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COMPUTER SCIENCE EDUCATION, 2017
VOL. 27, NOS. 3–4, 215–228
https://doi.org/10.1080/08993408.2018.1437115

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"But it doesn't come naturally": how effort expenditure shapes the benefit of growth mindset on women's sense of intellectual belonging in computing

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ABSTRACT

Research suggests growth mindset, or the belief that knowledge is acquired through effort, may enhance women's sense of belonging in male-dominated disciplines, like computing. However, other research indicates women who spend a great deal of time and energy in technical fields experience a low sense of belonging. The current study assessed the benefits of a growth mindset on women's (and men's) sense of intellectual belonging in computing, accounting for the amount of time and effort dedicated to academics. We define "intellectual belonging" as the sense that one is believed to be a competent member of the community. Whereas a stronger growth mindset was associated with stronger intellectual belonging for men, a growth mindset only boosted women's intellectual belonging when they did not work hard on academics. Our findings suggest, paradoxically, women may not benefit from a growth mindset in computing when they exert a lot of effort.

ARTICLE HISTORY
Received 20 December 2017
Accepted 2 February 2018

KEYWORDS
Gender; growth mindset; effort expenditure; belonging

Introduction

Despite women's growing representation in higher education over the last several decades, women remain starkly underrepresented in computing majors (e.g. computer science; informatics). This is problematic because a gender gap in computing may prolong gender inequity in our culture. That is, because computing professions are of high cultural status and financial reward (Forbes, 2016; U.S. News & World Report, 2016), low representation of women in these fields may perpetuate women's relatively low societal status (Cejka & Eagly, 1999; Sheffield, 2005).

Recently, researchers and practitioners have considered "growth mindset" as a tool for increasing the representation of women in the field of computing. Coined by psychologist Dr. Carol Dweck (2016), growth mindset is the belief that skills and

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aptitude are learned rather than innate. Growth mindset has gained popularity within education research (see Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013), in the mass media (e.g. Forbes, New York Times; see Kerpen, 2017; Kirp, 2016), and among women's advocacy groups in computing (e.g. the National Center for Women & Information Technology [NCWIT]; see DuBow, Quinn, Townsend, Robinson, & Barr, 2016). At the same time, skeptics criticize the utility of growth mindset in fostering diversity because it emphasizes changing the individual while ignoring larger systems of oppression (see Howard, 2015; Ris, 2015). For instance, in the context of computing, encouraging a growth mindset emphasizes women's individual coping styles, but does little to change the larger context of computing, which can be unwelcoming to women.

In the current work, we examine growth mindset in the context of computing education. Specifically, we focus on two factors that may shape the impact of growth mindset on students' outcomes: (1) perceptions about the amount of effort required for students to succeed in academics, or "effort expenditure", and (2) students' gender identity. Effort expenditure is particularly important to consider in the context of undergraduate computing courses, which are known to require a great deal of time and effort (Hoffman, 2017). Further, prior research suggests women (but not men) who feel they exhibit a high level of effort expenditure in technical fields also tend to believe that they do not belong in those fields (Smith et al., 2013). Thus, it is important for research to examine the role of growth mindset with consideration for student's – particularly women's – perceptions of effort expenditure.

The current study examines the impact of growth mindset on women's (and men's) sense of belonging in computing, taking into consideration the amount of effort students spend on academics. Of note, we examine a specific type belonging, namely, students' sense of "intellectual belonging", or one's belief that they are viewed as a competent member of the computing community. This particular type of belonging is important because students who feel that others acknowledge and value their intellect tend to feel motivated and persist in academics (Lewis & Hodges, 2015). We measure the potential discordance between a growth mindset and perceptions of effort expenditure in computing among women and men, thereby contributing to research on tools to broaden participation in computing.

Literature review

Sense of belonging and its importance in computing education

One reason for women's underrepresentation in computing is that women continually contend with cultural stereotypes that they do not belong. Sense of belonging in academic settings can be defined as "the feeling that one fits in, belongs to, or is a member of the academic community in question" (Good, Rattan, & Dweck, 2012, p. 700). Prior research has shown that students who feel a strong sense of belonging also show strong academic motivation, engagement in class, achievement, and retention in STEM and non-STEM disciplines (Good et al., 2012; Lewis et al., 2017; Walton & Cohen, 2007). Specifically in computing, sense of belonging is associated with increased interest in taking computing courses (Master, Cheryan, & Meltzoff, 2016) and intentions to persist in the major (Lewis et al., 2017).

Unfortunately, there is a well-documented gender gap in sense of belonging in computing, such that women feel less like they belong than men (Blaney & Stout, 2017; Cheryan, Plaut, Davies, & Steele, 2009; Lewis et al., 2017; Sax et al., 2017). Our primary goal was to address the following questions: Is a growth mindset equally beneficial for women and men's intellectual belonging in computing? Does the relationship between a growth mindset and intellectual belonging in computing depend on students' effort expenditure? Is effort expenditure more important for women's intellectual belonging compared to men's? We also sought to replicate prior work by examining the relationship between intellectual belonging and retention in STEM (here, computing), with consideration for how this relationship might differ for women and men.

Hypotheses

A great deal of research has documented the important role of growth mindset in fostering academic achievement and motivation (see Dweck, 2016), particularly among marginalized individuals (e.g. women in male-dominated fields; Good et al., 2012; Stout & Dasgupta, 2013). As such, it is possible that women and men who hold a strong growth mindset might also report a strong sense of intellectual belonging in computing. However, prior work indicates women (but not men) in STEM fields also use effort expenditure to gauge whether or not they belong (Smith et al., 2013). Thus, it is also possible that the benefits of a growth mindset for women might depend on the amount of effort women expend. Specifically, women who work particularly hard in computing may question their intellectual belonging, even when they believe computing ability can be learned. Thus, we tested competing hypotheses concerning the benefits of a growth mindset on women's sense of intellectual belonging in computing.

We also expected to replicate prior research (Lewis & Hodges, 2015) showing that students with low intellectual belonging in STEM (here, computing) are more likely to think about leaving their STEM major. Because prior research suggests that sense of belonging is particularly important for marginalized individuals' academic persistence (Lewis et al., 2017; Walton & Cohen, 2007), we expected the relationship between intellectual belonging and thoughts about leaving one's computing major would be stronger for women than for men. This particular hypothesis addresses the importance of a strong sense of intellectual belonging among computing students – especially women, whose underrepresented status means they are particularly important to retain in computing.

Method

Sampling procedure

This study utilized data collected during the fall of 2015 by the Computing Research Association's Center for Evaluating the Research Pipeline (CERP) and the Building, Recruiting, and Inclusion for Diversity (BRAID) research project at the University of California Los Angeles. CERP and the BRAID research team forged a collaborative data collection initiative that annually surveys undergraduate students enrolled in computing courses at a sample of institutions.

The two different research teams collected data using slightly different methods, but the same survey measures (see Measures below). For the CERP sample, students affiliated with[1] $N = 87$ computing departments across the U.S. were invited to complete an online survey via an email invitation sent by their department chair or an administrative staff person in their department. Students in the CERP sample were incentivized by being entered into a raffle to win a \$100 gift card. Because students in the CERP sample were "anonymous", response rate is not available for this sample. For the BRAID sample, students affiliated with $N = 15$ computing departments across the U.S. were directly contacted by the BRAID team and invited to complete an online survey. The first 400 students to complete the BRAID survey received a \$15 gift card as compensation. The BRAID team also raffled off two \$125 gift cards for the full sample. The BRAID team invited 18,732 introductory computing students and computing majors and minors to complete the survey; 4,402 completed the survey resulting in a 23% response rate.

The complete dataset (combined across research teams) rendered a sample of $N = 5{,}922$ ($n = 1{,}520$ from the CERP sample; $n = 4{,}402$ from the BRAID sample). For the purposes of this study, we focused on data collected from undergraduate students who met the following criteria: they were a declared computing major,[2] they were currently enrolled in courses required for their major, and they had complete data for all indices outlined in the Measures section. This resulted in a final sample of $N = 1{,}631$ students for the current analysis.

Within our final sample, 27% identified as women and 73% identified as men. The racial and ethnic makeup of the sample was 5% African-American, 1% Arab/Middle Eastern/Persian, 29% Asian or Asian American, 46% Caucasian, 9% Hispanic/Latinx, 8% more than one race/ethnicity, .5% either Native American or Native Hawaiian/Other Pacific Islander, 1% "Other", and .5% missing data. The sample consisted of 23% first-year students, 27% second-year students, 26% third-year students, 18% fourth-year students, and 6% fifth-year or greater students.

Measures

Embedded within the survey (distributed by both research teams) were questions pertaining to students' sense of intellectual belonging, growth mindset, effort expenditure in computing, persistence intentions, and major GPA.

Intellectual belonging

We assessed students' perceptions of intellectual belonging in their department by asking students three questions displayed in Appendix 1. While a great deal of existing work on sense of belonging has focused on students' sense of social belonging (e.g. "I feel welcomed in the computing community"), we measure students' sense of *intellectual* belonging. That is, our measure focuses on students' perceptions that others see them as a competent member of the computing community. In order to create an intuitive index of intellectual belonging, we reverse scored all three items; in this way, higher values represented higher intellectual belonging. These three items formed a reliable index (Cronbach's alpha = .83), so we aggregated them to create a composite measure.

Growth mindset

To measure growth mindset, we adapted measures from Dweck's (1999) Implicit Theories of Intelligence Scale (see Appendix 1 for items). In the scale used in our research, higher values indicated a lower growth mindset. We opted to create a more intuitive index of growth mindset by reverse scoring all three items; in this way, higher values represented a higher growth mindset. The reverse scored items formed a reliable index (Cronbach's alpha = .84), so we aggregated them to create a composite measure.

Effort expenditure

Effort expenditure was measured by asking students to report the number of hours they spend each week on studying and homework. Because the sample included students majoring in computing who were currently enrolled in courses for their major, we believed this measure was a good proxy for students' time spent on their computing studies. The full item and coding scheme is included in the Appendix 1.

Persistence intentions

To measure persistence intentions, we asked students if they had recently considered changing their major (see Appendix 1).

Major GPA

Students reported their computing major GPA using the conventional four-point scale used in the academic system. Major GPA was treated as a covariate in analyses testing our research questions (see Results).

Results

Preliminary analyses

We first assessed gender differences in each of the variables we measured in this study; we ran one-way analyses of variance (ANOVAs) for continuous measures and a Chi-square analysis for our dichotomous measure (persistence intentions). As seen in Table 1, women reported lower intellectual belonging than men $F(1,1629) = 24.92$, $p < .001$, $d = .27$, expended more academic effort than men $F(1,1629) = 16.94$, $p < .001$, $d = .23$, and were more likely to have thought about leaving their major than men X^2 ($N = 1631$) = 6.70, $p < .01$. There was no difference in students' major GPA, $F(1,1629) = 1.46$, $p = .23$, $d = .06$, or growth mindset, $F(1,1629) = 1.93$, $p = .13$, $d = .09$.

Table 2(a) and (b) displays simple correlations among all measures for women versus men. We use Cohen's (1988) guidelines for interpreting the magnitude of correlations: .10–.29 is a small effect; .30–.49 is a medium effect; and .50 or greater is a large effect. Values less than or equal to .10 are considered inconsequential and are not discussed. Among women, low intellectual belonging was associated with thinking about leaving the computing major, $r = -.23$. Among men, having a strong growth mindset was associated with feeling more intellectual belonging, $r = .35$. Major GPA was negatively correlated with having thought about leaving one's computing major for women, $r = -.19$, and for men, $r = -.14$ (i.e. students with a low GPA were more likely to have thought about leaving their major).

Perceptions of intellectual belonging as a function of growth mindset and effort expenditure among women and men

We next addressed the following questions: Does the relationship between a growth mindset and intellectual belonging in computing depend on students' effort expenditure? Is effort expenditure more important for women's intellectual belonging compared to men's? To address our questions, we regressed students' perceptions of intellectual belonging on gender (women = 0, men = 1), growth mindset (continuous, mean centered), effort expenditure (continuous, mean centered), their two-way interactions, and their three-way interaction, controlling for student' major GPA (continuous, mean centered; see Equation (1)). Given the presence of interaction terms in our model, lower order coefficients are dependent on (a) which variable is coded as zero for gender, and (b) where continuous variables are centered (Aiken & West, 1991). Thus, in what follows, we only discuss lower order coefficients as a means of understanding the three-way interaction term.

Table 1. Descriptive statistics for variables for women vs. men.

	Women		Men	
	$n = 440$		$n = 1191$	
	M	SD	*M*	SD
Major GPA	3.50_a	.48	3.47_a	.49
Intellectual belonging	3.97_a	.98	4.22_b	.90
Growth mindset	3.70_a	.91	3.78_a	.93
Time spent studying	5.66_a	1.47	5.31_b	1.54
	Frequency		Frequency	
Have thought about leaving	$18\%_a$		$13\%_b$	

Note: Different subscripts within rows indicate a significant gender difference, $p < .05$. M = mean, SD = standard deviation.

Table 2. Correlation coefficients among variables for women vs. men.

Women	1	2	3	4	5
1. Major GPA					
2. Intellectual belonging	.05				
3. Growth mindset	.05	.07			
4. Time spent studying	−.02	−.10	−.02		
5. Have thought about leaving	−.19	−.23	−.05	.08	
Men					
1. Major GPA					
2. Intellectual belonging	.08				
3. Growth mindset	.04	.35			
4. Time spent studying	.09	−.01	.04		
5. Have thought about leaving	−.14	−.09	−.07	−.01	

Notes: Women's correlation coefficients, $n = 440$, Men's correlation coefficients, $n = 1191$.

Equation 1: Regression equation predicting intellectual belonging

$$\begin{aligned}\text{Intellectual Belonging} = \beta_0 + \beta_1 \times \text{Gender (G)} + \beta_2 \times \text{Growth Mindset(GM)} + \beta_3 \\ \times \text{Effort Expenditure(EE)} + \beta_4 \times \text{G} \times \text{GM} + \beta_5 \times \text{G} \times \text{EE} \\ + \beta_6 \times \text{GM} \times \text{EE} + beta_7 \times \text{G x GM} \times \text{EE} + \beta_8 \times \text{Major GPA}\end{aligned}$$

The three-way interaction of gender, growth mindset, and effort expenditure was significant, $B = -.09$, $SE = .04$, $t(1, 622) = 2.48$, $p < .05$. We systematically investigated the interaction via conventional dummy coding protocol where our

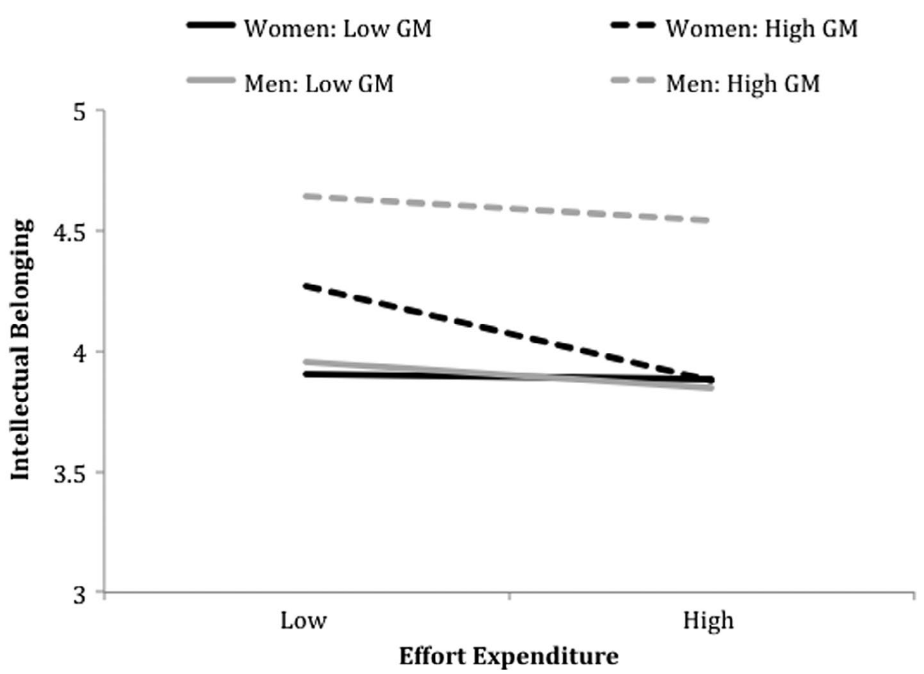

Figure 1. Pictorial representation of gender × growth mindset × effort expenditure interaction.
Notes: "Low" vs. "high" growth mindset (GM) and effort expenditure were modeled at 1 SD above and below their respective means.

reference group was coded as zero and the non-reference group was coded as 1 (e.g. to find a simple effect for women, we coded women = 0, men = 1; see Aiken & West, 1991). Figure 1 displays this interaction. Our analysis revealed that the effect of growth mindset on women's intellectual belonging was moderated by women's effort expenditure (the slopes of the black lines in Figure 1 are significantly different; to be discussed below), $B = -.07$, $SE = .03$, $t(1,622) = 2.07$, $p < .05$. For men, effort expenditure did not interact with the relationship between growth mindset and perceptions of intellectual belonging (the slopes of the gray lines in Figure 1 are statistically equivalent), $B = .02$, $SE = .02$, $t(1,622) = 1.37$, $p = .17$.

We investigated the Growth Mindset x Effort Expenditure interaction for women by way of simple effects tests and found the benefits of a growth mindset depended on women's effort expenditure. While effort expenditure was unrelated to perceptions of intellectual belonging among women who held a low growth mindset, $B = -.01$, $SE = .04$, $t(1,622) = -.21$, $p = .84$, women who held a high growth mindset reported weaker intellectual belonging as they expended more academic effort, $B = -.13$, $SE = .04$, $t(1,622) = 3.10$, $p < .01$. Looking at the interaction differently, women who held a high growth mindset reported stronger intellectual belonging than women who held a low growth mindset when effort expenditure was low (see spatial difference between solid and broken black lines at Low Effort Expenditure), $B = -.20$, $SE = .08$, $t(1,622) = 2.60$, $p < .01$. However, when effort expenditure was high, women's intellectual belonging did not differ as a function of the degree to which they endorsed a growth mindset, $B = -.001$, $SE = .06$, $t(1,622) = -.03$, $p = .98$; those with a high growth mindset reported the same level of intellectual belonging as those with a low growth mindset. This means, paradoxically, the benefit of a growth mindset on women's sense of intellectual belonging in computing appears to only occur when women are not actually spending a lot of time studying. In other words, even when women endorse a growth mindset, spending many hours studying appears to cancel out the benefit of a growth mindset on intellectual belonging.

The relationship between intellectual belonging and persistence intentions for women and men

This begs the questions: Why should we care about students' sense of intellectual belonging in computing education settings? Does feeling low intellectual belonging relate to retention in the major? To test this, we regressed students' thoughts about leaving their major on intellectual belonging (continuous, mean centered), controlling for students' major GPA. We also included students' gender and its interaction with intellectual belonging in our regression equation to assess whether intellectual belonging predicted persistence intentions to the same degree for women and men (see Equation (2)).

Equation 2: Regression equation predicting persistence intentions

$$\text{Persistence Intentions} = \beta_0 + \beta_1 \times \text{Gender (G)} + \beta_2 \times \text{Intellectual Belonging(IB)} + \beta_3 \times \text{G} \times \text{IB} + \beta_4 \times \text{Major GPA}$$

By way of a logistic regression, we found students' sense of intellectual belonging predicted thoughts about leaving their major for both women and men; however, the strength of this relationship differed among women and men (i.e. the Gender x Intellectual Belonging interaction was significant), $B = .30$, $SE = .15$, Wald = 3.83, $p = .05$. Intellectual belonging was a stronger predictor of women having thought about leaving their major, $B = -.55$, $SE = .12$, Wald = 19.82, $p < .001$, than was the case for men, $B = -.25$, $SE = .09$, Wald = 8.08, $p < .01$. This finding replicates past work linking low intellectual belonging with low retention in academic settings (e.g. Lewis & Hodges, 2015) – particularly among marginalized students (here, women in computing; see Lewis et al., 2017; Walton & Cohen, 2007).

Discussion

Summary and implications

Consistent with existing research, we found that women reported lower intellectual belonging in computing compared to men. Although a stronger growth mindset was associated with stronger intellectual belonging for men, the benefit of a growth mindset for women's intellectual belonging was dependent on the amount of effort women put into their computing studies. That is, high effort expenditure among women appeared to nullify the positive impact of growth mindset on women's sense of belonging. In other words, women only received the benefits of growth mindset when they spent a relatively low amount of time on their studies. Thus, when women perceive that they have to put in a great amount of effort, they tend to question whether they belong in computing even when they also endorse a growth mindset.

Our findings challenge the assumption that a growth mindset is consistently beneficial for students, pointing to a need for instructors to think critically about how best to use growth mindset as a tool for students' success. We suspect that encouraging a growth mindset may not be enough to foster women's sense of belonging in computing. Rather, instructors should couple their emphasis on a growth mindset with encouragement and reminders that all students belong in computing – even when students need to work hard to succeed. Further, instructors should explicitly refute traditional gender stereotypes in computing by providing students with concrete examples of the many women and men who have worked very hard to be successful in computing. Finally, instructors should consider the unintended consequences of assigning heavy homework loads to students. We certainly do not suggest an absence of homework altogether; rather, instructors should be mindful of the fact that spending a great deal of time on homework may threaten women's sense of belonging in particular.

Limitations and future directions

It is worth considering two methodological concerns about our study. First, rather than use an objective measure to capture students' effort expenditure, we asked students to self-report the amount of time they spent studying. Thus, students' reported effort expenditure might have been inaccurate. Given the nature of our research methodology (national online survey research), we were limited to students' self-reports for our measures. Future research should aim to replicate our work via a controlled study where effort expenditure can be manipulated rather than measured. Further, data in this study were cross-sectional; a controlled lab study would help establish the causal effect of growth mindset and effort expenditure on belonging and retention.

Also of note, our sample consisted of students from four-year colleges and universities. Future research should examine the extent to which our research questions are relevant to students at community colleges, where effort expenditure may be constrained by practical matters like employment and family obligations. Similarly, future research should assess whether effort expenditure is threatening for other underrepresented or marginalized groups in computing, including students of color and students from low socioeconomic backgrounds. We also cannot be sure whether our findings are generalizable to other disciplines. Perhaps effort expenditure signals low belonging to women across all academic disciplines and not only in computing.

While our work focused on growth mindset as an individual-level tool for broadening women's participation in computing, more research is needed to pinpoint effective systemic-level interventions. That is, a focus on growth mindset as a means of building diversity in computing may be part of a larger tendency among education researchers to focus on individual factors as a means of reconciling inequities. As other scholars have pointed out, this approach may be detrimental if it shifts the burden of diversifying the field to marginalized individuals and ignores larger societal problems. Future research should examine the different ways in which instructors are employing a growth mindset intervention in the classroom and how students interpret instructors' definition of growth mindset. This work may best be approached using qualitative methods.

Summary and conclusion

Our findings challenge popular beliefs about the benefits of growth mindset for students. Specifically, we found that the impact of growth mindset depends on contextual factors, like the academic discipline, students' gender identity, and expended effort. In our view, the computing education community should first address the culture of computing and the systems in place that lead women to feel like they do not belong in the field – even when women work very hard and genuinely believe hard work leads to intellectual growth. Perhaps then conventional education interventions, like teaching students to hold a growth mindset, can more reliably foster student engagement and success.

Notes

1. We define "affiliation" as majoring or minoring in computing, or simply being enrolled in computing courses.
2. We define computing field as computer science, computer engineering or electrical and computer engineering, computing information systems or information systems, or other computing related field.

Acknowledgments

We wish to thank Dr. Burcin Tamer and Ms. Heather Wright for comments on an earlier version of this manuscript and for assistance with data collection.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the National Science Foundation [grant number DUE-1431112], [grant number CNS-1246649], awarded to the Computing Research Association.

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References

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage.

Blaney, J. M., & Stout, J. (2017). Examining the relationship between introductory computing course experiences, self-efficacy, and belonging among first-generation college women. In Proceedings of the Special Interest Group on Computer Science Education (SIGCSE).

Bornholt, L. J., Goodnow, J. J., & Cooney, G. H. (1994). Influences of Gender Stereotypes on Adolescents' Perceptions of Their Own Achievement. *American Educational Research Journal, 31*(3), 675–692.

Burnette, J. L., O'Boyle, E. H., VanEpps, E. M., Pollack, J. M., & Finkel, E. J. (2013). Mind-sets matter: A meta-analytic review of implicit theories and self-regulation. *Psychological Bulletin, 139*(3), 655–701. doi:10.1037/a0029531

Cejka, M. A., & Eagly, A. H. (1999). Gender-stereotypic images of occupations correspond to the sex segregation of employment. *Personality and Social Psychology Bulletin, 25*(4), 413–423.

Cheryan, S., Plaut, V. C., Davies, P. G., & Steele, C. M. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology, 97*(6), 1045–1060.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cutts, Q., Cutts, E., Draper, S., O'Donnell, P., & Saffrey, P. (2010). Manipulating mindset to positively influence introductory programming performance. *Proceedings of the 41st ACM Technical Symposium on Computer Science Education,* 431–435.

DuBow, W. M., Quinn, B. A., Townsend, G. C., Robinson, R., & Barr, V. (2016). Efforts to make computer science more inclusive of women. *ACM Inroads, 7*(4), 74–80.

Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality and development*. Philadelphia, PA: Taylor & Francis.

Dweck, C. S. (2016). *Mindset: The new psychology of success*. New York, NY: Random House.

Forbes. (2016). The 10 best-paying STEM jobs for recent grads. Retrieved from http://www.forbes.com/pictures/efkk45ekgkh/the-10-best-paying-stem-jobs-for-recent-grads/

Good, C., Aronson, J., & Inzlicht, M. (2003). Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat. *Journal of Applied Developmental Psychology, 24*, 645–662.

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102*(4), 700–717.

Hoffman, M. (2017). Computer science for minorities: Why the lack of interest. *Computer Science Online*. Retrieved from http://www.computerscienceonline.org/cs-programs-for-minorities/

Howard, T. C. (2015). Student culture and learning: What's the connection? Presentation at the Education Writers Association's New Lens on Learning: The Hidden Value of Motivation, Grit and Engagement 2015 meeting. Retrieved from http://www.ewa.org/sites/main/files/file-attachments/2015-11-11-motivation-howard.pdf

Kerpen, C. (2017). How a confidence mindset can help close the gender gap in STEM. *Forbes*. Retrieved from. https://www.forbes.com/sites/carriekerpen/2017/06/21/how-confidence-mindset-can-help-close-the-gender-gap-in-stem/#7bb4cef56708

Kirp, D. L. (2016). Conquering the freshman fear of failure. *The New York Times*. Retrieved fromhttps://www.nytimes.com/2016/08/21/opinion/sunday/conquering-the-freshman-fear-of-failure.html

Lewis, K. L., & Hodges, S. D. (2015). Expanding the concept of belonging uncertainty in academic domains: Development and validation of the Ability Uncertainty Scale. *Learning and Individual Differences, 37*, 197–202.

Lewis, K. L., Stout, J. G., Finkelstein, N. F., Pollock, S. J., Miyake, A., Cohen, G. L., & Ito, T. A. (2017). Fitting in to move forward: Using a belonging framework to understand gender disparities in persistence in the physical sciences, technology, engineering and mathematics (pSTEM). *Psychology of Women Quarterly*, *41*, 420–436.

Master, A., Cheryan, S., & Meltzoff, A. N. (2016). Computing whether she belongs: Stereotypes undermine girls' interest and sense of belonging in computer science. *Journal of Educational Psychology, 108*(3), 424.

Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women's representation in science predicts national gender-science stereotypes: Evidence from 66 nations. *Journal of Educational Psychology, 107*, 631–644.

Perez, T., Cromley, J. G., & Kaplan, A. (2014). The role of identity development, values, and costs in college STEM retention. *Journal of Educational Psychology, 106*(1), 315.

Ris, E. W. (2015). Grit: A short history of a useful concept. *Journal of Educational Controversy, 10*(1). Retrieved from http://cedar.wwu.edu/jec/vol10/iss1/3

Sax, L., Blaney, J. M., Lehman, K. J., Rodriguez, S., George, K., & Zavala, C. (2017). Sense of belonging in computer science: The role of introductory courses for women and underrepresented minority students. Proceedings of the 2017 Paper presented at the Study of Higher Education (ASHE) Conference. Houston, TX.

Sheffield, S. (2005). Professionalizing women scientists. In Author (Ed.), *Women and science: Social impact and interaction* (pp. 127–156). New Brunswick: Rutgers University Press.

Siegle, D., Rubenstein, L.D.V., Pollard, E., & Romey, E. (2010). Exploring the relationship of college freshmen honors students' effort and ability attribution, interest, and implicit theory of intelligence with perceived ability. *Gifted Child Quarterly, 54*(2), 92–101.

Simon, B., Hanks, B., Murphy, L., Fitzgerald, U., McCauley, Thomas, L., & Zander, C. (2008). Saying isn't necessarily believing: Influencing self-theories in computing. Proceedings of the Fourth international Workshop on Computing Education Research, 173–184

Smith, J.L., Lewis, K.L., Hawthorne, L., & Hodges, S.D. (2013). When trying hard isn't natural: Women's belonging with and motivation for male-dominated fields as a function of effort expenditure concerns. *Personality and Social Psychology Bulletin, 39*, 131–143.

Steele, C.M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*, 613–629.

Stout, J.G., & Dasgupta, N. (2013). Mastering one's destiny: Mastery goals promote psychological challenge and enhance success despite social identity threat. *Personality and Social Psychology Bulletin, 39*, 748–762.

Stout, J.G., & Tamer, B. (2016). Collaborative learning eliminates the negative impact of gender stereotypes on women's self-concept. Proceedings for the Annual Meeting of the American Society for Engineering Education.

U.S. News and World Report. (2016). Best jobs 2015. Retrieved from http://money.usnews.com/careers/best-jobs/rankings

Walton, .M., & Cohen, G.L. (2007). A question of belonging: Race, social fit, and achievement. *Journal of Personality and Social Psychology, 92*(1), 82–96.

Appendix 1

Coding schemes for all scales

Measure	Coding
Intellectual belonging	
• Within your computing department and/or classes, how often do you feel that: People tend to attribute your success to special treatment or luck rather than to your competence? • Within your computing department and/or classes, how often do you feel that: You are "talked down to" by classmates, instructors, or advisors? • Within your computing department and/or classes, how often do you feel that: Your ideas or opinions are minimized or ignored?	1 = Never 2 = A little 3 = Sometimes 4 = Often 5 = All of the time
Growth mindset	
• People have a certain amount of computing ability that really can't be changed. • People can't really change how good they are in computing. • People can learn new things, but they can't change their basic ability to do computing.	1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly agree
Effort expenditure	
During this academic term, how much time did you spend during a typical week doing the following: studying/homework?	1 = None 2 = Less than 1 hour 3 = 1-2 hours 4 = 3-5 hours 5 = 6-10 hours 6 = 11-15 hours 7 = 16-20 hours 8 = Over 20 hours
Persistence intentions	
Over the past year, have you seriously considered changing to a non-computing major?	1 = No; 2 = Yes