GENDER DIFFERENCES OF GRADUATE STUDENTS WITHIN SCIENCE AND NON-SCIENCE FIELDS

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By
Katherine O'Neil

Thesis Committee:
Yue Yin, Chairperson
Shuqiang Zhang
Lois Yamauchi

We certify that we have read this thesis and that, in our opinion, it is satisfactory in scope and quality as a thesis for the degree of Master of Education in Educational Psychology.

THESIS COMMITTEE

Chairperson

"A small group of thoughtful people could change the world.

Indeed, it's the only thing that ever has."

-Margaret Mead

Acknowledgements

To Mum, you taught me to be creative.

To Dad, the best advisor and listener I know, you taught me to be confident.

To my thesis committee and all the teachers in my life, your guidance and knowledge made this possible.

To my friends, your nurturing, advice, patience and love made this fun.

Abstract

More women than ever are majoring in the sciences at the undergraduate level. But few are staying in sciences at the graduate level. To explore the possible reason for this phenomena, in this study I explored factors that may contribute to graduate students' decisions to enter the historically male-dominated graduate field of science, technology, engineering, and math (STEM) and compare them to non-STEM graduate students. Specifically, I examined how men and women graduate students in STEM and non-STEM differ on these personal and environmental factors. This study surveyed 227 graduate students within STEM and non-STEM programs. The results suggest that women are more influenced by value preferences than men in both programs. Graduate students in non-STEM fields were more interested in their fields than STEM graduate students. Compared to men, women in both fields also received more positive influences from their teachers regarding their graduate field choice.

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Chapter 1. Introduction

In the early 1980s, the National Science Foundation (NSF) warned that the United States was to be in a science education crisis, due to several factors such as declining enrollment in math and science. Now, twenty years later, more students are receiving baccalaureates of science and 49 percent of them are women (NSF, 2002). According to the NSF, a higher percentage of these women than men pursue graduate studies. Statistics, however, indicate that fewer women than men continue their graduate studies in Science, Technology, Engineering, and Math (STEM). In 1999, women constituted 45 percent of U.S. citizen and permanent resident graduate students in Science and Engineering fields. The difference in participation in bachelors versus graduate study is particularly evident in certain STEM fields. Notably in the physical sciences, in 1998 and 1999 women accounted for 39.2% of the enrollment at the undergraduate level. At the graduate level women accounted for 30% of the enrollment. In mathematics women accounted for 46.9% of the enrollment at the undergraduate level and 38.5% of the enrollment at the graduate level (NSF, 2002). Few studies have investigated attributes that contribute to women continuing from undergraduate level STEM to graduate level STEM in a quantitative way. Additionally, few studies have focused on graduate students in STEM.

The purpose of this study was to gain a deeper understanding of the personal and environmental factors that contribute to graduate students' decisions to enter the historically male dominated graduate field of STEM. In particular, this study explored what made students decide their graduate majors and how the factors differed between men and women within STEM and non-STEM graduate majors.

Several studies suggested that environmental factors influence women in the sciences. According to Sax (1996), the science-learning environment alienates women by encouraging competition, reinforcing the notion of science as "unconnected" to social concerns. Also, students are relatively unclear about future careers in science. Due to this disconnection with social concerns, women tend to choose social sciences over natural sciences. Women also are influenced by their parents (Chinn, 2002). Parents influence the career choices of children by fostering their children's feelings of self worth, interest, and abilities. These environmental factors influence women's self-efficacy and interest in science. The literature strongly suggested the causal relationship between self-perception and the environment (Chinn, 2002). That is, environmental and personal influences contributed to women's decisions or behavior to pursue graduate school. Therefore, Bandura's Social Cognitive Theory was used as the basis of the study to examine the effect of personal and environmental factors on students' field-choice behavior.

Theoretical Framework: Social Cognitive Theory

Zimmerman (1989) argued that one's academic goals could be altered through self-reflection potentially culminating in personal efforts to self-regulate (self) by undertaking tasks to improve achievement (behavior). Consequently, I hypothesized that environment combined with students' self-perceptions plays a significant role in their successful pursuit in STEM. This research models the work of Bandura (1986) and Zimmerman (1989) by measuring the relevant self and environmental variables under different behavior choices.

According to Bandura's social cognitive theory, human functioning is viewed as the product of a dynamic interplay of personal, behavioral, and environmental influences (Figure 1). This interaction he refers to as triadic reciprocality (the mutual action between causal factors), in which behavior, cognitive, and other personal factors, as well as environmental events, all operate as interacting determinants. According to Bandura, most behavior is regulated by forethought; people anticipate the likely consequences of their prospective actions, set goals for themselves, and plan courses of action for their cognized futures (Bandura, 1986). According to this theory, graduate students' behavior (i.e. choice of whether or not to continue education and in which field) might be influenced by this triadic reciprocality of personal and environmental factors.

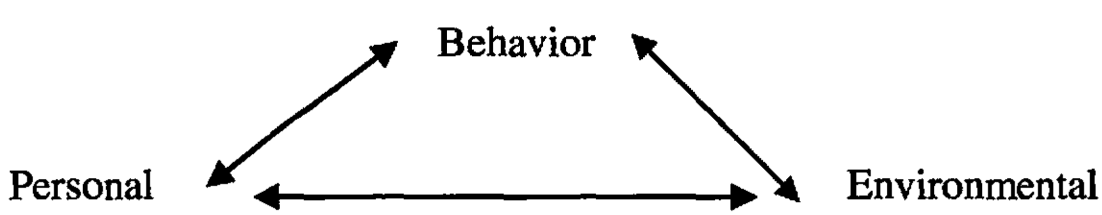

*Figure 1.*Interplay among behavior, personal factors, and environmental factors.

The interaction between behavior, personal factors, and environmental influences all operate as determinants of one another. Therefore, each of these segments should not be examined individually. Personal factors are defined as the feelings and/or thoughts of self that contribute to one's ability to self-regulate and to be self-reflective. Environmental factors are the modeling, tuition, or social persuasion that can influence one's feelings and/or thoughts.

Personal factors that are hypothesized to influence field-choice behavior include self-efficacy, interest, and value preference. Environmental factors include family/peer influence and teacher influence. Each of the factors will be discussed below:

Personal Factors

Self-efficacy. Self-efficacy is an important personal determinant of motivation and performance, and its development is subject to social influence (Bandura, 1977, 1986; Gist & Mitchell, 1992). A central construct in Bandura's (1986) social cognitive theory, self-efficacy, is described as a strong influence on the initiation, intensity, and persistence of behavior. In other words, people pursue activities which they believe they are capable of doing. Once people are involved in an activity, their efficacy beliefs influence how much effort they give to the task and how long they continue in the face of obstacles (Bandura, 1977). Many studies have found that boys tend to report higher levels of self-efficacy than girls regarding performance in math and science (Anderman & Young, 1994; Meece, Glienke, & Burg, 2006; Pajares, 1999; Pintrich & DeGroot, 2002; Zimmerman & Martinez-Pons, 1990).

Vogt, Hocevar, and Hagedorn (2007) found that the gender gap in STEM may be closing, however, it still is present where self-efficacy comes into play. Women undergraduates reported a lower self-efficacy in engineering than men. Vogt et al. suggested that this difference might be due to men feeling they are better with lab technologies and computers than their female peers. Also, men do not receive as many negative comments from professors and are comfortable elaborating on the material. Vogt et al. (2007) also noted faculty have a potential role in improving student performance through positively affecting students' self-efficacy.

Students' perceptions of a subject in high school can affect their self-efficacy in that same subject on a college level. Dalgety and Coll (2006) found that the self-efficacy of freshman students in college chemistry was affected by what the students remembered as being difficult in high school chemistry. They found the students were reasonably confident about the tasks they anticipated to conduct in first-year chemistry and that their confidence grew as the course progressed. However, these first-year students were not confident about the more advanced cognitive levels, such as teaching other students in chemistry (Dalgety & Coll, 2006).

In a longitudinal study, Sax (1996) predicted men and women's enrollment in STEM at the graduate level and found women's interest in science was hindered by a persistent relative lack of mathematical and scientific confidence. Researchers also have found math self-confidence an important predictor of math test performance, which in turn, predicts women's entry into science fields (Ethington, 1988; Grandy, 1987; Matyas, 1985; Peng & Jaffe, 1979; Sax, 1996; Ware, Steckler, & Lesserman, 1985).

Interest. Social cognitive theory suggests people develop interest in activities they believe they can perform (Bandura, 1986). The social cognitive theory relates self-efficacy and interest and suggests that the higher the self-efficacy the greater the interest, and also states that supreme self-efficacy, or being exceptionally capable at a task, also ca lead to disinterest when the activity lacks challenge. If a student is no longer challenged, his/her interest could be adversely affected (Bandura, 1986).

Interest can be fostered in the classroom. The opportunity for flexibility and creativity in the mathematics classroom can enhance motivation, confidence, and enjoyment, particularly among girls (Walkerdine, 1989). That math is often taught in a way that ignores real-world scenarios, or social concerns, and is likely a reason for students' apparent inability to transfer mathematics to the real world, could be the source of much of girls' underachievement and disinterest in mathematics (Boaler, 1994).

According to Ashby of the United States Government Accountability Office (GAO) (2006) the quality of teachers in kindergarten through twelfth grade has been shown to affect students' decisions about pursuing STEM fields.

Unqualified teachers were unable to impart the subject matter, causing students to lose interest in mathematics and science. In the 1999-2000 school year, 45 percent of high school students enrolled in biology/life science classes and approximately 30 percent of those enrolled in mathematics, English and social science classes were instructed by teachers without a major, minor, or certification in these subjects(Ashby, 2006).

Value preference. People act in terms of value preferences. They do things that bring about what they like, and prevent or remove what they dislike (Bandura, 1986). In a study that examined factors that predict the enrollment of men and women in science, math, and engineering graduate programs, Sax (1996) reported that women desire or value positions that can influence social change, whereas men desire positions of status and authority. She found that if men and women did not connect these values to science, math, and engineering then they might leave these fields (Sax, 1996). According to Sax and Bryant, women with higher degree aspirations became less inclined to continue in nontraditional fields. Teaching practices in science alienate many students, especially women, by supporting the notion of science as "unconnected" to social concerns (Rosser, 1990; Sax, 1996; Tobias, 1992). Values can be both developed and altered vicariously through the positive and negative experiences with others (Bandura, 1986).

Environmental Factors

Family/peer support. Parents can play an important role in influencing their children's course of study and eventual careers. One study found that daughters of more highly educated parents were more likely to choose a science major in college (Ware et al., 1985) and eventually to choose sex-atypical careers (Gruca, Ethington, & Pascarella, 1998). In her study of minority women in science and engineering, Chinn (1999, 2002) described the importance of the role of family as the place where the primary social identity is constructed. Children begin to grow their early understanding of self-worth, abilities, and interests through the supportive social network of the family, relatives, and peers. Playful games, like mental arithmetic while waiting in line for the movies, at times seemed "childish," but were remembered as contributing to an early interest in science and math. Parents can influence their children with cultural stereotypes of what is appropriate for men and women's careers (Chinn, 1999, 2002).

Teacher influences. The American Institute of Physics (Ivie & Guo, 2006) reported that women in physics decided their career early, primarily during secondary school; and these women also reported having positive attention from physics professors as undergraduates, and a positive relationship with their faculty advisors. During their education and careers, most women reported they relied on the support of teachers, along with their own determination, will power, and hard work (Ivie & Guo, 2006).

Research Question and Hypotheses

Although previous studies have identified some possible factors that contribute to a woman's decision to pursue a STEM graduate degree, they had some limitations, mainly in method and participants. Most studies applied qualitative approaches and the conclusions drawn were based on a small number of participants. Some researchers collected quantitative data focusing on undergraduate students (e.g. Sax, 1996). Also, the previous research did not compare those who enter STEM graduate programs to those who entered non-STEM programs. This comparison is important because non-STEM fields attract more women in graduate fields in STEM. If we understand the factors that contributed to women choosing non-STEM programs, and the similarities and differences to STEM programs; then in the future, we can improve teaching practices and policies to encourage more women to choose STEM programs. This study surveyed women and men graduate students who chose to continue in STEM to examine similarities and differences to those who did not choose to enter a graduate program in STEM.

To examine whether the same factors found in the previous studies contributed to women' field choice, I surveyed men and women graduate students in STEM and non-STEM fields to see how they differ on the personal and environmental factors identified in previous studies.

In particular, three research questions were raised in this study: (a) How do men and women graduate students differ on the personal and environmental factors that are suggested to influence students' graduate field choice? (b) How do STEM and non-STEM graduate students differ on the personal and environmental factors? (c) Is there an interaction between gender and field?

Women in STEM are known to have low self-efficacy (Anderman & Young, 1994; Meece et al., 2006; Pajares, 1999; Pintrich & DeGroot, 2002; Zimmerman & Martinez-Pons, 1990). According to Bandura, interest is associated with self-efficacy. Therefore, if female students are less efficacious in STEM than their male peers, they ought to be less interested in STEM than their male peers. Women tend to value contributing to social welfare more than men, which in turn influences their choice in graduate fields. Finally, a possible factor influencing graduate field choice, career aspiration, is understudied. Therefore, this research measured these three variables: self-efficacy, interest, and value preference. It was hypothesized that women in STEM would have lower self-efficacy, and therefore, less interest in their program, placing greater value on contributing to social welfare than men in STEM and both men and women in non-STEM.

Parents play an important role in their children's life. It is their modeling and interest that supports their children in continuing their education at the graduate level. Having parents with higher levels of education and supporting their children in their decision making led to women choosing to pursue graduate fields in STEM. Teacher's support also helped to foster interest in careers in science early on for women. Therefore, it was hypothesized that women within

STEM would have parents with a higher level of education, received support from family, peers, and teachers, relied greatly on their own determination, and have been more positively influenced by their teachers than men in STEM and both men and women in non-STEM.

Chapter 2. Method

Design and Procedures

A survey was developed based on previous research. Two pilot studies were conducted before the large-scale data collection. The first pilot study was conducted with 18 STEM graduates, and the second pilot was conducted with 10 STEM graduates. After the participants filled in the survey, they were asked to comment on the clarity, appropriateness, and completeness of survey questions. The feedback from the participants in the pilot studies was considered to improve the survey.

The finalized survey was turned into a web-based survey at an online survey site, Survey Monkey (www. surveymonkey.com). The finalized survey is in Appendix A. Details about the instrument are discussed in the instrumentation section.

The sampling pool of prospective participants was 1,016 graduate students from a broad range of disciplines in STEM and non-STEM programs at a state public university. The graduate student population at the university contained 2,634 women and 1,942 men. This is due to the large enrollment of women in non-STEM programs, such as education. An email was sent to the graduate department chairs and secretaries of 15 STEM, and six non-STEM departments, asking them to forward the email to the students in their departments (Appendix B). The email invited students to participate in an online survey about graduate student field choice that contained a web address for the online survey. Twelve days later, a reminder email was sent to the same graduate department chairs and secretaries (Appendix C). After the first invitation, 147 students completed the online survey (14.5% return rate). The second reminder led to an additional 80 participants (7.9% return rate). A total of 227 participants participated in the study, with a return rate of 22.5%.

Participants.

Among all the participants, 141 participants were from 15 STEM departments: Astronomy (n = 12), Botany (n = 26), Computer Science (n = 8), Physics (n = 4), Math (n = 5), Zoology (n = 12), Civil Engineering (n = 16), Chemistry (n = 1), Environmental Engineering (n = 3), Electrical Engineering (n = 10), Oceanography (n = 3), Entomology (n = 6), Geology (n = 26), Biology (n = 5), and Ecology (n = 4). The other 86 participants were from six non-STEM departments: Art (n = 5), Psychology (n = 32), English (n = 19), History (n = 6), Linguistics (n = 19), and Religion (n = 5). Forty four percent were master's students, 55 percent of the participants were doctoral students, and 1 percent postdoctoral. Participants' average age was 31 (SD = 8.36), ranging from 70 to 22.

Of the 227 graduate students, 61 participants (26.87%) were from 26 foreign countries. There is a significantly higher percentage of foreign students in STEM (34%) than non-STEM (15%), $\chi^2 = 9.94$, $p = .002$. About half of the participants (n = 114) were women. There is a higher percentage of women students in non-STEM (66%) than STEM (40%), $\chi^2 = 14.28$, $p < 0.001$.

Instrumentation

The survey consists of 19 questions (Appendix A). The first ten questions of the survey asked for demographic information. The following demographic information was requested in the survey: gender, ethnicity, citizenship, age, parent education level and major of highest degree, field of study, program, whether they continued in the same program as their major, and if not, what was their major.

Items 12 and 13 in the survey were drawn from the International survey of women physicists, by the American Institute of Physics (Ivie & Guo, 2006). Based on the attributes found in the literature and the social cognitive theory, the following constructs are addressed in the survey: personal factors (including self-efficacy, interest, and value preferences), and environment factors (including support from family, peers, and teachers). Both close-ended and open-ended questions were used in the survey.

The survey was constructed based on Bandura's social cognitive theory. Personal and environmental factors were addressed through five sub-scales. Personal factors were addressed through self-efficacy, interest, and value preference. Environmental factors were addressed through family and teacher influences.

Personal Factors

Self-efficacy. Self-efficacy was measured by eight items (items 16.1 to 16.7 and 16.11) that asked participants to rate, on a five-point likert scale, how strongly they agree or disagree with each statement (e.g., I can do well in all the course work related to my major).

Interest. Interest was assessed by five items (items 16.8 to 16.10 and 16.11) asking participants to provide their own rating of how strongly they agree or disagree on a five-point scale with each statement (e.g., I like my current major).

Value preference. Value preference was assessed by eight items 14.1, 14.3, 14.4, 14.6, 14.7; first by how important each of the following concerns was (e.g., welfare to society) in the particpants life BEFORE the participant entered his/her current graduate program. In addition, items 15.3 to 15.5, "how much did each of the following factors affect your decision to pursue graduate study in your current field," were also used to assess the reality concerns of the participants (e.g., expected salary). Participants indicated how frequently these concerns influenced their decision on a five-point frequency scale from never to always.

Environmental Factors

Family/peer support. Items 13.2, 13.4, 13.5 assessed family and peer influence, asking participants how supportive various people (e.g., parents) had been of their choice of current field of study.

Teacher influence. Four items, 12.1 to 12.4, assessed teacher influence. Participants were asked to rate the degree teachers influenced their decision to pursue their current field in graduate school, on a five-point scale.

In addition to the close-ended questions, one open-ended question was asked at the end of the survey to obtain more information about why students chose their graduate field. Participants were asked to provide any additional comments to clarify why they choose to continue their education at the graduate level.

Instrument Validation

To validate whether the items measured the constructs that they were designed to measure, principal component analysis, with promax rotation was conducted on the items measuring personal and environmental factors. A total of 28 out of the original 43 items were kept. Sixty-two percent of the items were included.

Five factors were extracted from the principal component analysis, accounting for 55.86% of the total variance. Table 1 presents the factor structure matrix created in exploratory factor analysis. Overall, the items are loaded on the corresponding constructs that they are designed to measure. Originally, conceptually the survey contained 8 variables; self-efficacy, interest, value preference, reality influence, career success, parent education, family/peer support and influence, and teacher support and influence. When checking the validity of these factors I found that only 5 remained valid based on their factor structure and inter factor correlations.

Table 1 *Factor Structure of the Items*

Component	1	2	3	4	5
Item	Self-efficacy	Interest	Value Preference	Support Family/peers	Teacher Influence
16.6	0.74	.	.	.	.
16.3	0.75	.	.	.	.
16.5	0.86	0.42	.	.	.
16.7	0.75	0.40	.	.	.
16.1	0.69	.	.	.	.
16.2	0.52	.	.	.	.
16.4	0.86	.	.	.	.
16.11	0.72	.	.	.	.
16.8	.	0.74	.	.	.
16.8		0.91	.	.	.
16.12		0.87	.	.	.
16.13		0.89	.	.	.
16.9	0.45	0.86	.	.	.
14.6	.	.	0.68	.	.
14.4	.	.	0.47	.	.
14.3	.	.	0.62	.	.
14.1	.	.	0.75	.	.
14.7	.	.	0.37	.	.
15.1	.	.	0.77	.	.
15.2	.	.	0.72	.	.
15.3	.	.	0.45	.	.
13.3	.	.	.	.	0.67
13.2	.	.	.	.	0.75
13.1	.	.	.	.	0.67
12.1	.	.	.	0.67	.
12.3	.	.	.	0.70	.
12.2	.	.	.	0.67	.
12.4	.	.	.	0.63	.

Note: a. when $r = 0.40$, any r below this value is not included, $r^2 = 0.16$, b. *55.86% of total variance accounted by the five components

Table 2 presents the correlations among the different factors. The correlations between the different factors or constructs are low, which provide evidence for discriminate validity.

Table 2 *Inter-Factor Correlation*

Factors	Interest	Value Preference	Support Family/peers	Teacher Influence
1 Self-efficacy	0.39	0.1	0	0.02
2 Interest		0.02	-0.04	0.09
3 Value Preference			0	0.01
4 Support Family/peers				0.07

Overall, the alpha coefficients indicate acceptable internal consistency of the factors generated from the principal component analysis (Table 3). Therefore, five composite scores were created for data analysis. Each composite score was calculated as the average of the standardized item scores. A constant value of four was added to this standardized construct score to convert negative into positive values. The item number included in each construct and coefficient alpha of each construct was calculated and presented in Table 3. The *Z* scores of each construct were used to find each person's mean score for a particular principal component, so that the items with larger variance will not influence the composite score more than those with smaller variance. Standardization will make sure that all item scores have a variance of 1, that is, the items are equally weighted before being combined.

Table 3 *Factors, Items Included in Each Factor, and Coefficient Alpha*

Factor	Item Number	# of Items	Coefficient Alpha
Self-efficacy	16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.11	8	.88
Interest	16.8, 16.9, 16.10, 16.12, 16.13	5	.92
Value Preference	14.6, 14.4, 14.3, 14.1, 14.7, 15.1, 15.2, 15.3	8	.76
Family/peers Support	13.3, 13.2, 13.1	3	.66
Teacher Influence	12.1, 12.2, 12.3, 12.4	4	.65

Chapter 3. Results

Table 4 presents the means and standard deviations for men and women in STEM and non-STEM programs.

Table 4 *Descriptive Statistics for Scale Scores*

Gender	Field	Variable	*N*	*Mean*	*SD*	*Min*	*Max*
Men	STEM	Self-efficacy	84	4.01	0.65	1.39	5.09
		Interest	84	3.75	0.88	1.53	4.79
		Value preference	84	3.98	0.62	2.15	5.27
		Family/peer Support	84	4.06	0.67	2.16	5.04
		Teacher Influence	84	3.89	0.75	0.47	5.99
	Non-STEM	Self-efficacy	29	3.85	0.82	2.08	5.09
		Interest	29	4.16	0.76	2.83	4.79
		Value preference	29	3.72	0.74	2.03	5.39
		Family/peer Support	29	3.79	0.86	1.36	5.04
		Teacher influence	29	3.79	0.69	1.33	4.89
Women	STEM	Self-efficacy	57	3.91	0.87	1.44	5.09
		Interest	57	4.00	0.95	1.17	4.78
		Value preference	57	3.98	0.59	2.62	5.26
		Family/peer Support	57	4.06	0.73	1.94	5.04
		Teacher influence	57	4.24	0.67	2.59	5.57
	Non-STEM	Self-efficacy	57	4.16	0.67	2.43	5.09
		Interest	57	4.28	0.71	3.12	4.79
		Family/peer Support	57	3.97	0.9	0.30	5.04
		Teacher influence	57	4.03	0.59	2.83	5.31

I conducted two-way ANOVA on each environmental factor and personal factor to answer the research questions. Those environmental and personal factors were dependent variables. Gender and field were independent variables.

The open-ended responses were divided by factor, gender, and program. The responses that were pertinent to my quantitative findings or opposed my findings were included with the results. A total of 72 comments were recorded Appendix D contains all comments by factor, gender, and program.

Personal Factor

Value preference. Participants were asked "How important was each of the following concerns (e.g., welfare to society) in your life BEFORE you entered your current graduate program" as well as "How much did each of the following factors affect your decision to pursue graduate study in your current field?" Two-way ANOVA indicated significant gender effect $F(1, 223) = 7.13, p = .01$ and significant interaction between gender and field, $F(1,223) = 7.32, p = 0.007, r^2 = 0.05$. A Tukey-Kramer *post-hoc* comparison indicates that the 95% confidence limits of the least square mean difference between men and women were from -0.40 to -0.06, indicating that overall, women ($M = 4.08$) reported a significantly higher influence from value preference than male students ($M = 3.85$) (Figure 2). Tukey-Kramer *post-hoc* comparison indicates that the 95% confidence limits of the least squares mean difference between men and women were from -0.81 to –0.11, indicating that women ($M = 4.18$) reported higher influence from value preference than male students ($M = 3.72$).

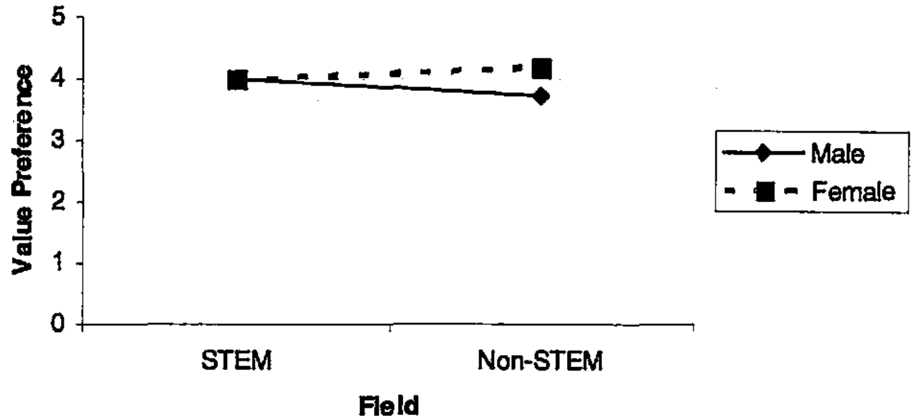

Figure 2. The value preference importance/influence on field and gender.

In addition to the fixed choices, the survey asked students to specify other factors that affected their decision to pursue graduate study in their current field. A non-STEM female participant added, "To engage in a fulfilling career." This comment is consistent with my finding that women in non-STEM were more influenced by value preferences than women in STEM and men in both fields when choosing their graduate program.

Self-efficacy. The two-way ANOVA indicated that none of the gender, field, or the interaction of the two has a significant effect on self-efficacy. The three effects together accounted for only 2% of the variability in self-efficacy.

Interest. Participants provided their own rating of how strongly they agree or disagree on statements such as "I like my current major." Two-way ANOVA indicated a significant field effect, F (1, 223) = 7.97, p = .005, r^2 = 0.06. Non-STEM participants reported (M = 4.22) significantly higher interest in their field than STEM participants (M = 3.88) (Figure 3). Tukey-Kramer *post-hoc* comparison indicates that the 95% confidence limits of the least squares means difference between STEM and non-STEM were from –0.58 to –0.1, suggesting that overall non-STEM students have a significantly higher interest in their graduate field.

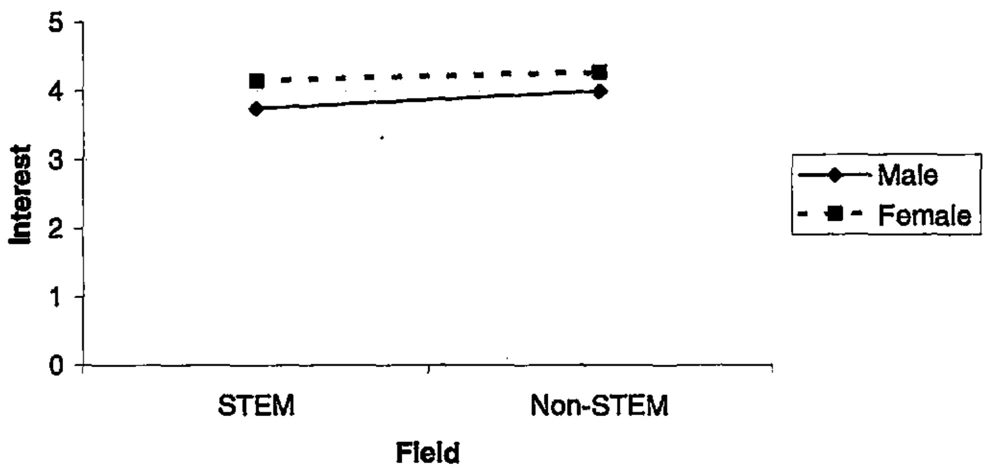

Figure 3. Gender effect on interest component

In addition to the fixed choices, the survey asked students to specify other factors that affected their decision to pursue graduate study in their current field. A non-STEM male participant added, "I wanted to pursue my interests/dreams..." This comment is consistent with my finding that non-STEM participants have a higher interest in their graduate field. Also a male in STEM added "interest and fascination in the current field" as why he chose to continue to graduate level work in STEM, which was inconsistent with my findings.

Environmental Factors

Family support. Participants provided their own rating of how supportive various people (e.g., parents) had been of their choice of the current field of study. Two-way ANOVA indicated that none of the gender, field, or the interaction of the two has a significant effect on the participant's family support. The three effects together accounted for only 1% of the variability in the participant's family support.

Teacher influence. Participants were asked, "To what extent have/did your teacher(s) influence you on choosing your current field?" Two-way ANOVA (Figure 4) indicated a significant gender effect, $F\ (1, 223) = 9.05, p = .003, r^2 = 0.05$. Tukey-Kramer *post-hoc* comparison indicates that the 95% confidence limits of the least squares means difference between STEM and non-STEM is from –0.49 to –0.10, meaning that overall female students ($M = 4.14$) reported significantly higher influence from their teacher than male students ($M = 3.84$).

In addition to the fixed choices, students were asked to specify other factors that affected their decisions to pursue graduate study in their current fields. A male in the STEM group added "mentors in college" as one other factor. Another male in STEM added "professors in my Master's program encouraged me into my current PhD program/field." A female in the STEM group added "previous professors were the most influential." A female in the non-STEM group added "Job/Mentor in the field after college - very positive influence." Another female in the non-STEM group added "Graduate School (Master's): Strongly

Positive." The written comments indicate that in general, the participants were greatly influenced by their teachers and mentors.

Chapter 5. Discussion and Conclusions

This study focused on how men and women in STEM and non-STEM graduate programs differ in factors that were conceivably influential in their field choice. I identified several factors from the literature that were previously found differences between gender and field.

As expected, there were notable important gender differences in the personal factors between STEM and non-STEM fields. Women in non-STEM also were significantly more influenced by value preference than men in non-STEM prior to entering their graduate field. Interestingly, women in non-STEM programs were more influenced by these concerns than men in non-STEM. This pattern is consistent with what was found in the Sax (2006) study, that is, women with higher degree aspirations become less inclined to pursue nontraditional fields; women who tend to be more interested in social welfare are less apt to pursue science. Bandura suggested that people act terms of their value preferences. If participants are not choosing STEM because of social welfare, job opportunity, salary, and social status, then why are they choosing to go into STEM, what do they value? Future studies need to investigate what value makes undergraduates choose to go to graduate level.

Interest significantly contributed to non-STEM participants' field choice. This raised an interesting question: why do STEM students have lower interests in their fields? This can be explained by Boaler's (1994) finding that a source of girls disinterest in math is that it is often taught to ignore real-world scenarios. Walkerdine (1989) suggested that flexibility and creativity in the mathematics classroom is believed to enhance motivation, confidence, and enjoyment, particularly for women. Walkerdine's suggestion is supported by the social cognitive theory that people develop interest in activities they believe they can do (Bandura, 1986). It is, however, not supported by my finding. Self-efficacy did not vary over field or gender, therefore lack of self-efficacy is not creating the difference between STEM and non-STEM graduate students' interest. Non-STEM participants could have experience with teachers who were more highly qualified in their field, as STEM subjects tend to be taught by teachers who are under qualified in their subject matter (Ashby, 2006). To attract more women to graduate studies in STEM, fostering interest in the classroom could be beneficial, as well as hiring teachers who have a degree, a minor, or a certificate in science or math.

Support from teachers significantly contributed to women's decisions to continue their education at the graduate level in both STEM and non-STEM fields. This finding is consistent with the report of the American Institute of Physics (2006), which found that women reported receiving positive attention from physics professors as undergraduates, as well as positive relationships with their faculty advisors. During their education and careers, most women reported they relied on the support of at least one teacher (Ivie & Guo, 2006). Women depend on teacher's support to guide their future choices. Their mentorship creates the spark that ignites women's cognized future in graduate school.

Studies have shown that boys tend to report higher levels of self-efficacy in science and math, and at the undergraduate level women tend to have low self-efficacy in engineering(Anderman & Young, 1994; Meece et al., 2006; Pajares, 1999; Pintrich & DeGroot, 2002; Vogt et al., 2007; Zimmerman & Martinez-Pons, 1990). Self-efficacy was not affected by gender or field in this study, and therefore does not support this finding. Self-efficacy lack of influence might be due to the fact that it is a predictor of women's entry into science fields; as a result, women and men with higher levels of self-efficacy persist into graduate school (Ethington, 1988; Grandy, 1987; Matyas, 1985; Peng & Jaffe, 1979; Sax, 1996; Ware et al., 1985).

Parents play an important role influencing their children's course of study and eventual careers. Family and peer support was not effected by gender, or field in this study, hence supported Chinn's (1999, 2002) finding that children grow their self-worth early, and interest through the supportive social networks of family, relatives, and peers.

This study makes an important contribution to Bandura's social cognitive theory. In the social cognitive theory, interest and self-efficacy are related, based on the thought that as one feels able to do an activity one's interest rises. In my research I found an exception to the theory, I found that non-STEM participants have a higher interest in their field. I would except from the theory that they would have a higher self-efficacy than STEM participants, who reported a lower level of interest in their fields. I found no such correlation in my analysis.

Gender and field decision did not create enough variance to be statistically significant. My findings also support the social cognitive theory. According to Bandura (1986), participants cognized future of going to graduate school is based on the interaction or interplay between these factors and their behavior. I found this to be true: the students' behaviors were influenced by both personal and environmental factors.

Educational Implications

This study examined the differences between women and men in STEM and non-STEM graduate programs on the factors that were conceivably influential to women's decisions to pursue a graduate program in STEM. Findings in this study suggest teachers at all grade levels need to improve men and women's interest and confidence in science and math. Building interest in these subjects needs to begin early in students' education careers.

Teachers also should educate their students early on about opportunities for careers in STEM. Women need to understand the importance of STEM research and the contributions that those who continue in STEM make to society. Introducing real world issues to classroom activities and standards may encourage students to find the connection between STEM research and STEM subjects.

Teachers need to be aware of the influence they have on their students' career paths. Their support and encouragement is important particularly for women's persistence in education. Teachers have the opportunity to foster this relationship through assignments, and educating not only students about careers in

STEM, but parents as well, so that parents can advocate advanced degrees in STEM.

Hiring teachers who have degrees, minors, or certificates in the field that they teach is also important as their lack of knowledge or motivation in the field could hinder students from choosing to continue in STEM. This could be achieved by offering incentives to undergraduate students with bachelors in science or math to teach, or by motivating teachers to go back to school and gain higher degrees in the field they are teaching.

Limitations and Future Directions

This study has limitations. First, the data were only collected from one university. All our conclusions must be interpreted within the context of the institution studied a geographically isolated Carnegie Doctoral/Research University-Extensive institution, which offers 87 bachelor's degrees, 87 master's degrees, and 51 doctorates. On the other hand, there are advantages to studying only one university. When evaluated with other national data sets, researchers are able to make statements about the larger population of graduate students, and they must consider the impact that different institutions have on students. By studying only one institution we were able to control for institutional effects on students.

Second, I asked the participants to recall feelings prior to entering their current graduate programs. The validity of the participants' responses is somewhat threatened due to the length of time since they began their current program. Their current feelings about their program may be biased answers, affected by their memory and experience in the current program. On the other hand, sampling graduate students about their personal and environmental factors does have its advantages. When using undergraduate students, researchers are unable to follow through to see who actually continues on to graduate school without the cost and time of a longitudinal study. If possible, future studies should only survey incoming graduate students.

Third, my ability to explain why students choose their particular graduate program is limited. While I was able to integrate and analyze many of the personal and environmental factors that influence a student's choice, some variables were not included in my model. For example, Chinn (2002) found that cultural values have some explanatory power for the academic success of Asian American men in science and engineering, but they do not prepare Asian women for the competitive, individualistic fields. Our instrument did not have sufficient measures we could use to develop a cultural value construct. Additionally, evaluating family support was only based on three items. Future studies should involve these factors, so that their influence can be examined.

Fourth, the participants self-selected to participate in this study. The participants received an email from either their division secretary or chair of their department to participate in the survey. Students chose to participate based on their own intrinsic motivations. These graduate students may not be the average graduate students. It is possible that they might be more influenced by their faculty, or more interested in their field than the typical graduate student. Future studies should reduce this bias by surveying graduate students in graduate level classes to get a more representative sample.

Fifth, most of the literature surveyed in this study focus on STEM students. The personal and environmental factors influencing non-STEM graduate students' choice of a graduate field were not researched. Therefore, only the factors influencing STEM students' field choice were addressed. This limitation could have influenced what questions were asked and how questions were phrased. For example, value preference for a student choosing religious studies could be very different from that for a graduate student choosing zoology. Future studies should review literature on both STEM and non-STEM students.

Finally, although I was able to sample from a large number of departments, the number of participants is not evenly distributed sufficiently to determine interdepartmental effects of our results. Future studies could further examine departmental effect by increasing the sample size of students from different departments and including more than one university.

Appendix A *Survey*

Graduate Student Survey

Dear Students:

This study is to explore the factors that may contribute to graduate students' choice of field. Your responses are very important for graduate education. Thank you very much for your input!

Please respond to the following questions by marking or filling in your answers. Your responses are anonymous. Specific information about the individual students will be kept strictly confidential. NO PERSONAL INFORMATION WILL BE RELEASED IN ANYWAY AT ANYTIME.

Should you have any questions regarding the study, please feel free to contact me by phone 808-391-7745 or email at oneil.survey@gmail.com. If you have any questions about your rights as a participant in the research project, you may contact the University of Hawai'i Committee on Human Studies at 956-5007.

Katherine O'Neil
Graduate Student
Department of Educational Psychology
University of Hawai'i, Mānoa

1. What is your gender? 1. Male 2. Female

2. Are you a citizen of the United States? 1.No 2.Yes

3.If you are not a US citizen, what is your country of citizenship?

____

5. How old are you? ________ years old

6. Are you a: 1. Undergraduate Student 2. Masters Student 3. Doctoral Student

7. What is(are) your field of study? (ex. Civil Engineering)

____

8. What is your mother's HIGHEST level of education?
   1. Below high school
   2. High school graduate
   3. College graduate
   4. Masters degree
   5. Doctoral degree

9. If relevant, what is your mother's major for her HIGHEST level of education?

____

10. What is your father's HIGHEST level of education?
  1. Below high school
  2. High school graduate
  3. College graduate
  4. Masters degree
  5. Doctoral degree

11. If relevant what is your father's major for his HIGHEST level of education?

____

12. To what extent have/did your teacher(s) influence you on your choosing your current field?

	Strongly Negative	Negative	No Influence	Positiv e	Strongly Positive
1. Elementary school	1	2	3	4	5
2. Middle School	1	2	3	4	5
3. High School	1	2	3	4	5
4. College	1	2	3	4	5
5. Other (Please specify):					

13. To what extent was each of the following groups supportive or against your choice of your current field?

	Strongly Against	Agains t	Neutral	Support	Strongly Support	N/A
1. Parents	1	2	3	4	5	0
2. Other family members	1	2	3	4	5	0
3. Friends/Classmates	1	2	3	4	5	0
3. Other (Please specify):	1	2	3	4	5	

14. How important was each of the following concerns in your life BEFORE you entered your current graduate program?

	Very Unimportant	Unimportant	Neutral	Important	Very Important
1. Job Opportunity	1	2	3	4	5
2. Education Enrichment	1	2	3	4	5
3. Financial Concern	1	2	3	4	5
4. Family	1	2	3	4	5
5. Research Progress	1	2	3	4	5
6. Career Success	1	2	3	4	5
7. Welfare of Society	1	2	3	4	5
8. Other (Specify):	1	2	3	4	5

15. How much did each of the following factors affect your decision to pursue graduate study in your current field?

	Never	Rarely	Sometimes	Usuall y	Consistently
1. Future job opportunity	1	2	3	4	5
2. Expected salary	1	2	3	4	5
3. Social status	1	2	3	4	5
4 Others (specify):	1	2	3	4	5

16. Indicate to what degree you agree or disagree with each of the following statements, BEFORE you entered graduate school:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I can be a good researcher in my major.	1	2	3	4	5
2. I can be a good teacher in my major.	1	2	3	4	5
3. I can do well in all the course work related to my major	1	2	3	4	5
4. I can figure out how to do difficult work in my major.	1	2	3	4	5
5. I can learn my major well.	1	2	3	4	5
6. I can make a great contribution to the field of my major.	1	2	3	4	5
7. I can perform well in a job related to my major in the future.	1	2	3	4	5
8. I enjoy the activities in the course work in my major.	1	2	3	4	5
9. I enjoy working with most people in my current major.	1	2	3	4	5
10. I like my current major.	1	2	3	4	5
11. My current major fits my intellectual strength.	1	2	3	4	5
12. My current major is fascinating to me.	1	2	3	4	5
13. What I learn in my major is interesting.	1	2	3	4	5

17. Are you getting your graduate degree in the same major as your undergraduate degree?

1. Yes 2. No

18. If not, what was your undergraduate major?

____

19. Please feel free to provide any additional comments to clarify why you choose to continue your education at the graduate level:

Appendix B. Invitation Email

Aloha!

Please email the following link to the graduate students within your department. If you prefer a survey on paper please email me and I can bring it to your department. Sorry if you get this more then once!

This study is to explore the factors that may contribute to graduate students' choice of field. This survey should only take 5 minutes. Your responses are very important for graduate education. Thank you very much for your input!

https://www.surveymonkey.com/s.aspx?sm=FuDmUuaqJQAP3ttlJNO66g_3d_3d

Mahalo!

Katie O'Neil
Graduate Student
Dept.of Educational Psychology
University of Hawaii, Manoa
Oneil.survey@gmail.com
(808)XXX-XXXX

Appendix C. Reminder Email

Aloha all,

Please email the following link to the graduate students within your department again, as a final reminder. The survey should only take 5 minutes and will contribute to graduate level education. Thank you for your time and participation!

https://www.surveymonkey.com/s.aspx?sm=FuDmUuaqJQAP3ttlJNO66g_3d_3d

Sincerely,

Katie O'Neil
Graduate Student
Dept.of Educational Psychology
University of Hawaii, Manoa
Oneil.survey@gmail.com
(808)XXX-XXXX

Appendix D. Participants' Responses to the Open-ended Questions

Factor	Program	Program	Comment
Support family/peers	STEM	male	I have been an active researcher in my field since the 1990's, have returned to work on a PhD at the urging of my colleagues
		female	Ex professors
	non-STEM	female	Advisers in Undergrad
Value Preference	STEM	male	Contributing to national security and future of Western civilization--very important!
			chance to go to Hawaii
			just for the pleasure of doing something interesting
			After working for 4 years in the semiconductor industry, I found that I lacked the education to do any cutting edge research, so was relegated to pretty mundane tasks. I came back to school so I could get a research position. Now I find that I want to work on alternative energy sources to help alleviate the impending energy shortage. Things never go the way you plan.
	non-STEM	male	I do personality research internationally.
			I felt that it was necessary to get a higher education to advance my family's social status and financial position.
			Many of my heroes do not have graduate degrees
		female	Personal interest in the field
			Professors-Consistently
			To engage in a fulfilling career
			Prayer
			I was a high school teacher before. My experiences in the classroom-- particularly the challenges of teaching writing well-- prompted me to pursue a PhD in Composition and Rhetoric. I think that over the long run I can make a greater contribution with a PhD-- in terms of influencing policy, training teachers, conducting my own research-- than as an individual high school classroom teacher. Plus, the balance of getting to spend some time researching and some time teaching appeals to me.
Teacher influence	STEM	male	Mentor in college

			Professors in my Masters program encouraged me into my current PhD program/field
			Internships helped me to choose my major
			Professors in my Masters program encouraged me into my current PhD program/field
		female	Volunteer opportunities that began in high school introduced me to my field.
	non-STEM	male	I discovered psych by exploring courses. Still want to take classes in other subjects.
		female	Home schooled K-12, so really had the same "teacher" throughout Graduate School (Master's): Strongly Positive
			Job/Mentor in the field after college - very positive influence
			nursing school
			Spouse
			Friends and most family
			Home schooled K-12, so really had the same "teacher" throughout Graduate School (Master's): Strongly Positive
			Friends and most family
			nursing school
			Job/Mentor in the field after college - very positive influence
Interest	STEM	male	I continued for the PhD due to my interest doing research and be able to conduct my own investigation
			My primary reasons for continuing education in physics were my interest in fundamental research, and a desire to continue to challenge myself. A previous extremely unpleasant engineering job I held immediately after my undergraduate degree, which was entirely intellectually stagnant, was a major motivator to this end.
			It seemed like fun. I enjoy learning
			Curiosity is the principal motivator in my academic pursuits.

During my undergrad, I knew I would get more education before seeking a job. I eventually chose my Master's program primarily based on my own interests. During that degree, I was encouraged to join the CIS PhD program. It was revealed to me that I could also get a TAship that would cover tuition as well as pay me a small stipend. The ability to stay in school (and not have to decide what to do with my life yet) and get more education for FREE was my major motivation.
I really like what I am studying and this was the main reason I decided to go to graduate school. In addition, I chose to do a PhD in order to have a better voice in my domain. In my country, you get people's attention when you hold a PhD or you are refereed to as "professor". This certainly affected my decision but my choice was at 98% (just a figure!) affected by my wish to contribute to the way people do science in certain parts of the world. I see this as a chance for me to be able to inspire other young people to do well in research and in my field. Another reason is to be able to publish and get known! I strongly believe that it is doable and I am going to get there!

Interest and fascination in the current field! After a certain level you cannot go down, have to move up (Cannot go back to undergrad to learn the same thing again).

female

I am very interested in every step of the research process. I like asking questions and trying to answer them. I also enjoy teaching at the college level and so the professor job is best for me. It helps that there are opportunities such as scholarships and grants too. If I didn't have financial support, I couldn't do this at all. Also, my personality likes the flexible hours of doing research work, the opportunity for travel, the collegial atmosphere, and the independence to do whatever I want to work on with the support that goes with it. Also, being able to find a program and an advisor that I can work with was crucial for me. Have a good summer too and good luck with your survey! :)

I think we need our maters these days no matter what job we want, it will help. There are some great classes in ethno botany that I like taking and learning about.
Career enrichment, interest to reach potential learning experience on the graduate level, higher salary, promotion in my job

	non-STEM	male	Personality is fascinating. Psychology ignores it. For example, developmental psychology doesn't know personality affects psychological development of children and parenting style. Why is knowledge so terrifying?
			I wanted to pursue my interests/dreams...
			My main goal for entering graduate school was personal enrichment.
		female	Wanted to teach college/university, required an advanced degree. Also, I just like to learn.
			I just enjoy studying Chinese language and culture, and I'm hoping to find some industry where I can combine Chinese language with computing.
Self-efficacy	STEM	male	I simply felt that I still had a lot to learn, and I have the capacity and drive to learn it. I feel that I can make a positive impact on many levels once I complete my degree and continue contributions through education and research.
			A math Ph.D. does not guarantee you a job (not in the least) but math has always been my greatest strength. Any other pursuit would be ill-fitting although possibly more remunerative and definitely easier to find employment in.
			Before I entered the graduate program, I have worked in industry for many years. The primary objective of my graduate study is to do a different job in the future, i.e., no longer just follow the design manuals and repeat the routine procedures, but to work with my own intelligence.
		female	A PhD degree would provide me with the freedom to be more intellectually creative and direct the focus of the research. I like the creative process that does into developing the research question, designing the experiments, and writing the grant proposals.
	non-STEM	female	I knew I was capable of it. I was intellectually curious and felt a great desire to be back in an academic community.
Miscellaneous	STEM	male	chance to go to Hawaii (but I don't regret it, in fact I am not leaving this island)
			Completion of an undergraduate thesis (honors research project)

female

For question 19 before I started my masters I didn't know what careers were likely, so I wouldn't be able to answer the questions for then.. I answered the questions for 19 as I saw the answers while I was getting my MS ....number 20 is for how I feel and felt by the end of masters degree and now into my PHD

I had resigned from my previous job for health and career reasons, so I took a position as adjunct faculty teaching introductory computer courses. I discovered that I liked teaching, and seemed to be good at it. I knew that if I wanted to continue teaching at the college level, I needed to have a PhD, so I went back to school.

I object to being labeled a postdoctoral student. We are not students; we do not take classes nor are we working toward a degree. Some of the categories in questions #12-15 are too vague. I had several encouraging and discouraging teachers at each level and have encouraging and discouraging several members of my family. Question #20 is ambiguous, do you mean how likely are we to get the job we want or how likely are we to want those types of positions?

Working in my industry post-baccalaureate has shown that I want to continue technical education.

This is my second masters, first was in education and used to teach high school (4 years). I didn't want to continue teaching anymore and wanted to go back to expand my experience so I could work in a science related field

non-STEM male

FYI, questions 15 and 20 are oddly worded. 15 Asks how much, but then the answers use the words "sometimes, frequently, etc." This doesn't work. It's like How much water is in the glass? Sometimes. To go all linguisticy on you, how much implies a mass noun, while sometimes and frequently are things you can count. As for 20, I think it's missing a verb. It needs to be, "how likely is it that you will find..."

I dropped out of English grad program and worked as a journalist. Now employed at the university, I returned to again take up creative writing.

There were many reasons and it was a way to fulfill many of my goals in life. One that was not captured in this survey is the desire to lead a more fulfilled existence.

I want to go the distance.

I was misled into believing that the university would be able to provide an academically challenging course load and also that they would be able to foster and help cultivate my intelligence and creativity to allow me to continue my doctoral work at a finer institution. I am extremely unhappy with the quality of instruction and overall university structure.

female A large influence was that I didn't want to start work just yet.

Pursuing psychology without a graduate degree was essentially meaningless. Academic success, for me, was defined in part by achieving a post-graduate degree.

I cannot advance in a clinical psychology career without a graduate degree. I've always wanted to get my doctorate.

I chose to continue my education at the graduate level to gain the tools and skills needed to become a better Japanese language teacher to Hawaii's students.

I would like to teach Japanese at the community college level.

Based on what I want to do (teach at the university level), completing graduate school was necessary. I'm graduating with my PhD this summer, and am very happy that I stuck with the long and grueling graduate school process. It made my goals attainable, and widely increased my options for employment.

I knew that I wanted to teach; having a horrendous experience teaching at the high school level led me to choosing to be a college professor. In order to do that, I needed the Ph.D.

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