Do I Belong? Gender, Perceived Competence and the Development of Field Belonging for Physics Undergraduates

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Abstract

Women in physics and engineering continue to remain underrepresented in higher education. To illuminate underlying processes, we used data from undergraduate Physics students ($N= 338$) enrolled in an introductory physics course to investigate the development of field belonging and its association with gender and perceived competence. Latent change models showed a decrease in students' perceived field belonging across one academic term. While males and females did not differ in their initial level, females reported a stronger decline in their perceived field belonging. In addition, while perceived competence was associated with a higher initial level of perceived field belonging for both genders, higher levels of perceived competence buffered the decline in field belonging for females, but not for males.

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1.   Objectives and theoretical framework

The underrepresentation of women in STEM higher education programs persists despite the continuing call for the diversification of the science workforce (National Science Foundation, 2019). Males continue to represent the vast majority of enrollees in physics and engineering programs (National Science Board, 2018). Paired with a higher proportion of attrition of women in these fields, this perpetuates the gender disparity in STEM (Geisinger & Raman, 2013). Research has pointed to the importance of studying sociocultural and motivational factors in elucidating factors that contribute to and foster women's persistence and success in these male-dominated fields.

One motivational factor that bears influence on students' success is their sense of belonging. Students' sense of belonging, i.e., students' perception that they are a valued and important member of the academic community they are in, is predictive of their academic achievement, motivation and persistence (Hausmann, Schofield, & Woods, 2007; Strayhorn, 2012; Walton, Cohen, Cwir, & Spencer, 2012). Thus, a lack of sense of belonging contributes to students' attrition from STEM fields. Research finds that feelings of belonging are lower for women than for men in STEM fields (Lewis et al., 2017).

Students', and in particular women's, feelings of belonging can be supported and STEM attrition can be prevented (see Lewis, Stout, Pollock, Finkelstein, & Ito, 2016 for review): Research into supporting belongingness underscores the importance of social influences such as female peers and role models as well as the psychological influences such as ability stereotypes and perceived competence. Students' perceived competence, i.e., feeling capable with regards to the task at hand, is one of the crucial components of student motivation and is associated with positive academic outcomes, such as achievement (Eccles et al., 1983; Wigfield & Eccles, 2000; Wigfield et al., 2015). Sense of belonging is also positively associated with perceived competence (Pittman & Richmond, 2007; Zumbrunn, McKim, Buhs, & Hawley, 2014). However, whether the direction of influence could also be reversed such that higher levels of perceived competence boost students' feelings of belonging is an empirical question that warrants investigation. This might be particularly important given the salience of the ability stereotype in Physics and Engineering that women are less innately talented and need to try harder (Smith, Lewis, Hawthorne, & Hodges, 2012). As women feel more out of place within the physics and engineering communities than men, feeling academically capable within these settings might help reinforce belongingness for this at-risk group. To investigate this, we pose the following research questions;

RQ1:   Are there gender differences in the perceived field belonging of undergraduate Physics students in an introductory course and its development across the academic term?

RQ2:   What is the association of perceived competence with perceived field belonging in an introductory Physics undergraduate course and its development across the academic term?

RQ3:   Does the association of perceived competence with perceived field belonging in an introductory Physics undergraduate course and its development across the academic term differ by gender?

2.   Methods and Data Sources

The current study used data from students enrolled in a ten-week gateway physics course at a large public university in Southern California. Students were surveyed about their attitudes online at the beginning (Time 1) and at the end (Time 2) of the course. Students received $5 for the completion of each of the surveys. The current study utilizes data from 338 students (37% female, 58% FG) enrolled in three sections across two different academic terms.

Measures:
Field belonging. Field belonging assessed students' feelings of belonging in the field of physical and engineering sciences using a 3-item Likert scale ($\alpha = .85$ at Time 1, $\alpha = .86$ at Time 2, e.g., "I don't know if I really belong in the physical and engineering sciences."). The response scale ranged from 1= "Not at all true" to 7= "Very true". Negatively worded items were recoded so that high values indicate a high level of perceived field belonging.
Perceived competence. Student's perceived competence for the course was assessed using a 4-item Likert scale ($\alpha = .91$ at Time 1, $\alpha = .94$ at Time 2, e.g., "I am confident that I will do well in this course."). The response scale ranged from 1= "Not at all true" to 7= "Very true".
Gender. Students' gender was dummy coded (1=Female).
Socioeconomic status (SES). Students' SES was measured two ways. Students' reports of parents' education level were recoded to capture whether student were *first-generation college going* students (1= Parents did not complete Bachelor's degree). *Family income* was assessed using a single item ("Please indicate what your family's income was when you were in your last year of high school"; 1= < $15,000, 8= > $150,000).

We used a latent change model to evaluate the development of field belonging across the course and investigate our research questions (McArdle & Grimm, 2010). In this longitudinal model two parameters are estimated: the initial level of field belonging and the change in field belonging, which is modeled as a latent difference score. To estimate associations of field belonging with student's sociodemographic background and perceived competence, several models were estimated. In the first model student's gender, first-generation college going status and family income predicted the initial level and the change in field belonging. In the second model, students' perceived competence at Time 1 and Time 2 were added to the model as predictors of the initial level and the change in field belonging, respectively. In the third and final model, the interactions between gender and perceived competence were added as a predictor (see Figure 1 for final conceptual model). Analyses were conducted with M*plus* 7.1 and FIML was used for missing data (Muthén & Muthén, 2013).

3.   Results

In a first step, results from the unconditional change model excluding predictors showed a significant decrease in field belonging across the academic term (Initial level: M = 5.16; change: M = -.42, p < .001). Further descriptive statistics can be found in Table 1.

To test our first research question (RQ1), we added student's gender as a predictor (see Table 2, Model 1). First-generation college-going status and family income were included as controls due to the diverse sociodemographic background of our sample. Females and males did not differ in their initial level of perceived field belonging. However, females showed a significantly stronger decrease in their perceptions of field belonging than males.

To test the association of perceived competence with the development of perceived field belonging, we added student's perceived competence as predictors (see Table 2, Model 1). Students' perceived competence at the beginning of the course (Time 1) was statistically significantly and moderately associated with students' initial level of perceived field belonging. In addition, students' perceived competence at the end of the course (Time 2) was positively associated with the change in perceived field belonging. In other words, students with higher perceived competence had a lower decline in their perceived field belonging.

To test whether association of perceived competence and field belonging differed by gender, interaction terms of perceived competence and gender were added to the model (see Table 2, Model 3). At the beginning of the course (Time 1), the association of students' perceived competence and perceived field belonging did not differentiate by gender. However, the association of perceived competence at the end of the course (Time 2) and the change in field belonging significantly differentiated by gender. This association was smaller and not statistically significant for males, while perceived competence was moderately and statistically significantly associated with the change in field belonging for females. In other words, females reporting higher perceived competence at the end of the course had a lower decline in their perceived field belonging than females with lower levels of perceived competence. In contrast, perceived competence was not statistically significantly associated with the change in field belonging for males.

4.   Scientific significance

The findings of the current study corroborate and extend previous findings in important ways. While females did not report a different level of field belonging at the beginning of the course, they decreased more strongly than males in their feeling of belonging in the field of physical and engineering sciences. This finding corroborates previous findings that women struggle with feelings of belonging more than males. The positive association of students' perceived competence their feelings of belonging and the change in their perceived belonging underscore the importance and potential buffering effect of feeling competent. However, an important gender difference emerged. Perceived competence positively related to student's feelings of field belonging only for females, not for males. On the one hand, this finding shows that for males changes in their feelings of belonging in the field of physics and engineering is not contingent on their feelings of competence. This points to the fact that the typically male-dominated environment likely provides males with other types of supports and cues signifying that they belong. On the other hand, this finding highlights the importance of supporting female students'

feelings of competence in physics. The observed divergence of belongingness of males and females in physics over time is foreshadowing females' likelihood to discontinue their persistence within the major. Ensuring that female students feel competent and capable in their mastery of physics courses will bolster feelings of belonging, which, in turn, will likely support their persistence and success. Future research should look into other factors, including motivational beliefs and attitudes that could support students' feelings of belonging in physics and engineering over time to secure their long-term success and persistence.

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Table 1. *Descriptive statistics for relevant variables.*

	Total (N=338)		Female (N=121)		Male (N=217)		
	M	SD	M	SD	M	SD	Range
Field belonging							
Time1	5.16	1.42	5.14	1.39	5.20	1.45	1-7
Time 2	4.72	1.55	4.46	1.64	4.91	1.51	1-7
Perceived competence							
Time 1	5.16	1.22	4.77	1.16	5.36	1.15	1-7
Time 2	4.47	1.60	3.92	1.53	4.76	1.54	1-7
Sociodemographic background							
Family income	5.44	2.16	5.02	2.20	5.68	2.11	1-8
	%		%		%		
FG	37		46		32		0,1

Note: FG= First-generation college-going status; ***p <.001, ** p <.01,* p <.05.

Table 2. *Latent change models predicting field belonging.*

	Field belonging											
	Model 1				Model 2				Model 3			
	Initial level		Change		Initial level		Change		Initial level		Change	
	β	(SE)	β	(SE)	β	(SE)	β	(SE)	β	(SE)	β	(SE)
Female	0.01	(.06)	-.11*	(.05)	.11*	(.05)	-.07	(.05)	.00	(.23)	-.36**	(.15)
FG	-.10†	(.06)	-.11†	(.06)	-.02	(.06)	-.08	(.06)	-.02	(.06)	-.07	(.06)
Family income	0.11	(.06)	.09	(.06)	.18**	(.06)	.10†	(.06)	.18**	(.06)	.09	(.06)
Per. Comp. Time 1					.43***	(.05)			.42***	(.06)		
Per. Comp. Time 2							.19***	(.05)			.11†	(.07)
Female*Per.comp.Time 1									.11	(0.22)		
Female*Per.comp.Time 2											.30*	(.15)

Note. FG= First-generation college-going status, Per. Comp.=Perceived Competence; Model fit for Model 1: CFI=.98,TLI=.97, RMSEA=.05, SRMR=.04, Model 2: CFI=.95,TLI=.94, RMSEA=.07 , SRMR=.07, Model 3: CFI=.95,TLI=.94, RMSEA=.06 , SRMR=.06; ***p <.001, ** p <.01,* p <.05, † p <.10.
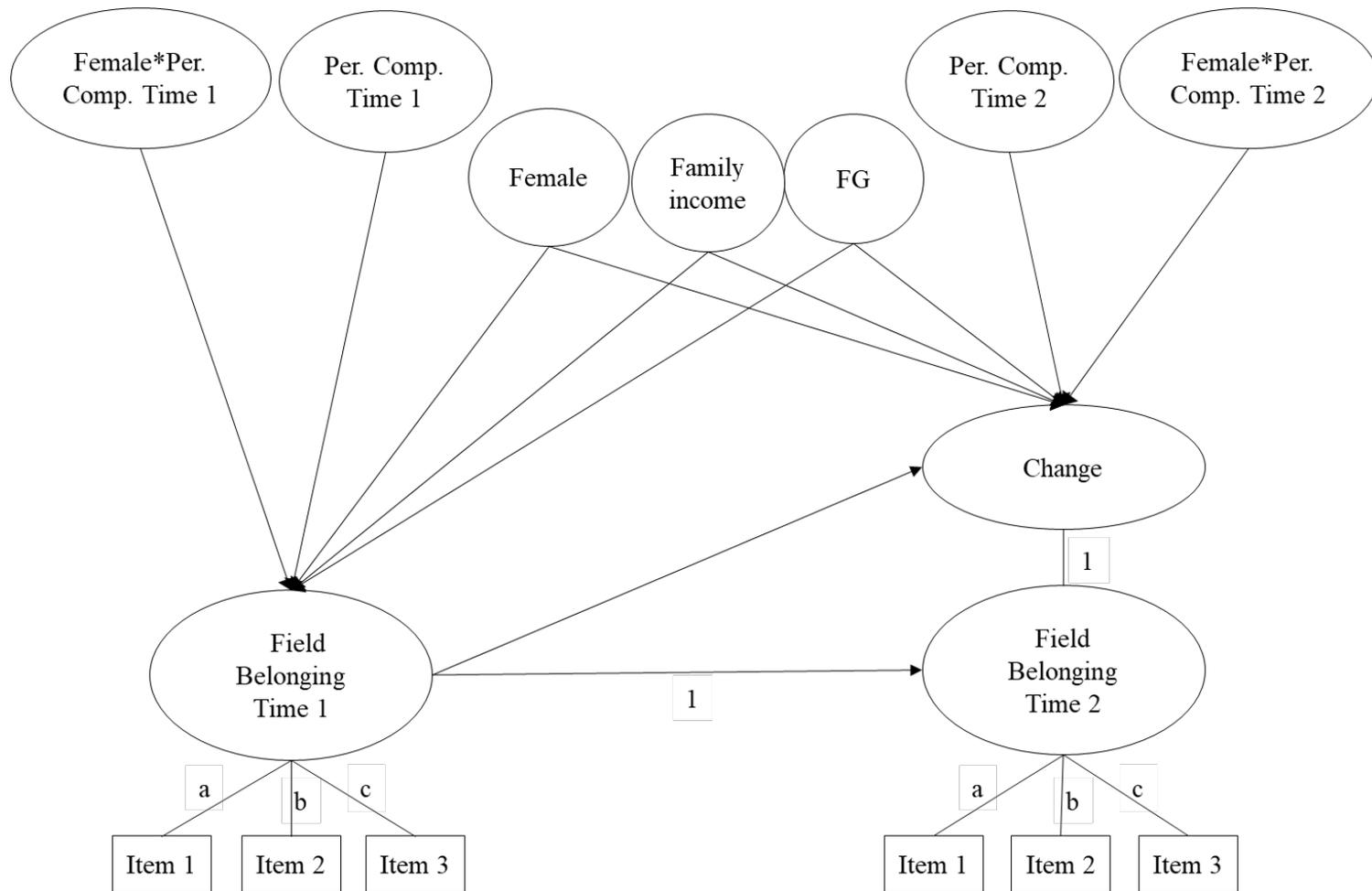
Figure 1. Final latent change model including predictors and interaction terms. FG = First-generation college-going status; Per. Comp.= Perceived Competence.