt it was easier to stay in the subfield she knew than find another. As graduate school progressed, she faced many issues within her nuclear physics research group.

Stevie’s communication with her advisor became non-functional as the scope of her research work kept changing and conflicts with other students developed. Stevie faced discriminatory actions by her peers with

respect to her sex and gender. For example, she had a member of her research group who believed *'that women should be homemakers'* and another student who *'really didn't think women should be in science.'* Stevie was limited by one of these students in her ability to conduct research. He was above her in the *'chain of command'* and refused her access to work on certain experiments. Stevie's advisor was rarely available, and when she brought these issues to his attention he refused to confront them. Stevie decided to leave her research group in search of a new advisor.

Stevie found a new advisor by talking to female colleagues in the department with whom she felt comfortable. She chose her new advisor based on his personality, and the fact that he also had a research group that included multiple women.

Stevie is currently finishing her PhD and searching for a post-doctoral position. She wants to do something more applied than basic nuclear physics research. She believes it's her duty to help the world, but she fears that many of the applied nuclear physics jobs are in weapons research. Her desire to help people is echoed in her outreach work that focuses on teaching nuclear physics to school children and showing them that they can be scientists.

Janis

Janis developed her love for physics and astronomy early in high school in a new class where they would watch astronomy demonstrations and *'explain it in a lab notebook.'* Janis said she was *'sold'* on physics after taking an advanced placement class her senior year of high school. She only took the class after the advancement placement biology course was dropped. Janis loved math and how *'[she] could just figure things out using numbers and logic.'* She decided to major in astronomy at the collegiate level and went to a top research school for astronomy.

In her undergraduate institution, Janis focused hard on her astronomy classes and less so on her physics courses. Janis *'got this feeling from some of the physics professors that they were too good for [students] and it was below them to have to teach an undergrad class.'* However, her astronomy professors were *'really into teaching the class[es]... not using a textbook, [keeping] up on current research and really helping [students] understand back-of-the-envelope calculations.'*

Janis participated in undergraduate research, but found her advisor to be distant and discouraging. He questioned why she was there and asked her if the debt was really worth her attendance. Janis succeeded with the aid of an *'amazing'* female post-doctoral scientist.

This post-doc taught Janis how to do astronomical research and how to code to analyze starlight data.

Janis applied to the best graduate schools, but inevitably went to the program that accepted her. She went in having one advisor but became concerned once she realized *'how busy he was, and [that] he wasn't the kind of guy [she] wanted to work with.'* She became *'worried [she] wouldn't have anyone to work with.'* Janis looked for a new advisor and found one. He was *'amazing'* and *'has energy.'* She feels comfortable communicating with her new advisor and *'he's always giving [her] information about networking, and careers and various project ideas.'* With regards to her course work, Janis did quite well and found working with her peers to be critical in learning the material.

Janis feels that she has gained a lot working with her new advisor and is preparing to finish her dissertation. She wants to seek a career in either educational outreach, which she did throughout college, or teaching at a small college. She doesn't want the life of a research professor and eventually wants to start a family. She feels that she can't start her family, though, until her and her boyfriend's careers are set.

Grace

Grace grew up with science in the home. Her mom gave them *'educational placemats'* and *'educational games.'* Her family played math games on car rides and she did building activities with her father. She knew she wanted to be a physicist at 14 when she enjoyed the hands on experiments in her physical sciences class. She really enjoyed how the physics *'matches with the math.'*

Grace went into college studying both math and physics, but she found math to be too abstract and switched to just physics with a second major in the arts, which was a life-long passion of hers. Grace got through her physics courses by studying with other students. She also enjoyed having course work outside of physics so she could stay *'literate'* in the arts.

Grace did undergraduate research with an advisor who was interested in her professional progress and supportive of her work. She also worked with a very supportive graduate student who enjoyed mentoring students. Grace particularly liked the *'hands-on'* nature of her work. She felt the only way to continue in physics was to go to graduate school, so she continued into a graduate program in physics at a large research school.

Grace entered her graduate program and successfully got through the course work and qualifying exams by studying with her peers. Grace

entered a research group during this time but found it hard to balance her time practicing music with her workload. She was invited into a group doing work similar to her undergraduate research, however, within this group there was little support and poor communication. Grace's interest decreased, as did her work output. After the group project lost funding, Grace switched to another research group in a completely different department.

Grace's new advisor '*bull doze[d]*' people with his ideas and was very '*aggressive.*' She felt that he was trying to have her tackle things outside of her experience range and she grew frustrated and uninterested in the work. Grace began to look at her graduate experience and physics to find where her '*effort [was] going.*' Grace found that she was putting significant amounts of time into her teaching and wondered if a project in the physics education research (PER) group would be a good fit.

Grace discussed her interest in PER with a graduate student colleague who was '*really happy*' in that research group. Grace then discussed this option with a professor and found an interested ear and '*a project waiting.*' Grace found the hands-on nature of her project and interactions with students enjoyable. She also has found an advisor that communicates often and is '*very approachable...very helpful.*' He also allows her to take charge of her research and guide its progress.

Grace does not want to seek a research-intensive position after graduate school; she believes at those schools there is '*a lot of pressure to perform*' and she wants time to have a family and enjoy other things. Grace's '*dream job would be to be in some sort of organizational level of a hands-on museum.*' Grace is also open to working at a small school where teaching is valued.

CONCLUSIONS

For the women in this pilot study, their pathway to graduate work in nuclear physics, astronomy, and physics education was paved with peer collaboration and advisor encouragement. All three participants were captivated by math before pursuing work in physics, although each had her own goal in mind: finding a career for Stevie, solving the mystery of space for Janis, and doing hands-on work for Grace. Each had a supportive figure or experience in their youth that helped guide them to these fields. All three also had positive classroom experiences at the middle school and high school levels. Most striking was the value of peer collaboration and good communication from research advisors. All three women worked with their colleagues either in the form of studying or

seeking advice. All three also ended their graduate careers with a different advisor than they started, finding advisors who were more helpful and interested in their development.

In addition, all three participants felt they had to go to graduate school to continue their work in physics and astronomy. Coupled with this was Stevie's explicit lack of advice and guidance with respect to her career aspirations and goals. This emergence shows the importance of exploring career choices and career preparation of future participants. This became a dominant topic as the project progressed.

Though no theory has emerged yet as to why women choose the graduate research fields of astronomy, physics education, and physics overall, analysis of the later interviews may. By collecting and analyzing more individual stories it was possible to find more concrete themes and similarities across students, universities, and research groups.

This pilot study and analysis presented a range of experiences that were important to discuss in later interviews, such as experiences with advisors, interactions with other graduate students, and knowledge of available career choices. Explicit questions were formed around these themes to increase the response rates on these topics. The results also suggest that the research question about choice of research subfield may not be as important as other factors such as advisors, student interactions, and career choices. As more data emerge, the research questions may need to be adjusted.

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