Reducing the STEM Gender Gap

The Effect of Psychological Interventions on the Social Networks and Academic Persistence of Women Ph.D. Students in STEM

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Abstract

Can there be a treatment for bridging the gender gap in STEM (science, technology, engineering, and mathematics) fields? This study demonstrates that psychological interventions can be effective in promoting women STEM Ph.D. students' persistence in school. Multilevel model analyses suggested that female students (but not male) who received a values affirmation or social belonging intervention were nine percentage points more likely to remain in their graduate program after 3-4 years than those who were not treated. The social belonging intervention was effective for both women and men in helping them persist in STEM Ph.D. programs, with the odds of retention increased by 2.29 times compared to the control condition. These findings indicate the importance of providing psychological support for female STEM Ph.D. students to reduce gender disparities in STEM.

Introduction

STEM (Science, Technology, Engineering, and Mathematics) education has been critical to the modern economy as it is a key to research-based development and higher productivity (Freeman et al., 2016). According to The U.S. Bureau of Labor Statistics (2019), STEM workers are in high demand with an 8% increase in the number of STEM jobs in the next 10 years. Yet women are historically underrepresented in these high-demand occupations and advanced degrees in STEM fields (Fry et al., 2021). Women are more likely to drop out of STEM Ph.D. programs. As social experiences in classrooms and a sense of belonging in an institution play a critical role in students' persistence (Justyna et al., 2017; Tinto, 2017), interventions that could help foster positive social interactions might be helpful to increase the retention of women in STEM.

This paper investigates whether psychological interventions could promote STEM Ph.D. students' social networks and help them remain in their graduate program, with a particular focus on female students. More specifically, we analyzed data from STEM Ph.D. students at Columbia University, Penn State University, and Stanford University to test if a value affirmation intervention or a social belonging intervention could have a positive impact on women students' social network (in terms of their total number of friends and interpersonal closeness with these friends) and their retention in graduate programs.

Relevant Works

The Underrepresentation and Stereotypes of Women in STEM

Women make up almost half of the American working age population but they presently account for only a small portion of science, technology, engineering and math (STEM) professionals, as shown by 2019 US Census Bureau estimates. Compared to 1970, when 38% of the US workforce and 8% of STEM workers were women, the representation of women has increased across STEM occupations, but only 27% of STEM workers are women, whereas men dominated 73% of STEM jobs in 2019. This gender disparity in STEM has long been a topic of research for many years and many efforts have tried to reduce this disparity, as it disproportionately repels women from pursuing some of the most lucrative careers (Kalwarski et al., 2007). Reducing the gender gap is crucial not only for ethical reasons but also for improving scientific and financial outcomes. Increased gender parity can lead to more sales, customers, and profits (Herring, 2009). A 2015 McKinsey report suggested that the companies in the top quartile for gender diversity, out of 366 public companies they examined, had 15% more chance to have financial returns than national industry medians.

Yet stereotypes towards women make it hard for them to progress in STEM fields. A study done by Master et al. (2021) identified that societal gender stereotypes towards girls in computer science and engineering could start as early as the age of six, which would make many girls feel that they don't belong in the field and thus choose not to pursue the degrees. In their previous research, Master et al. (2016) argued that stereotypes would harm girls' sense of belonging in computer science. They also identified that a computer science classroom that didn't make the gender stereotypes salient helped female students express more interest in taking the course.

Social Exclusion of Women in STEM

Women are often less socially connected in STEM fields. For example, women engineering students had a different experience from men students in the process of professional socialization in engineering internships and summer jobs in research by Seron et al. (2015). Women students experienced exclusion with fewer opportunities to practice and more frequent assignments to supporting roles. They also reported that their coworkers assumed a lack of expertise. In contrast, men students gained confidence throughout the engineering internship and described it as a collaborative experience and supportive turning point.

Researchers have studied why women are socially excluded in male-dominated fields. According to a study by Cyr et al. (2021), women's exclusion from social networks in STEM is partially explained by the fact that connections to female colleagues are seen as less valuable in workplaces dominated by men. This study showed that men with stronger implicit gender stereotypes, such as "think STEM, think men," socialized with fewer female teammates, which could harm women's outcomes in the workplace. Women who had fewer social relationships and interactions with men, based on the social ties reported by men, had more negative outcomes in the workplace. In contrast, women who felt more included by men at work reported greater work engagement and self-efficacy as well as lower social identity threat (Cyr et al., 2021).

Psychological Interventions for Academic Persistence of Minority Students

Individual traits such as grit are widely studied in psychology for their role in improving academic persistence and achievement, but scholars have also identified that psychological interventions targeting social factors can be a treatment for students' dropout and underachievement. One such intervention is values affirmation, which is a writing activity that asks students to select values that are important to them and write about how they integrate these

values into their lives. When people complete values affirmation interventions in psychologically threatening environments, such as challenging academic environments that raise questions like "Am I good enough?" or "Am I smart enough?", the reminder of their core values can put the threat into perspective and reassert their sense of self-worth and personal adequacy. Turetsky et al. (2020) suggested that this intervention can lessen psychological threats in stressful environments, increasing social integration with peers and improving students' academic persistence. Research has found that another intervention, the social belonging intervention, has also been beneficial for students' success (Walton et al., 2011). Sense of belonging plays a crucial role as one of the key dimensions of student motivation (Walton et al., 2012). Students who feel a greater sense of belonging in an institution are more likely to persist with higher motivation and willingness to get involved with other students, which leads to further persistence (Tinto, 2017). Thus, interventions that have boosted students' sense of belonging in academic environments have led to increased performance and persistence (Walton & Cohen, 2011).

These interventions caught the attention of scholars especially due to their contribution to the success of underrepresented minority and women students in STEM fields by addressing psychological processes that inhibit achievement (Casad et al., 2018). The psychological interventions could be particularly helpful for the marginalized group in STEM, as people of color and women have historically been and still are facing higher levels of psychological threat and concerns about belonging to STEM fields due to stereotypes and bias (Seron et al., 2016). Jordt et al. (2017) demonstrated that the values affirmation intervention decreased the achievement gap between underrepresented minority and White students in introductory biology classes. Values affirmation reduced the gender achievement gap in a college-level introductory physics class as well by raising female students' modal grades from C to B range (Miake et al.,

2010). The belonging intervention was also helpful in increasing women's engineering GPA, eliminating gender differences (Walton et al., 2015).

Psychological Interventions to Strengthen Social Networks for Academic Persistence

Moynihan and Pandy (2007) suggested that a strong intraorganizational social network leads to long-term commitment of employees to the organizations. In the academic context, a values affirmation intervention that strengthened students' social networks led to persistence in STEM, according to Turetsky et al. (2020). They tested whether the values affirmation could strengthen students' social networks and thus encourage students to persist in challenging STEM environments through mediation analysis. They conducted an experiment with about two hundred students in a biology course. The treatment, values affirmation exercise, led to stronger social networks based on social network centrality measures (closeness centrality, degree centrality) and elevated students' persistence. Students who were in the treatment group were 11.7 percentage points more likely to take the next course in the undergraduate bioscience sequence compared to the students in the control condition. It was found that an important component influencing enrollment was students' centrality in the course friendship network; affirmed students' greater integration into the course social network mediated the effect of the intervention on persistence in biology. Another study conducted by Yeager et al. (2016) also showed that the social belonging intervention was effective to enhance the development of friendship networks among disadvantaged students as well as their full-time enrollment.

Data

The analyses used a subset of data from Study for the Advancement of Graduate Education and Scholarship (SAGES), which is a project investigating whether psychological interventions can improve the experiences and outcomes of Ph.D. students in STEM (Science, Technology, Engineering, and Math) fields. Participants were two cohorts of incoming Ph.D. students at Columbia University, Penn State University, and Stanford University during the 2018-2019 and 2019-2020 academic years. SAGES researchers randomly assigned the students into one of three groups, a values affirmation, social belonging, or control condition, to test if these interventions could help them advance in their graduate programs. The participants completed a baseline survey before the intervention and their first semester started (See Figure 1). Fourteen surveys, eight end of week surveys (EOW) and six follow-up surveys (FU), were administered following the intervention to measure changes in their psychological experiences and behavior (See Table 1 for additional details on the timing of each survey. EOW and FU differed in the timeline but included same measures.).

As our main interest is investigating the impact of the interventions on doctoral students' retention and social networks in graduate school, we examined data from the baseline survey and the fifth end of week survey (EOW 5) where the participants answered questions about their social networks in their graduate program at the beginning of their second semester (see Figure 2). In addition, students completed these two surveys before the Covid-19 pandemic started, so we could avoid the effect of the pandemic on their social networks.

Figure 1. Timeline of Surveys

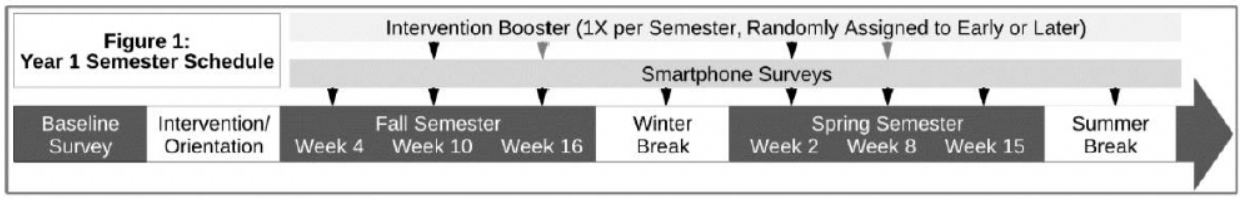


Table 1. Start Date of Surveys

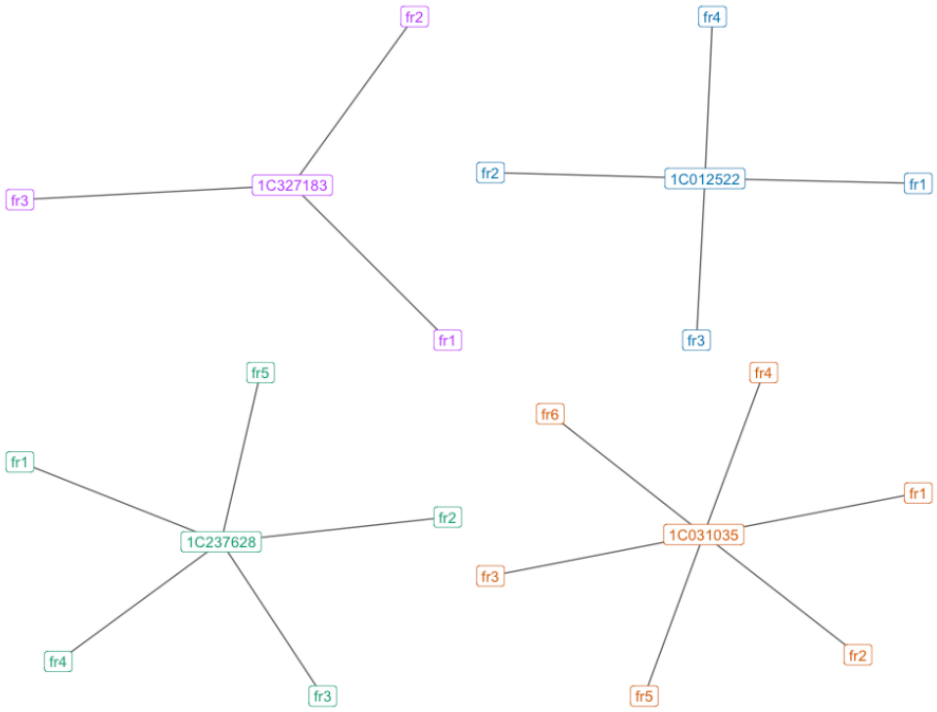
	Cohort 1	Cohort 2
Baseline	2018-08-13	2019-08-19
EOW 1	2018-09-17	2019-09-23
EOW 2	2018-10-29	2019-11-04
EOW 3	2018-12-10	2019-12-16
EOW 4	2018-12-27	2020-01-02
EOW 5	2019-01-21	2020-01-27
EOW 6	2019-03-04	2020-03-09
EOW 7	2019-04-15	2020-04-20
EOW 8	2019-05-20	2020-05-25
FU 1	2019-09-10	2020-09-07
FU 2	2019-10-25	2020-10-19
FU 3	2019-12-09	2020-12-07
FU 4	2020-01-21	2021-01-18
FU 5	2020-03-03	2021-03-08
FU 6	2020-04-27	2021-04-12

There were 1085 participants who finished the baseline survey, but this study has a sample size of 564, taking into account participant attrition over time across the surveys. Participants were randomized to conditions using blockTools, R package (Moore, 2012), which led to randomization that maximizes balance across conditions and improves the precision of

treatment effect estimation (Gerber & Green, 2012). It took into account students' gender, race, whether they were first-generation college students, and whether they were international students. Therefore, each participant had a 33% chance of assignment to the affirmation, belonging, or control condition.

In the affirmation condition, students were asked to select the most important two or three values from a list of 11 values, such as belonging to a social group, relationships with friends and family, or religious values, and write about why those values were important. The students who were in the belonging condition read about how previous Ph.D. students had concerns about belonging in graduate school and their experience of overcoming these concerns and feeling at home in school. Then they were asked to write about why those Ph.D. students overcame their concerns about belonging and write a brief letter for incoming graduate students, explaining how people's experience in graduate school can change over time. Those who were in the control condition followed a similar format and steps as in the belonging condition, but with the topic of study skills, a less psychologically relevant topic. For example, they read that many Ph.D. students feel uncertain about how to study in graduate programs, but learn study techniques eventually.

Figure 2. Columbia Students' Ego Networks Examples



Dependent Variables

We examined the effect of the interventions on three dependent variables. Table 2 shows the descriptive statistics of the three variables.

- **Total number of friends EOW 5**: The number of names (up to six) of fellow graduate students in their Ph.D. program whom participants listed as a friend in the beginning of their second semester in the end of week 5 (See Appendix 1). The mean number of friends in EOW 5 was 3.824.
- **Mean Close EOW 5**: How close the participants felt to each of the listed friends on a scale of 1 to 5 at the beginning of their second semester (EOW 5), averaged across friends (See Appendix 1). Their average closeness rating in EOW 5 was 2.856.

- **Enrollment**: The students' enrollment status (whether they had left their program or not) as of 2022. This is a binary variable provided by each school. 91% of participants were still registered in 2022.

Table2. Summary Statistics of Dependent Variables

Mean Close EOW 5	Total number of Friends EOW 5	Enrollment
Min. :0.000	Min. :0.000	Min. :0.0000
1st Qu.:2.500	1st Qu.:2.000	1st Qu.:1.0000
Median :3.250	Median :4.000	Median :1.0000
Mean :2.856	Mean :3.824	Mean :0.9167
3rd Qu.:3.750	3rd Qu.:6.000	3rd Qu.:1.0000
Max. :5.000	Max. :6.000	Max. :1.0000

Predictor Variables

Condition (affirmation, belonging, or control group) and gender were the predictor variables. The goal of the analyses was to examine whether condition assignment led to a change in the dependent variables (total number of friends, average friendship closeness, and enrollment) and whether gender moderated the effects of the condition on these variables. Table 3 shows the number of participants in each condition group and gender.

- **Condition:** 202 people were assigned to the control group, 178 people to the affirmation group, and 184 people to the belonging group. See Appendix 2 for the materials for the three conditions.

- **Gender:** 284 Female, 269 Male, and 11 Unknown, identified in the baseline survey by participants based on their original birth certificate.

Control variables

We controlled for the following variables to make sure that any changes in the dependent variable (total number of friends, average friendship closeness, and enrollment) were solely due to the changes in condition or gender.

- **Total number of friends Base:** The number of names (up to six) of fellow graduate students in their Ph.D. program listed by participants before the first semester started in the baseline survey (See Appendix 1). This variable ranges from 0 to 6 with a mean of 2.016 friends listed. This was a control variable only for analyses predicting participants' total number of friends at the beginning of their second semester in graduate school (total number of friends EOW 5).
- **Mean Close Base**: The mean closeness of friendship with the listed friends in the baseline survey (See Appendix 1). Closeness was measured on a scale of 1 to 5. The participants' average closeness rating was 1.6 in the baseline survey. This was a control variable only for analyses predicting participants' mean friendship closeness at the beginning of their semester in graduate school (mean close EOW 5).
- **School:** Columbia University (C), Penn State University (P), Stanford University (S).
- **Program:** 116 different graduate programs in STEM fields at Columbia University, Penn State University, and Stanford University.

- **Cohort:** There are two cohorts during 2018-2019 and 2019-2020 academic years. 293 students who began graduate school in Fall 2018 were in cohort 1. 271 students who began graduate school in Fall 2019 were in cohort 2.

Table 3. Summary Statistics of Predictor and Control Variables

Gender	Condition	School	Cohort	Program	Mean Close Base	Total number of Friends Base
F :284	Control :202	C:117	1:293	F_CE : 28	Min. :0.000	Min. :0.000
M :269	Affirmation:178	P:285	2:271	F_GS : 25	1st Qu.:0.000	1st Qu.:0.000
NA's: 11	Belonging :184	S:162		F_JL : 23	Median :2.000	Median :1.000
				F_JS : 21	Mean :1.599	Mean :2.016
				F_CA : 16	3rd Qu.:3.000	3rd Qu.:4.000
				F_BN : 14	Max. :5.000	Max. :6.000
				(Other):437		

Methods

We used three different multilevel models to measure the impact of the interventions on three dependent variables (mean closeness, number of friends, enrollment status) while accounting for the nested structure of our data; students (level 1) are nested within programs (level 2) and the programs are clustered within schools (level 3).

Unlike a typical regression model which only uses fixed effects (population average effects), multilevel models allow us to obtain the cluster specific effects by using random effects in addition to the fixed effects (Clark, 2019). Under the typical regression model, the assumption is that all observations would behave in the same way, regardless of how the observations are grouped together. Separate regression models can be created for each group in order to account for the group effect with the regression model, but this approach will have less statistical power and make results unreliable unless each group has enough sample size. Given that our research has a sample size of 564 (293 students in cohort 1 and 271 students in cohort 2) and 116 programs across three universities, each cluster (program) doesn't have a large enough sample (students) to generate the best estimates of the interventions' impact under this approach.

However, multilevel modeling can be a solution because these models have the benefit of "shrinkage," also known as partial pooling (Mahr, 2017). It prevents possible influence of outliers by pulling extreme estimates toward an overall average. In other words, the multilevel model not only considers cluster specific effects but also borrows information from the population-average effect. This function can be especially useful when a research dataset has extreme clusters or clusters with very small data because it helps consider potential commonalities among the clusters (Clark, 2019).

In this research, we included random intercepts for the program and school for the mean closeness model (Model 1) and the number of friends model (Model 2), which partitions the residual error between individual and group components. This allowed us to include predictor variables (condition, gender) at the individual and group level to explain variation in the dependent variable in our models. This model accounts for the fact that students within the same programs and schools are more likely to be similar than students in different programs and schools, because they are in the same academic context, such as having the same faculty and same graduation requirements.

In the fixed portion of our model, we identified whether students experienced the interventions differently depending on their gender by including interaction terms for *condition x gender* besides including the main effect of both conditions and gender. Conditions were coded as two dummy variables. Condition_Affirmation was coded as 1 for affirmation intervention and 0 for the control group. Likewise, Condition_Belonging was coded as 1 for social belonging intervention and 0 for the control group. The student's gender was simple-coded as -0.5 if they were male and 0.5 if they were female. As initial friendship may be associated with later friendship in the second semester, we controlled for the baseline number of friends or baseline closeness in models predicting the number of friends and closeness at the beginning of student's second semester in graduate school. Both the baseline number of friends and baseline closeness were grand mean centered by subtracting the mean of each variable from the original value. The cohort was also included as a fixed effect, simple-coded as -0.5 if the students were in the first cohort, and 0.5 if they were in the second cohort.

As such, the models for mean closeness and the total number of friends were specified as follows (reported in R syntax), where *(1 | school/program)* creates the random intercepts for program and school:

M ← lmer(friendship_variable_EOW5 ~ condition_Affirmation * gender + condition_Belonging * gender + friendship_variable_baseline + cohort + (1 | school / program))

The model predicting enrollment status was specified as follows, where *(1 | program)* creates the random intercepts on the program level. The full three-level multilevel model predicting enrollment did not converge with both program and school random intercepts, so we controlled for school as a fixed effect instead of including a random intercept for school.

M ← glmer(enrollment ~ condition_Affirmation * gender + condition_Belonging * gender + cohort + school + (1 | program))

Results

Model 1

Hypothesis 1: Students in the affirmation condition or belonging condition will report greater closeness to their fellow graduate students in their second semester than those in the control condition, with stronger effects for female STEM Ph.D.

Table 4. Results of Model 1

	Mean Close EOW 5		
Predictors	*Estimates*	*CI*	*p*
Intercept	2.79	2.42 – 3.15	**<0.001**
Condition_Affirmation	0.11	-0.16 – 0.38	0.424
Condition_Belonging	0.08	-0.19 – 0.34	0.566
Gender	-0.12	-0.49 – 0.25	0.517
Mean Close Base	0.32	0.25 – 0.39	**<0.001**
Cohort	0.32	0.10 – 0.54	**0.004**
Condition_Affirmation * Gender	0.42	-0.11 – 0.96	0.123
Condition_Belonging * Gender	0.38	-0.16 – 0.91	0.166
Random Effects			
σ^2	1.71		
$\tau_{00\ program:school}$	0.01		
$\tau_{00\ school}$	0.08		
ICC	0.05		
$N_{program}$	115		
N_{school}	3		
Observations	553		
Marginal R^2 / Conditional R^2	0.140 / 0.183		

Table 5. Estimated Marginal Means by Condition and Gender in Model 1

Condition	Gender	emmean	SE	df	lower.CL	upper.CL
Control	Male	2.853741	0.2112006	4.567409	2.294996	3.412487
Affirmation	Male	2.752048	0.2143873	4.842997	2.195531	3.308566
Belonging	Male	2.743597	0.2143874	4.865413	2.187880	3.299315
Control	Female	2.732354	0.2067406	4.155971	2.166747	3.297961
Affirmation	Female	3.052579	0.2166585	5.007288	2.495885	3.609274
Belonging	Female	2.997913	0.2122369	4.650779	2.439785	3.556040

Table 6. Estimated Pairwise Effects of Condition on Closeness by Gender in Model 1

Condition_Pairwise	Gender	estimate	SE	df	t.ratio	p.value
Control - Affirmation	Male	0.101693237	0.1959394	542.4788	0.51900342	0.6039700
Control - Belonging	Male	0.110144101	0.1966602	541.0238	0.56007310	0.5756614
Affirmation - Belonging	Male	0.008450865	0.1992618	541.2327	0.04241086	0.9661868
Control - Affirmation	Female	-0.320225471	0.1915013	539.8832	-1.67218420	0.0950674
Control - Belonging	Female	-0.265558831	0.1879451	543.1381	-1.41295933	0.1582405
Affirmation - Belonging	Female	0.054666640	0.1982770	543.2460	0.27570843	0.7828769

Table 7. Comparison of Estimated Effect of Condition on Closeness between Female and Male in Model 1

contrast	condition	estimate	SE	df	t.ratio	p.value
Female - Male	Control	-0.1213875	0.1890615	494.3621	-0.6420528	0.5211365
Female - Male	Affirmation	0.3005312	0.2013375	543.6416	1.4926737	0.1361027
Female - Male	Belonging	0.2543154	0.1968301	538.9575	1.2920554	0.1968917

There were no significant differences in mean closeness to friends between the treated groups and control group overall (See Table 4). However, women in the affirmation condition reported marginally higher average closeness to their friends than women in the control

condition (See Table 6), controlling for cohort and the mean closeness reported in the baseline survey. The estimated mean of average closeness with friends was 0.32 higher among women in the affirmation condition than among women in the control condition. The direction of the result was the same for the women in the belonging group, though it was not statistically significant. For male students, there were no significant differences between any of the conditions. In terms of the predictive power of the model, the variance explained by both fixed and random effects was 0.183 (conditional R^2) and 0.14 variance was explained by only fixed effects (marginal R^2).

Model 2

Hypothesis 2: Students in the affirmation condition or belonging condition will report a higher number of friends in the program in their second semester than those in the control condition, with stronger effects for female STEM Ph.D. students.

Table 9. Results of Model 2

	Total number of friends EOW 5		
Predictors	*Estimates*	*CI*	*p*
Intercept	3.71	3.15 – 4.26	**<0.001**
Condition_Affirmation	0.07	-0.35 – 0.50	0.732
Condition_Belonging	0.13	-0.29 – 0.55	0.548
Gender	-0.00	-0.60 – 0.59	0.987
Total number of friends Base	0.34	0.26 – 0.42	**<0.001**
Cohort	0.04	-0.31 – 0.40	0.807
Condition_Affirmation * Gender	0.56	-0.30 – 1.41	0.203
Condition_Belonging * Gender	0.17	-0.68 – 1.03	0.689
Random Effects			
σ^2	4.27		
$\tau_{00\ program:school}$	0.18		
$\tau_{00\ school}$	0.16		
ICC	0.07		
$N_{\ program}$	115		
$N_{\ school}$	3		
Observations	553		
Marginal R^2 / Conditional R^2	0.117 / 0.182		

Table 10. Estimated Marginal Means by Condition and Gender in Model 2

Condition	Gender	emmean	SE	df	lower.CL	upper.CL
Control	Male	3.715570	0.3273777	4.929958	2.870410	4.560730
Affirmation	Male	3.512381	0.3324228	5.223533	2.668743	4.356018
Belonging	Male	3.758511	0.3324269	5.242707	2.915743	4.601279
Control	Female	3.710692	0.3191782	4.420119	2.856761	4.564623
Affirmation	Female	4.063401	0.3363229	5.423708	3.218780	4.908022
Belonging	Female	3.927830	0.3287102	4.968735	3.081252	4.774409

Table 11. Estimated Pairwise Effects of Condition on Number of Friends by Gender in Model 2

Condition_Pairwise	Gender	estimate	SE	df	t.ratio	p.value
Control - Affirmation	Male	0.20318944	0.3133414	541.9983	0.6484603	0.5169619
Control - Belonging	Male	-0.04294085	0.3142766	542.6017	-0.1366339	0.8913708
Affirmation - Belonging	Male	-0.24613029	0.3181435	535.7232	-0.7736456	0.4394817
Control - Affirmation	Female	-0.35270881	0.3056702	535.5908	-1.1538868	0.2490612
Control - Belonging	Female	-0.21713846	0.3007927	543.0658	-0.7218874	0.4706744
Affirmation - Belonging	Female	0.13557035	0.3173851	542.8271	0.4271478	0.6694411

Unlike friendship closeness, neither female nor male students benefitted from the interventions in total number of friends. In other words, participants in the affirmation group and the belonging group did not differ significantly from participants in the control group in terms of the total number of friends in their Ph.D. programs. The condition x gender interactions were also not significant. As seen in Table 11, the female affirmed participants reported a higher number of friends by 0.35 on average than those in the control group, controlling for cohort and the number of friends reported in the baseline survey, but this effect was not statistically

significant. There was no significant difference in the total number of friends between the female belonging group and the control group either.

Table 12. Comparison of Estimated Effect of Condition on Number of Friends between Female and Male in Model 2

contrast	condition	estimate	SE	df	t.ratio	p.value
Female - Male	Control	-0.004878259	0.3040506	534.2545	-0.01604424	0.98720509
Female - Male	Affirmation	0.551019992	0.3218874	540.8493	1.71184089	0.08749926
Female - Male	Belonging	0.169319353	0.3160314	542.2083	0.53576749	0.59233895

It is notable that there was a marginally significant difference between female students and male students in the affirmation condition (see Table 12). The average affirmed female students had more friends, by 0.55, than the average affirmed male students.

Model 3

Hypothesis 3: Students in the affirmation condition or belonging condition will be more likely to stay in their Ph.D. programs than those in the control condition, with stronger effects for female STEM Ph.D. students.

Table 13. Results of Model 3

	Enrollment		
Predictors	*Odds Ratios*	*CI*	*p*
Intercept	15.98	5.83 – 43.80	**<0.001**
Condition_Affirmation	1.95	0.85 – 4.46	0.116
Condition_Belonging	2.29	0.98 – 5.32	0.055
Gender	0.52	0.19 – 1.40	0.197
Cohort	1.89	0.98 – 3.64	0.058
School_PennState	0.47	0.17 – 1.28	0.141
School_Stanford	0.59	0.19 – 1.77	0.345
Condition_Affirmation * Gender	6.33	1.17 – 34.22	**0.032**
Condition_Belonging * Gender	5.79	1.07 – 31.30	**0.041**
Random Effects			
σ^2	3.29		
$\tau_{00\ program}$	0.29		
ICC	0.08		
$N_{\ program}$	115		
Observations	553		
Marginal R^2 / Conditional R^2	0.134 / 0.204		

Regardless of gender, our model indicates that the belonging intervention improved the persistence of STEM Ph.D. students in graduate school relative to the students in the control group (though marginally significant) overall. The odds of remaining in the graduate programs

were 2.29 times higher among the students in the belonging group than in the control group. Women in both the affirmation and belonging conditions were also significantly more likely than women in the control condition to still be enrolled in their graduate programs as of 2022, which is 3-4 years after the intervention, whereas the interventions had no significant effect on men's continued enrollment.

Table 14. Estimated Marginal Means by Condition and Gender in Model 3

Condition	Gender	predicted	std.error	conf.low	conf.high
Control	Male	0.9345238	0.4555985	0.8538839	0.9721129
Affirmation	Male	0.9168966	0.4199369	0.8288994	0.9617264
Belonging	Male	0.9313402	0.4613839	0.8459477	0.9710205
Control	Female	0.8812683	0.3206500	0.7983532	0.9329528
Affirmation	Female	0.9732229	0.6347948	0.9128460	0.9921335
Belonging	Female	0.9761161	0.6324231	0.9220730	0.9929658

Figure 3. Predicted Probabilities of Enrollment for Each Condition Group by Gender

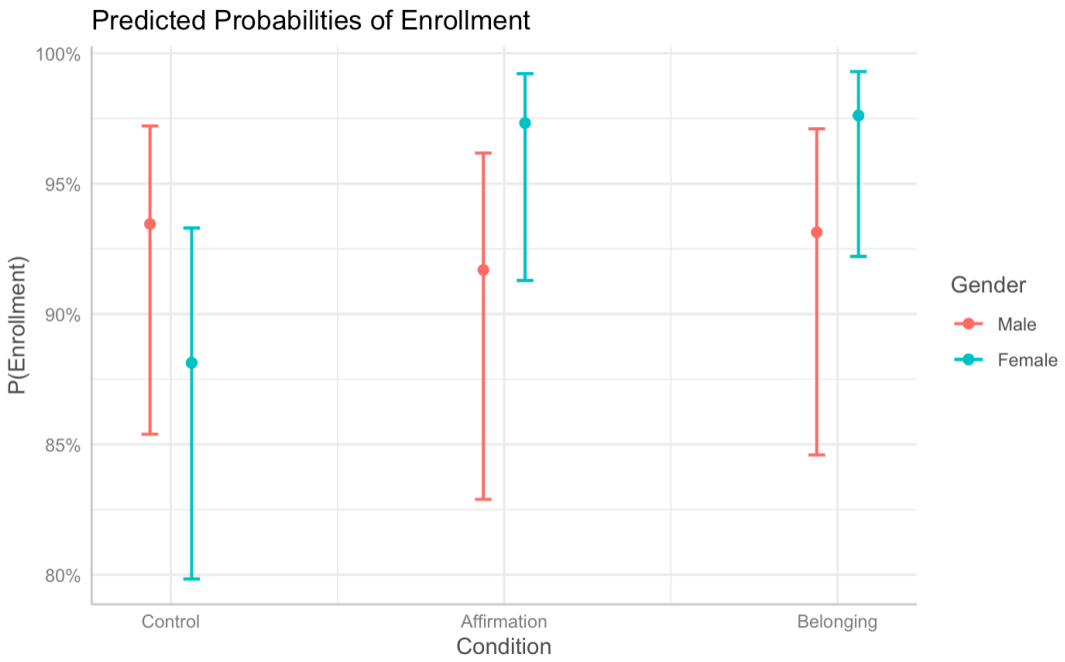


Table 14 and Figure 3 show the predicted probabilities of enrollment for each group, control, affirmation, and belonging group. The probability of remaining in school 3-4 years after the experiments is expected to be approximately 97.3% (95% CI [91.3%, 99.2%]) for women in affirmation and 97.6% (95% CI [92.25, 99.3%]) for those in the belonging group, compared to only 88.1% for women in the control group. In other words, compared to the women in the control group, the women in the affirmation or the belonging group were more likely to stay in their graduate program by 9-10 percentage points. Figure 3 visualizes the predicted probabilities of enrollment for each condition group by gender, described in table 14.

Table 15. Estimated Pairwise Effects of Condition on Enrollment by Gender in Model 3

Condition_Pairwise	Gender	estimate	SE	df	z.ratio	p.value
Control - Affirmation	Male	0.017447073	0.03590777	Inf	0.48588573	0.627048184
Control - Belonging	Male	0.003150484	0.03348766	Inf	0.09407897	0.925046430
Affirmation - Belonging	Male	-0.014296589	0.03669579	Inf	-0.38959754	0.696834174
Control - Affirmation	Female	-0.091011361	0.03501625	Inf	-2.59911765	0.009346373
Control - Belonging	Female	-0.093871707	0.03454366	Inf	-2.71747983	0.006578116
Affirmation - Belonging	Female	-0.002860345	0.02057314	Inf	-0.13903296	0.889424101

Table 15 indicates that our interventions had a significant impact on the enrollment of female students in the affirmation and belonging group relative to the female students in the control group. The table shows the estimates in probabilities which are converted from the log odds ratio scale. We can expect to see approximately a 9.1% increase in the probability of being enrolled in the program in 2022 for the female affirmation group, compared to the female control group. Likewise, the female belonging group will have approximately 9.4% more chance of being enrolled in the program in 2022 than the female control group. However, the difference

between the treated group and the controlled group was not remarkable among male STEM Ph.D. students in that there were no statistically significant results among men across the conditions.

Table 16. Comparison of Estimated Effect of Condition on Enrollment between Female and Male in Model 3

contrast	condition	odds.ratio	SE	df	null	z.ratio	p.value
Female / Male	Control	0.5200374	0.2634828	Inf	1	-1.290516	0.19687144
Female / Male	Affirmation	3.2941769	2.3040361	Inf	1	1.704476	0.08829223
Female / Male	Belonging	3.0129440	2.1397441	Inf	1	1.553003	0.12042240

Though marginally significant (See Table 16), the odds of remaining in the graduate programs were 3.29 times higher among affirmed female Ph.D. students than affirmed male Ph.D. students.

Limitations

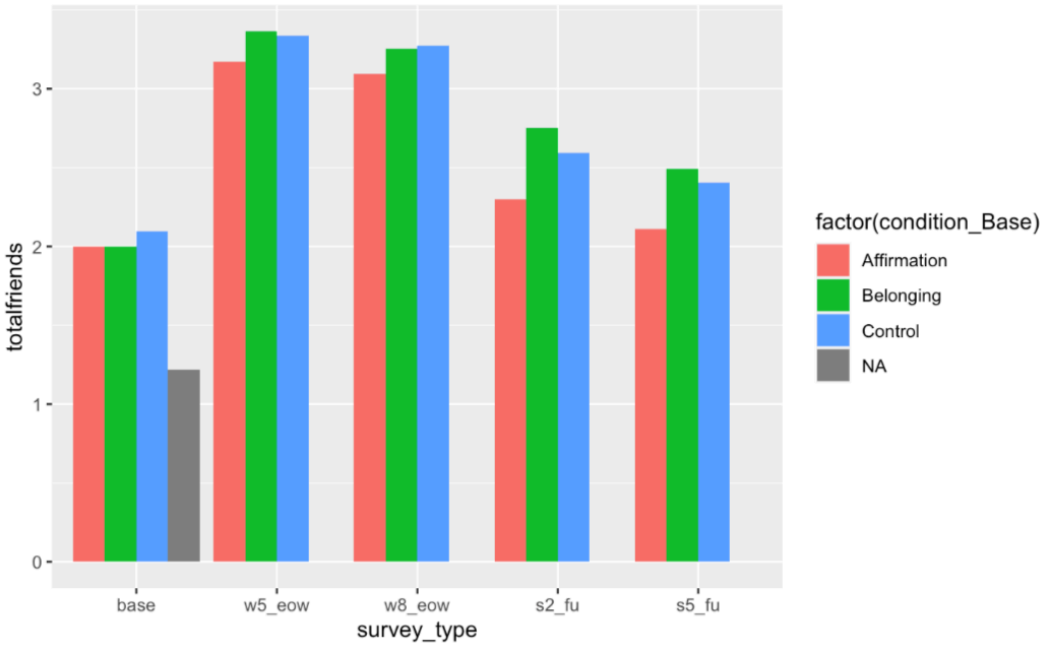
One of the challenges of this research was in processing the students' names data, which limited this study to ego network analysis. It was hard to identify the students' names and relationships between the students. During the surveys, the students were not provided with a roster of all students in the program to identify or choose their friends. Instead, they were asked to write down their friends' names. The survey question was "Which grad students in your program, if any, would you consider to be your friends? Please give both first and last names [Text Entry]." After collecting the data, the texted names were coded as a string, such as "Olivia Shin." However, we often noticed that the same student was called differently by their friends in the program. For example, some of them would type "Olivia Shin" as "Olivia Hyunyoung Shin," with the middle name, but others would type her name as "Olivia Sin" or "Olivia S." Given that we did not have access to overall program rosters, we weren't able to investigate whom exactly they were referring to. This made it difficult to construct an adjacency matrix for whole network analysis and visualization and calculate centrality, as we couldn't determine whether they were mutually linked or not. Therefore, this study was limited to analyzing the students' ego networks after counting the total number of friends that they typed in.

Another limitation was the limited usage of the survey data due to the overlap between the survey timeline of this study and the timeline of Covid 19 pandemic outbreak. The novel coronavirus started to spread in early 2020 and World Health Organization declared a pandemic on March 11^{th,} 2020. Social gatherings were strictly prohibited in the majority of the countries. Likewise, students needed to practice physical distancing to stop the spread of the virus, with many schools closing entirely, which restricted their in-person social interactions and hindered them from building more social connections. While a myriad of medical research was conducted

to develop vaccines and end the pandemic, researchers also started to study the psychological impact of the pandemic on people or the impact of social distancing on people's social networks (Sommerlad et al., 2021). They suggested that the pandemic and social distancing could affect people's psychological well-being, mental health, or social relationships (Sommerlad et al., 2021; Jakhar and Kharya, 2021).

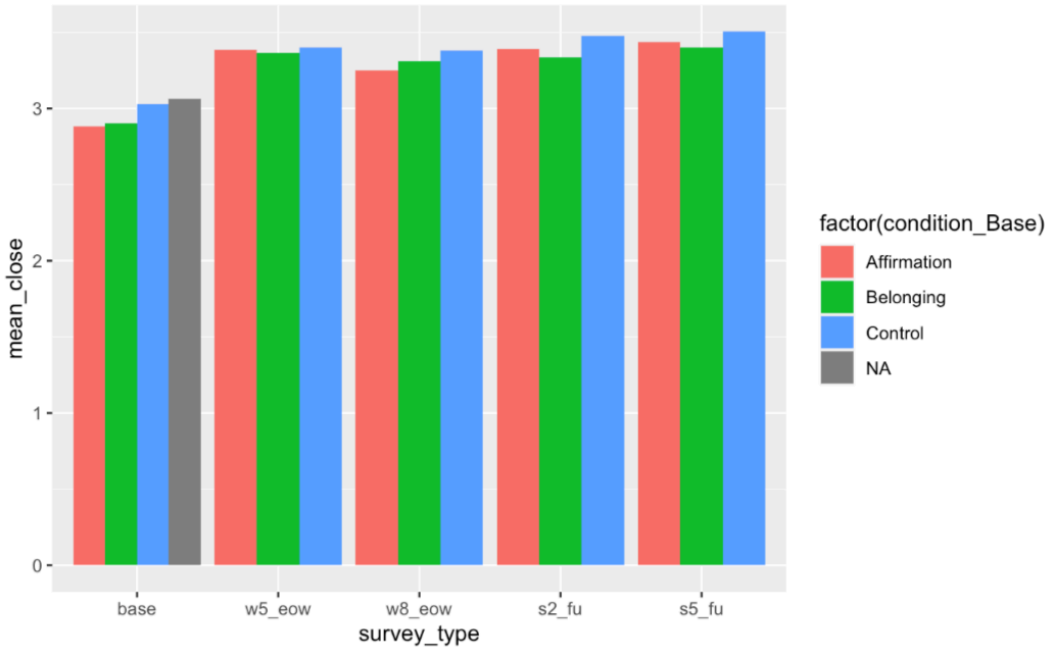
As the surveys for this study were conducted in the midst of the pandemic, we couldn't use the entire survey data (baseline, end of week 1-8, follow up 1-6). As shown in Table 1, many surveys were conducted after the outbreak of Covid 19, so we had to limit our dataset until the 5th end of week survey, Jan 27th, 2020, to exclude the possibility of the impact of the pandemic on the students' psychology or social network. It was hard to identify whether trends in the students' social network resulted from patterns of social withdrawal during graduate school (similar to the withdrawal Turetsky et al. (2020) observed over time in a stressful biology course) or from the isolation during the pandemic. To be specific, Figure 4 shows the trend of the average total number of friends over time, from the baseline survey to the 5th follow up survey (s5_fu in Figure 4 and Figure 5). There is a declining trend in students' total number of friends under all conditions after the end of week 5 (w5_eow in Figure 4 and Figure 5), though we were unable to test whether the cause of the trend was the Covid-19 pandemic or graduate school-related factors. Figure 5 presents the changes in average mean closeness between friends over time. The cause of this change was not identified as well.

Figure 4. Average total number of friends by conditions over the surveys



[1]

Figure 5. Average mean closeness by conditions over the surveys



[1] totalfriends = Total Number of Friends, base = Baseline Survey, w5_eow = End of Week Survey (Week 5), w8_eow = End of Week Survey (Week 8), s2_fu = Follow Up Survey 2, s5_fu = Follow Up Survey 5

Lastly, this study does not include mediation analysis. One of the initial research questions was whether the students' social network could mediate the relationship between the interventions (value affirmation and social belonging) and persistence in the Ph.D. program (enrollment). To do so, the first requirement was to demonstrate a statistically significant relationship between intervention conditions and enrollment. Second, there had to be a statistically significant relationship between the intervention condition and students' social network (number of friends, closeness) to test the mediation effect. However, our results from Model 1 and Model 2 suggested that both of the relationships were not statistically significant, and hence a mediation analysis was infeasible.

Conclusion

Our research results suggest that value affirmation and social belonging intervention could help to promote academic persistence among female STEM Ph.D. students. Compared to the female control group, women who were treated in the values affirmation condition and social belonging condition experienced an approximately 9 percentage point increase in the probability of continued enrollment in their graduate program. Moreover, the belonging intervention improved the persistence of Ph.D. students regardless of their gender. The odds of remaining in the programs were 2.29 times higher for belonging group students, compared to control group students. These findings indicate the importance of psychological interventions that bolster students' sense of belonging, especially for female students who have higher psychological barriers and threats to belonging in STEM fields. Providing support for students in STEM by offering these interventions could not only help them achieve their academic goals but also potentially help to alleviate the societal issue of gender disparities in STEM.

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Appendix

Appendix 1) Survey Questions

Social networks
Source: Lab generated
Items: Now we are going to transition into some questions about your relationships with other graduate students in your doctoral program. We're asking these questions because we're interested in the types of social networks people form in graduate school.
Given that the semester hasn't started/has only just started/has only just started, we know you may not have met many other students in your department yet! Most students will not yet have friends in their program, but some might if they have already spent some time in their department or on campus before starting graduate school.
We ask that you provide FULL names so that we can accurately connect students' social networks. However, **ALL names provided in any of our questionnaires will be replaced with unique, anonymous code numbers before analysis, and no information you provide will be linked to you or others except via these anonymous code numbers.**

1. Please list the names of up to six fellow graduate students in your program whom you would consider to be a friend. If you do not consider anyone in your program a friend at this point, please leave this question blank.
    - ❖ **[socNetFriends_P1_name_1, socNetFriends_P2_name_1, socNetFriends_P3_name_1, socNetFriends_P4_name_1, socNetFriends_P5_name_1, socNetFriends_P6_name_1] Which grad students in your program, if any, would you consider to be your FRIENDS?**
      Please give **both FIRST AND LAST NAMES** [Text entry]
    - **[socNetFriends_P1_closeness, socNetFriends_P2_closeness, socNetFriends_P3_closeness, socNetFriends_P4_closeness, socNetFriends_P5_closeness, socNetFriends_P6_closeness] How CLOSE do you feel to this person?**
        - 1 = Not very close; 2; 3; 4; 5 = Very close
2. Please list the names of up to six fellow graduate students in your program whom you would go to for support or advice on a personal or academic problem. If you would currently not go to another graduate student in your program for support or advice, please leave this question blank.
    - ❖ **[socNetConfidants_P1_name_1, socNetConfidants_P2_name_1, socNetConfidants_P3_name_1, socNetConfidants_P4_name_1, socNetConfidants_P5_name_1, socNetConfidants_P6_name_1] Which grad students, if any, would you go to for SUPPORT with a problem related to academics or personal matters? These individuals may or may not overlap with the people you named as friends.**
      Please give **both FIRST AND LAST NAMES** [Text entry]

- **[socNetConfidants_P1_freqSupport, socNetConfidants_P2_freqSupport, socNetConfidants_P3_freqSupport, socNetConfidants_P4_freqSupport, socNetConfidants_P5_freqSupport, socNetConfidants_P6_freqSupport] How FREQUENTLY would you turn to this person for support if you had a problem?**
    - 1 = Almost never
    - 2 = Rarely
    - 3 = Sometimes
    - 4 = Often
    - 5 = Always

3. [If Q1 > 0] Please answer the following questions for the people you indicated were your friends.
    - **[friendsSocial_P1_phone, friendsSocial_P2_phone, friendsSocial_P3_phone, friendsSocial_P4_phone, friendsSocial_P5_phone, friendsSocial_P6_phone]** Do you have this person's phone number stored in your phone?
        - 1 = Yes
        - 0 = No
    - **[friendsSocial_P1_socialTime, friendsSocial_P2_socialTime, friendsSocial_P3_socialTime, friendsSocial_P4_socialTime, friendsSocial_P5_socialTime, friendsSocial_P6_socialTime] On average**, how often do you spend time **socially** with this person? This could include eating a meal together, going to a movie or another social activity together, meeting up for study breaks, and/or hanging out in each other's apartments, among other social activities.
        - 1 = Less than once a month
        - 2 = Once a month
        - 3 = 2-3 times a month
        - 4 = Once a week
        - 5 = 2-3 times a week
        - 6 = 4-5 times a week
        - 7 = 6 or more times a week
4. [If Q2 > 0] Please answer the following questions about the people you indicated you turn to for support or advice on a personal or academic problem.
    - **[confSupport_P1_emotional, confSupport_P2_emotional, confSupport_P3_emotional, confSupport_P4_emotional, confSupport_P5_emotional, confSupport_P6_emotional]** How much emotional support (e.g., offers of reassurance, expressions of concern, positive feedback) do you receive from this person?
        - 1 = None; 2; 3; 4; 5; 6; 7 = A lot
    - **[confSupport_P1_practical, confSupport_P2_practical, confSupport_P3_practical, confSupport_P4_practical,**

confSupport_P5_practical, confSupport_P6_practical] How much practical support (e.g., advice, suggestions of course of action, offers of direct assistance) do you receive from this person?

- 1 = None; 2; 3; 4; 5; 6; 7 = A lot

Modifications from original scale: None
Used: Baseline; End-of-week survey—Weeks 5 and 8; Follow-up survey
Note: Stanford Engineering students complete this variable during the first end-of-week survey rather than in the baseline survey; Items 2 and 4 eliminate from Cohort 2 baseline survey; instructions contracted in Item 1 in the Cohort 2 baseline survey; "**How CLOSE do you feel to this person?**" was asked as part of item 3, rather than item 1, during the Cohort 2 baseline survey

Appendix 2-1) Intervention Materials – Value Affirmation

Activity 1

Instructions:

Please carefully read the instructions on the following pages. When you're finished with the activity, return the pages to the envelope.

Thank you.

Overview

Sometimes it can be helpful for people to write about what's important to them. Today, you will answer some questions about your ideas, your beliefs and your life. There are no right or wrong answers. Anything you write will be kept private.

Please take your time. About 20 minutes is a good amount of time.

When you're finished return these pages to the envelope.

Your Personal Values

A value is something that is important to you – something that gives some meaning to your life, or that makes you feel better or happy.

Please read the list of values below. Then choose the 2 or 3 values that are MOST IMPORTANT to you. Even if you feel that many of the values are important, please pick only 2 or 3 of them below.

_____Being good at art

_____Being creative

_____Relationships with friends or family

_____Following government or politics

_____Being independent – having the freedom to do what I want

_____Enjoying sports

_____Belonging to a social group (such as your community, culture, or a club)

_____Listening to music or playing music

_____Spiritual or religious values

_____Sense of humor

_____Kindness

Instructions:

1) Look at the values you picked as being most important to you on the previous page.

2) Think about times when these values were very important to you. Maybe these values bring some meaning to your life, or make you feel better.

3) Write about why the values you chose above are important to you.

   Focus on your thoughts and feelings. Don't worry about spelling, grammar, or how well written it is. There are no right or wrong answers.

(Feel free to continue on the reverse side if you like.)

Again, look at the values you picked as most important.

Sometimes it's helpful to summarize your thoughts and feelings. List the top two reasons why these values are important to you.

Reason 1.

Reason 2.

Circle your responses to the statements below.

1. In general, I try to live up to these values.

Not at all A little bit A lot

2. These values are an important part of who I am.

Not at all A little bit A lot

3. I care about these values.

Not at all A little bit A lot

Activity 1

Instructions:

Please carefully read the instructions on the following pages. When you're finished with the activity, return the pages to the envelope.

Thank you.

Overview—Past Students Survey

Below is a summary of results from a survey of Ph.D. students at several institutions, including Penn State—the "Past Students Survey." To help us better understand students' experiences in graduate school and the transition to Penn State, we would like to ask you for your help in understanding the results and meaning of the Past Students Survey. As a student who has recently begun their graduate training, you are in the perfect position to help us understand the results. First, we will share these results with you. Later we will ask you to help us interpret them.

The Past Students Survey focused on the first-year experiences of graduate students in recent years. A broad sample of graduate students in different stages of their program completed the survey and shared their experiences. Thus, the experiences described are generally representative of the experiences of graduate students. Students from all groups reported similar experiences. There were no differences by students' race/ethnicity, gender, department, and so forth.

Almost all students reported a positive experience in graduate school, including meeting other students, taking classes, and pursuing research and other opportunities. But here we will focus on some of the challenges students face in the transition to graduate school, and how students overcome these challenges with time.

Next is a brief summary of the what previous graduate students in past years had to say…

Summary of Results

- Almost all graduate students reported that they worried, at first, about whether they fit in and belonged in graduate school.

- Students commonly reported that early on in graduate school they:
  - Worried about whether they would connect with other students and make friends in their program
  - Were concerned about whether they would be able to compete academically with their graduate peers
  - Worried that other people might view their abilities negatively
  - Felt intimidated and sometimes worried about whether they would be rejected by professors and other graduate students

- A follow-up survey was conducted with some of the same students, after more than a year in their graduate programs. These same graduate students reported that, over time they came to feel more confident that they belonged in graduate school. These students reported that, with time, they:
  - Made good friends in graduate school
  - Felt more confident they could meet the demands of their program
  - Saw that when professors challenged them and critiqued students' work they did so because they were confident that, when pushed, students could meet a higher standard
  - Felt confident that other students and professors valued their abilities and contributions
  - Learned that struggles and setbacks were the times when they learned the most

Conclusions

- Many Ph.D. students worry at first about whether they fit in and belong in graduate school. and whether they can reach the higher standard in their program. With time, they overcome these concerns and come to feel at home in graduate school.

Past Students Survey—Representative Quotes

Next you will read quotations that illustrate the major findings of the "Past Students Survey." These quotations are representative of the responses of participating students – what most students experienced, though they have been edited slightly for this activity. Please take your time and read these carefully.

"I was really excited to start graduate school--but at first I was nervous too. I worried about whether I would fit in, connect with people in my program, and make friends. And early on, getting criticized by professors and TAs made me worry whether I could meet the standards. But eventually, I saw that just about everyone has these worries. It's ironic. Everyone thinks they are the only one when really we're all insecure at first. It's just something you go through when you start a new program. Now, with time, I've made some good friends and I've found people I work well with. And I've learned that, when the work is challenging, it doesn't mean I can't do it—in fact, working on tough material is how you learn. Now I feel like I belong here, and I'm glad to be a part of my graduate community."

-Karen, Ph.D. Student in Anthropology

"My department has a reputation for really difficult comps. I was worried about them even before I started the program. My first attempt I missed the cutoff. Even though I knew you could take them a second time, it made me doubt if a Ph.D. was for me. Over spring break, I started to think about alternative plans; I even applied to an industry internship. During office hours one time, I mentioned the internship to a professor I looked up to and he asked why I wasn't going to do the Ph.D. I told him that I'd failed comps and I wasn't sure if I could cut it. He laughed and told me that as a graduate student he had failed his first comprehensive exam too but that, in the end, the timing just doesn't matter much. You have to master the material at your own pace. That really surprised me—I'd always thought that how fast you understand something means you how well you understand it. But to hear someone so accomplished say that made me realize that it really is a process. The key is to focus on what you don't understand yet and do what you need to do to learn it. So, I decided to get a study group together with some other students in the same position. We helped each other out and, over time, we became close. That helped me learn the material and pass comps, and I made some close friends in the process."

-Mike, Ph.D. Student in Electrical Engineering

“My first year in graduate school was mixed. Socially, it was great. I met a lot of people, and made some good friends at happy hours and the like. But looking back, there was some academic stress—and that was quite a shock. Grad school can humble you. I remember this one class in particular was especially hard. It had really challenging material that I’d never seen before, but deep down inside of me I guess I was excited to learn it. There was one class my first year that was especially difficult, although I was interested in the material. On a couple occasions, I asked my TA a question and I got a kind of snickering response. It was like he thought it was a dumb question. It made me feel stupid. But my friends all had the same experience. Eventually we realized that the TA just wasn’t a great teacher. He couldn’t relate to the perspective of a first-year student. So, we learned to go to another TA, who understood the material well and was an excellent teacher. It was a tough class, but I ended up learning a lot. I'm excited to apply my knowledge to the real world.”

-Wei, Ph.D. Student in Mathematics

“Initially my transition to grad school wasn't bad. I made some friends and for the most part I enjoyed my classes. My first research experience was another story, though. I felt like I didn’t have skills to contribute to the lab, like I was always catching up. I had to learn a ton of new research methods and I made a lot of mistakes along the way. I even screwed up some experiments. It was painful. I wondered if I belonged in the lab at all, if I could ever contribute. Eventually I had a talk with a senior student in the lab. It seemed like he knew how to do everything. But he told me he’d struggled in exactly the same way—he’d screwed up experiments too! There’s just a ton to learn as a new grad student—methods, procedures, coming up with interesting questions, etc. I realized that learning to do good research is a process. You can't rush it, and you’re always learning as you go. He offered to help me learn more in the lab. Now I don’t get caught up comparing myself to others. Instead, I realized that what I’m doing is investing in myself as a researcher. Every day with a bit of effort and work on your own and with others you build your skills over time. I also realized that everybody here has a common goal—to share knowledge and to learn and to do cool things together. In the end, research is a team effort. Now, my skills are light years ahead of where I was at the start of grad school. It feels great to actually help conduct cutting edge work. And I’m starting to mentor younger students too.”

-Terrell, Ph.D. Student in Biology

“As excited as I was to come to grad school, I must admit that part of me thought I had been accepted due to a stroke of luck. I worried that my preparation wasn't up to par. I had good grades in college but I didn’t go to a top university. Penn State seemed like the best of the best. Then, I bombed a midterm my first quarter. It was the worst grade I'd ever received, and it was in one of the main classes for my program. I felt dumb–like I was the only one. But I decided that, instead of just moping, I should reach out to the TA. He told me that I wasn’t the only one who had a difficulty with the exam. The professor had set the standard very high. He was challenging us to master the material and knew that if we worked hard, we could meet that standard eventually. That really helped change how I saw things. First, I came to realize that there wasn’t some barrier separating me and the other students. Almost everyone struggles in their first grad-level physics courses. Second, I saw that even when professors and TAs are critical or their grading harsh, that doesn’t mean they looked down on me or that I don’t belong. It was just their way of motivating students to reach a new level. When I understood that, I began to feel more comfortable asking questions and getting help when I needed it. It was hard at first, but looking back I'm glad I was challenged, it’s made me a better scientist.”

-Lisa, Ph.D. Student in Physics

“I’ve always loved to make cool things that can help people. So, I was thrilled to get accepted to the Ph.D. program in Information Sciences and Technology at Penn State. But I was anxious too. It’s a long way from home. I had been near my siblings, parents and extended family all through college. I got along well with people in my department. But I missed a broader sense of community. Eventually, I decided not to just sit back and wait for new friends, but to reach out to others, pursue my interests, and let things fall into place. I got involved in extracurriculars, especially a group of Hispanic and Latina grad students. I formed a real bond with a few of the other students there. We organized evening study sessions and informal lunchtime talks with IST faculty. It was our way of contributing to the IST community. I also developed some good study partners in class. I love it here now, and I’ve had a wonderful experience here. Moving to grad school was challenging at the start but with time I found a comfort zone by exploring my interests and reaching out to others. It's rewarding for me to feel well connected to others in the IST community. I know my family is proud of what I’ve accomplished here.”

-Luciana, Ph.D. Student in Information Sciences and Technology

Your Thoughts on Students' Transition to Graduate School

Many Ph.D. students described worrying at first about whether they would fit in and belong in graduate school. However, over time students reported that they developed good relationships and came to feel confident they belonged in their Ph.D. program.

To help us further understand students' experiences entering graduate school, we would like to ask you to think about why this is so—why do Ph.D. students worry at first if they belong in graduate school but with time come to feel at home in their departments?

Please illustrate your response (on the next page) with examples from your own experiences in or expectations for graduate school so far, as well as your expectations for how your experience will change over time (e.g., in classes, study groups, and research labs). For instance, consider worries or concerns you might have about taking graduate classes and pursuing your Ph.D. at Penn State. Consider how these concerns are likely to be common when students begin graduate school, and how they are likely to change over time.

What you write is confidential — there's no need to include your name. However, we may take excerpts of what students write here and share them with future students to improve their experience in the transition to graduate school.

In the space below, describe why you think it is common for many students to worry at first about whether they belong in graduate school and why, with time, these worries go away as students come to feel at home.

Be sure to use examples from your own experiences so far at Penn State. Feel free to look back at the quotations from the Past Students Survey if you like.

You may write using bullet points if you like, and don't worry about grammar or spelling. The goal is just to express your ideas.

Please take your time, but try to finish up and go on to the next page in 3-4 minutes.

(Feel free to continue on the reverse side if you like.)

Thank you. We think future students will benefit from learning more about students' experience in the transition to graduate school—what it's like, and how it changes over time. As you probably know, it can be difficult to come into a new situation not knowing what to expect. As a graduate student who is going through the same experience right now, you are in a great position to help future students out.

Letter to a First-Year Student

In order to help future students, please write a letter to an entering graduate student next year. You can basically rewrite what you just wrote above into a letter describing your experience so far in graduate school. Please describe how people's experience in graduate school changes over time—how many students feel unsure at first about whether they belong but with time come to feel at home in grad school. Be sure to illustrate your letter with examples from your own experiences in classes, lectures, sections, study groups, labs, and the like. We know that sometimes it might feel a little awkward to write a letter to a stranger. But thank you for doing this. We think it will be especially valuable for future graduate students to learn directly from a previous student. We will distribute some of the letters written here to graduate students next year. To the extent possible, we will distribute your letter to a new student who is the same degree program, gender, and ethnicity as yourself, so you can imagine it will be someone like you.

Your letter will be provided anonymously. No personal information about you will be included.

Please take your time but try to finish in 4-5 minutes. When you're finished return these pages to the envelope.

(Feel free to continue on the reverse side if you like.)

Activity 1

Instructions:

Please carefully read the instructions on the following pages. When you're finished with the activity, return the pages to the envelope.

Thank you.

Overview—Past Students Survey

Below is a summary of results from a survey of Ph.D. students at several institutions, including Penn State—the "Past Students Survey." To help us better understand students' experiences in graduate school and the transition to Penn State, we would like to ask you for your help in understanding the results and meaning of the Past Students Survey. As a student who has recently begun their graduate training, you are in the perfect position to help us understand the results. First, we will share these results with you. Later we will ask you to help us interpret them.

The Past Students Survey focused on the first-year experiences of graduate students in recent years. A broad sample of graduate students in different stages of their program completed the survey and shared their experiences. Thus, the experiences described are generally representative of the experiences of graduate students. Students from all groups reported similar experiences. There were no differences by students' race/ethnicity, gender, department, and so forth.

Almost all students reported a positive experience in graduate school, including meeting other students, taking classes, and pursuing research and other opportunities. But here we will focus on some of the challenges students face in the transition to graduate school, and how students overcome these challenges with time.

Next is a brief summary of the what previous graduate students in past years had to say…

Summary of Results

- Some students reported that they expected to have to develop their study skills to be successful in graduate school; while others did not expect to have to change their study skills.

- Students commonly reported that they:
  - Found the workload challenging
  - Had difficulty keeping track of due dates and deadlines
  - Had problems prioritizing their time

- The same students reported that, over time, they developed proper study techniques. They reported:
  - Recording exams and assignment due dates in a day planner
  - Taking study breaks
  - Attending class regularly
  - Attending office hours

Conclusions

- Many Ph.D. students feel unsure of how to study when they first take graduate-level engineering classes, but over time they learn proper study techniques.

Past Students Survey—Representative Quotes

Next you will read quotations that illustrate the major findings of the "Past Students Survey." These quotations are representative of the responses of participating students – what most students experienced, though they have been edited slightly for this activity. Please take your time and read these carefully.

"When I first got to graduate school, I had trouble absorbing all of the material in some of my textbooks. I realized that one thing I could do was to do all the practice problems a week or two before the exam. That way if I still had questions about the material I could go to the TA or prof. When I did that for a set of exams, it worked. It was hard to get my act together a week ahead of time, but it paid off."

-Karen, Ph.D. Student in Anthropology

"There can be a lot of work in grad school. When I got to campus, I realized I didn't know how to study properly. I signed up for seminar on the secrets of successful graduate students. The best suggestion they had was to review your lecture notes at the end of each day. That helps you learn them, and then you can tell if there is something you missed, or something you don't understand, and you can ask about it. I'm glad I took the time to do that.

-Zhu, Ph.D. Student in Computer Science and Engineering

"There are a lot of assignments and tests you have to keep track of in graduate school. When there's a lot on your mind it helps to make a list. Sometimes there's just too much to keep track of in your head. I found writing down a bunch of due dates in my planner really helped. That way I wouldn't drop the ball or lose points for turning things in late."

-Robert, Ph.D. Student in Comparative Literature

"One of the things that you learn in grad school is that there is just too much work to do and not enough time. You have to prioritize. I learned that it's important to pay attention to the professors, and where they concentrate their lectures. Usually the weight of each topic depends on the amount of teaching time spent on it. And of course, even if you're exhausted, it's important to show up for lectures. Even if you are still half asleep, you'll pick up a thing or two and take a few notes."

-Luciana, Ph.D. Student in Information Sciences and Technology

"In my first quarter, I found you always have to look ahead. Sometimes you have to do more work this week so that next week, you have enough time to get everything done. If you've looked ahead, you only need to worry about the task at hand. If you can focus on what comes next, everything suddenly becomes a lot easier."

-Terrell, Ph.D. Student in Biology

"I realized in my first year that if I wanted to get everything done, I need to become a more efficient studier. Learning doesn't happen simply by stuffing material into your brain; what you learn needs to be integrated with what you already know. That's why taking a 10-minute break for every 50 minutes of studying helped me to hold information. After my relaxing break, it also helped to change the subject or task that I was studying to a new one. This way, my brain didn't get tired of absorbing the same material hour after hour."

-Wei, Ph.D. Student in Mathematics

"One of the things I learned in graduate engineering is that it's not only important how you study, but where you study. Even little things such as if the room was too warm or too cool, or if there was a lack of circulating air made me sleepy and unable to concentrate. I also found that studying in my dorm room with my friends around was too distracting. Sometimes just putting on headphones and listening to music helped me ignore these distractions. Other times, if I really needed to concentrate, I would head over to the library."

- Lisa, Ph.D. Student in Electrical Engineering

"So, after attending my first graduate school lecture, I realized right then and there that I needed to become basically a better listener and a better note-taker. And I soon became a more positive and active listener basically just by sitting at the front of the class and sitting quietly. I found it particularly important to try to make extra effort to pay attention in the second 20 minutes of the lecture just because that's when I tended to drift away and lose it, and especially also during the last few minutes when a summary or conclusions was given by the prof. When it comes to taking good notes in lectures, you want to try and make sure that you're being accurate and focusing on the main ideas. I also liked to leave space between the main ideas just so that I could go back later and add notes in my own words. And I felt that that really helped make the lecture sink in."

-Mike, Ph.D. Student in Physics

In my first few weeks, I spent more time worrying about doing well in my courses than studying for them. I read in a pamphlet that I should start a worry book because writing your worries down initially helps to diminish them somewhat. Setting aside time and problem solving around what I had written helped me further to find a way to deal with them. With my worries soon under control, I was able to focus on studying instead of worrying.

-Ha-Yoon, Neuroscience PhD Student

Your Thoughts on Students' Transition to Graduate School

Many students described worrying at first about the challenging workload and keeping track of deadlines and prioritizing their work in their Ph.D. program. However, over time students reported that they developed proper study techniques, used their day planner to record exams and due dates, attended class regularly, and attended office hours.

To help us further understand students' experiences entering graduate school, we would like to ask you to think about why this is so—why do students worry at first if they can keep up with the challenging workload in graduate school but with time come to develop proper study techniques?

Please illustrate your response (on the next page) with examples from your own experiences in or expectations for graduate school so far, as well as your expectations for how your experience will change over time. For instance, consider worries or concerns you might have about taking graduate classes and pursuing your Ph.D. at Penn State. Consider how these concerns are likely to be common when students begin graduate school, and how they are likely to change over time.

What you write is confidential — there's no need to include your name. However, we may take excerpts of what students write here and share them with future students to improve their experience in the transition to graduate school.

In the space below, describe why you think it is common for many students to worry at first about whether they can manage the challenging workload and keep track of deadlines in graduate school and why, with time, these worries go away.

Be sure to use examples from your own experiences so far at Penn State. Feel free to look back at the quotations from the Past Students Survey if you like.

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If used, your letter will be provided anonymously. No personal information about you will be included.

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