Who Is Part of the "Mindset Context"? The Unique Roles of Perceived Professor and Peer Mindsets in Undergraduate Engineering Students' Motivation and Belonging

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In the current study, we explore the unique roles that perceived professor and peer beliefs play in creating a mindset context for undergraduate engineering students. We found that students (N = 304) perceived their peers, as compared to their professors, to endorse stronger fixed beliefs about intelligence and more negative beliefs about effort and failure, what we refer to as "unproductive mindsets". Students' perceptions of their professors' unproductive mindsets negatively predicted their motivation (utility, attainment, and intrinsic value of engineering) and sense of belonging, even controlling for students' own mindsets. Further, students' perceptions of their peers' unproductive mindsets negatively predicted their motivation (intrinsic value and mastery goals), sense of belonging, and choice of a difficult assignment, even controlling for students' own mindsets and their perceptions of their professors' unproductive mindsets. These results suggest that when considering the mindsets that permeate academic contexts, it is important to consider the unique role of perceptions of both teachers (professors) and peers.

Keywords: mindset beliefs, peers, professors, motivation, belonging

INTRODUCTION

In Science, Technology, Engineering, and Mathematics (STEM) fields, students' motivational beliefs, values, goals, and sense of belonging are critical influences on their academic performance and retention (e.g., Wang, 2013; Wang and Degol, 2013; Perez et al., 2014; Wilson et al., 2015; Cromley et al., 2016). Thus, it is important to determine what kinds of academic contexts promote higher motivation and sense of belonging in students (e.g., Hilts et al., 2018; Murdock-Perriera et al., 2019). Some of the literature on academic contexts has focused on objective contextual features, such as class size or instructional characteristics (e.g., Ehrenberg et al., 2001; Corkin et al., 2017). However, a large portion of the research has focused on *perceived* contexts, highlighting the importance of how one's surroundings (physical and social environments) are psychologically experienced by the individual learner (e.g., Muenks et al., 2020; Starr et al., 2020). For example, one body of research has explored how students' perceptions of their teachers' mastery-oriented vs. performance-oriented instructional practices predict their motivation and achievement (e.g., Meece et al., 2006). Building on this work, the present study explores how perceived mindset contexts (e.g., Murphy and Dweck,

2010)—defined here as the perceived unproductive mindsets of teachers and peers around intelligence, effort, and failure—are associated with undergraduate engineering students' motivation and belonging. Though prior research has demonstrated that the unproductive mindsets of college professors—both self-reported (e.g., Canning et al., 2019) and perceived by students (e.g., Rattan et al., 2018; LaCosse et al., 2020; Muenks et al., 2020)—negatively predict students' motivation and belonging in those professors' classes, no studies to our knowledge have examined students' perceptions of their peers' unproductive mindsets. However, it is reasonable to assume that peers are also an important part of the perceived mindset context of a classroom (e.g., Yeager et al., 2019), particularly in a highly competitive field such as engineering (e.g., Goubeaud, 2010). Thus, in the present exploratory study, we examine the unique role of undergraduate engineering students' perceptions of their professors' and peers' mindsets about intelligence, effort, and failure on their motivation and belonging in engineering.

The Important Role of Students' Motivation and Belonging in STEM

A major focus of educational funding agencies across the world is encouraging more students to pursue and retain careers in STEM that contribute to the development and growth of industrialized societies (e.g., Atkinson and Mayo, 2010; UK Commission for Employment and Skills, 2015). To this end, researchers have explored what factors predict students' performance in undergraduate STEM classes and their persistence in STEM fields more broadly. Much of this work has focused on students' motivational beliefs, values, goals, and sense of belonging as predictors of their performance and retention in STEM (e.g., Bong, 2001; Wang and Degol, 2013; Cromley et al., 2016; Watt et al., 2017; Lazarides and Lauermann, 2019).

According to situated expectancy-value theory (Eccles and Wigfield, 2020), students' expectancies and subjective task values within specific domains, such as STEM, are key indicators of their motivation and predict their performance and choices in those domains. Expectancies refer to students' beliefs about their capabilities to accomplish certain tasks, and are highly related to students' self-efficacy beliefs, or their beliefs about their competence in a specific domain. Subjective task values are separated into utility value, defined as the usefulness of a task or domain; attainment value, defined as the importance of a task or domain; and intrinsic value, defined as one's interest in a task or domain (Eccles and Wigfield, 2020). Both expectancies and values have been shown to predict students' STEM outcomes across many studies (e.g., Andersen and Ward, 2013; Perez et al., 2014; Canning et al., 2018; Gaspard et al., 2019).

Within another theoretical framework, goal orientation theory, students' broad purposes for engaging in academic tasks are important indicators of their motivation (Urdan and Kaplan, 2020). Specifically, students can be oriented toward mastery goals (i.e., goals focused on mastery of concepts or skills) or performance goals (i.e., goals focused on performance; Dweck and Leggett, 1988). Performance goals are further separated into performance-approach goals (i.e., goals focused on performing well or doing better than others) and performance-avoidance goals (i.e., goals focused on avoiding performing poorly or doing worse than others; Elliot and Harackiewicz, 1996). In general, research demonstrates the beneficial effects of mastery goals and, to a somewhat lesser extent, performance-approach goals; and the maladaptive effects of performance-avoidance goals (e.g., Wolters, 2004; Chouinard et al., 2007; Hernandez et al., 2013), for students' STEM performance and retention. Relatedly, students' choices about what tasks they will pursue, such as whether they are willing to choose a difficult class or assignment in which they may learn a lot over an easy class or assignment in which they will learn very little, are likely to impact their ultimate performance and success in STEM fields (e.g., Hong et al., 1999).

Finally, students' sense of belonging is also a key predictor of their performance and retention in STEM fields (e.g., Strayhorn, 2012; Rainey et al., 2019). If students do not feel secure, comfortable, or that they "fit in" with others around them, they are likely to experience decreased motivation and are more at risk of dropping out of STEM (e.g., Thoman et al., 2014; Wilson et al., 2015).

In sum, students' motivational beliefs, values, goals, sense of belonging, and academic choices are critically important to their performance and retention in STEM. So, what predicts students' motivation and belonging in STEM? We turn next to the role of mindset contexts.

What Predicts Students' Motivation and Belonging? The Role of Mindset Contexts

According to Dweck, 1999 mindset theory, people hold different implicit beliefs about intelligence, also known as intelligence mindsets. A growth mindset is characterized by the belief that intelligence is malleable, whereas a fixed mindset is characterized by the belief that intelligence is fixed. Further, people's intelligence mindsets are strongly linked to other implicit beliefs they hold about effort and failure, and create a broader meanings system (e.g., Dweck, 1999; Molden and Dweck, 2006; Blackwell et al., 2007; Dweck and Yeager, 2019). Specifically, a fixed mindset about intelligence is thought to be closely tied with the belief that effort is a sign of low ability (e.g., Blackwell et al., 2007) and that failure is debilitating (e.g., Haimovitz and Dweck, 2016). In the present study, we will refer to this constellation of beliefs as "unproductive mindsets."

Researchers have found that students' own growth mindsets positively predict their motivation and belonging (e.g., Dweck and Leggett, 1988; Hong et al., 1999; Tabernero and Wood, 1999; Robins and Pals, 2002; Bråten and Strømsø, 2006; Blackwell et al., 2007; Payne et al., 2007; Nussbaum and Dweck, 2008; Chen and Pajares, 2010; Burnette et al., 2013; Degol et al., 2018; Lee and Seo, 2019; Bai and Wang, 2020; Lytle and Shin, 2020); most of this work has focused on intelligence mindsets. However, building off of earlier work on mastery vs. performance goal structures within a classroom (e.g., Ames, 1992; Meece et al., 2006; Patrick and Ryan, 2008; Murayama and Elliot, 2009), recent work by has

shifted away from focusing on mindsets at an individual level and has instead examined the motivational effects of different mindset *contexts* (Murphy and Dweck, 2010; Gasiewski et al., 2012; Schmidt et al., 2015; Canning et al., 2019; Fuesting et al., 2019; LaCosse et al., 2020; Muenks et al., 2020). Thus far, mindset contexts have been conceptualized and operationalized as the fixed vs. growth mindset values espoused by an organization (e.g., Murphy and Dweck, 2010; Canning et al., 2020) or by the actual or perceived fixed vs. growth mindsets of powerful people within those contexts, such as employers in a workplace or teachers in a classroom or school (e.g., Canning et al., 2019; LaCosse et al., 2020; Muenks et al., 2020).

The actual or perceived mindsets of teachers have been found to predict students' motivation and belonging. Schmidt et al. (2015) found that when middle school teachers emphasized growth intelligence mindsets in their teaching, their students benefited more from a student-centered growth mindset intervention, reporting sustained growth mindsets and mastery goal orientations over time. In a college STEM context, Canning et al. (2019) found that when professors reported more fixed intelligence mindsets, their students were less motivated in their classes, as measured by course evaluation items (e.g., "How much did your instructor motivate you to do your best work?"). Muenks et al. (2020) found that when undergraduate students *perceived* their professor to have stronger fixed intelligence mindsets, they reported more psychological vulnerability (including decreased belonging), and less interest and engagement in that professor's class throughout the semester (see also LaCosse et al., 2020). These results held when controlling for students' own intelligence mindsets, suggesting a unique effect of the perceived mindset context (here, operationalized as students' perceptions of their professors' intelligence mindsets) on students' outcomes. Similarly, Rattan et al. (2018) found that when students perceived STEM professors to believe that only *certain* students (rather than all students) could succeed, they experienced lower belonging in STEM.

In sum, recent research suggests that, above and beyond students' own intelligence mindsets, the perceived mindset contexts that surround students also affect their motivation and sense of belonging. However, in most of these studies, motivation was operationalized somewhat broadly (e.g., by course evaluation items; Canning et al., 2019; or by interest and engagement in a STEM class; Muenks et al., 2020). Only Schmidt et al. (2015) examined students' goal orientations, and this study focused on middle school students. No studies to our knowledge have examined how undergraduate students' perceptions of their professors' intelligence mindsets predict specific aspects of their motivation (self-efficacy, value, goal orientations), belonging, or their choices to pursue difficult tasks. Additionally, research thus far has focused on professors' intelligence mindsets, without examining students' perceptions of their professors' effort or failure mindsets, which may be more visible or salient to students in actual classroom contexts (e.g., Haimovitz and Dweck, 2016). Finally, research has thus far operationalized mindset contexts as the actual or perceived mindsets of professors, while neglecting the role of peers.

The Unique Role of Peers

In addition to teachers, peers are an integral and influential part of students' academic contexts and are critically important to students' motivation and belonging (e.g., Urdan and Schoenfelder, 2006; Song et al., 2015; King, 2016; Wentzel, 2017). Peers can create a positive motivational context by providing companionship, help, and emotional support (e.g., Riegle-Crumb and Morton, 2017; Wentzel, 2017; Zander et al., 2018), but can also create a negative motivational context by increasing competition and social comparison among classmates (e.g., Marsh, 1987; Fischer, 2017; Covarrubias et al., 2019; von Keyserlingk et al., 2020). Peer beliefs and norms can also spread quickly among students; in one study, Paluck et al., 2016 found that training just a few highly connected, "social referent" students on conflict reduction resulted in a spread of new anti-conflict norms throughout the student network. Examining mindsets specifically, King (2020) found that intelligence mindsets were socially contagious among classmates, such that students who were in classrooms in which their peers had stronger fixed intelligence mindsets were more likely to develop stronger intelligence fixed mindsets themselves over time. Peer mindsets have also been demonstrated to be impactful for students' outcomes: in a recent field experiment in the United States with a nationally representative sample, Yeager et al. (2019) found that an intervention aimed at changing students' own intelligence mindsets toward a growth mindset was most effective at increasing students' grades in schools where peer norms were also supportive of growth intelligence mindsets.

In sum, many studies have found that peers are important to students' motivation, and a few studies have specifically examined how peers' intelligence mindsets relate to students' own intelligence mindsets and performance outcomes. Thus, it may be particularly important to examine how peers play a unique role, above and beyond teachers or professors, in the perceived mindset contexts that permeate classrooms. That is, even if the teacher or professor espouses productive mindsets about intelligence, effort, or failure, students may still remain unmotivated or feel a lower sense of belonging if they perceived their peers to espouse unproductive mindsets. This may especially be the case in competitive undergraduate engineering contexts (e.g., Goubeaud, 2010; Covarrubias et al., 2019) such as the one used in the present study.

The Present Study

The broad purpose of the present study is to explore the role of undergraduate engineering students' perceptions of their professors' and peers' unproductive mindsets about intelligence, effort, and failure on their motivation and belonging. We seek to extend prior research in three key ways. First, though previous work has examined how students' perceptions of their professors' mindsets influence students' motivation and belonging (e.g., Canning et al., 2019; Muenks et al., 2020), "motivation" has often been broadly defined and has not been examined with respect to specific motivational beliefs, values, and goals. In the present study we will be able to examine more specific associations among

students' perceptions of their professors' mindsets and their motivation. Although the present study is exploratory in that we do not have specific hypotheses about which aspects of students' motivation would be most strongly related to their perceptions of their professors' and peers' unproductive mindsets, there are reasons to believe that these perceptions would be related to students' motivational beliefs, values, and goals. If students perceive an unproductive mindset context around them—that others in their field believe that their intelligence is fixed, that effort is a sign of low intelligence, and that failure is debilitating—they may become more worried about making a mistake or trying something new, which may lower their confidence and cause them to focus more on performing well (or on *not* performing poorly) rather than mastering the content (Schmidt et al., 2015) in that field. They may even decide to make choices that will make them look smart (such as choosing an easier assignment or to take a class with a professor who is known for giving easy grades) over choices that will help them learn more. They also may experience lower belonging in that field and start to value the field less—to feel that it is less useful, important, and/or interesting to them (LaCosse et al., 2020; Muenks et al., 2020).

Second, we examine the unique role of students' perceptions of their peers' unproductive mindsets in their motivation and belonging, which no previous studies have done. Thus, we will examine whether, above and beyond students' perceptions of their professors' unproductive mindsets, their perceptions of their *peers'* unproductive mindsets negatively predict their motivation and belonging. Third, we go beyond intelligence mindsets to explore other kinds of unproductive mindsets, including unproductive mindsets about effort (i.e., believing that effort is negatively associated with one's ability or intelligence; Blackwell et al., 2007) and unproductive mindsets about failure (i.e., believing that failure is debilitating; Haimovitz and Dweck, 2016). Given that other people's mindsets about effort and failure may be more salient or visible to students, because they are more proximal to the learning context, than intelligence mindsets (e.g., Haimovitz and Dweck, 2016), we sought to explore all three of these mindsets in the present study.

Although the central purpose of our study is to examine how professors' and peers' unproductive mindsets predict students' motivation and belonging, we start by simply examining the mean-level differences between students' perceptions of their professors' and peers' mindsets—that is, do students perceive that their professors or peers have more unproductive mindsets? Thus, we explore two research questions:

(1) What are the mean-level differences in students' perceptions of their and professors' and peers' unproductive mindsets about intelligence, effort, and failure?

(2) How do students' perceptions of their professors' and peers' unproductive mindsets about intelligence, effort, and failure predict students' motivation (self-efficacy, value, goal orientations), belonging, and academic choices, above and beyond their own mindsets?

MATERIALS AND METHODS

Participants

Participants were 304 undergraduate students majoring in Electrical and Computer Engineering at a large, public southwestern university (78.6% male, 21.4% female, 51.8% Asian, 28.1% White, 9.6% Hispanic/Latino, 7.4% Biracial or Multiracial, 2.3% Black, 0.3% Native Hawaiian or Pacific Islander, 0.7% Prefer not to say; Mean age = 19.56 years).[1] The sample consisted of 29.3% freshmen, 28% sophomores, 21.4% juniors, and 21.4% seniors.

Measures

Student mindsets. Participants responded to two items each measuring their intelligence mindsets (sample item: "You can learn new things, but you can't really change your basic intelligence"; α = 0.90; Dweck, 1999) and failure mindsets (sample item: "Experiencing failure inhibits my learning and growth"; α = 0.72; Haimovitz and Dweck, 2016), which were averaged to form composite scores. Participants also responded to two items measuring their effort mindsets ("To tell the truth, when I work hard at my schoolwork, it makes me feel like I'm not very smart" and "If you're not good at a subject, working hard won't make you good at it") taken from Blackwell et al., (2007); however, the two items had low internal consistency (α = 0.52). Thus, for the purposes of the present study, we only used the second item ("If you're not good at a subject, working hard won't make you good at it") as a measure of participants' effort mindsets. All items had a response scale of 1 = Strongly disagree to 6 = Strongly agree, where higher scores indicated stronger unproductive mindsets about intelligence, effort, and failure.

Perceptions of professors' mindsets. Participants responded to two items each measuring their perceptions of their professors' intelligence mindsets (sample item: "My ECE professors seem to believe that students have a certain amount of intelligence, and they really can't do much to change it"; α = 0.91; adapted from Dweck (1999)), effort mindsets (sample item: "My ECE professors seem to believe that if students are not good at a subject, working hard won't make them good at it"; α = 0.85; adapted from Blackwell et al. (2007)), and failure mindsets (sample item: "My ECE professors seem to believe that failure inhibits students' learning and growth"; α = 0.76; adapted from Haimovitz and Dweck (2016)) on a scale from 1 = Strongly disagree to 6 = Strongly agree. Higher scores indicated stronger perceived unproductive mindsets about intelligence, effort, and failure. Items were averaged to form composite scores.

Perceptions of peers' mindsets. Participants responded to two items each measuring their perceptions of their peers' intelligence mindsets (sample item: "My ECE peers seem to believe that people have a certain amount of intelligence, and they really can't do much to change it"; α = 0.95; adapted from

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[1]Women were slightly overrepresented in this sample compared to the undergraduate population (18.9% women) and faculty (12.2% women) in the Electrical and Computer Engineering department.

Dweck (1999)), effort mindsets (sample item: "My ECE peers seem to believe that if people are not good at a subject, working hard won't make them good at it"; α = 0.85; adapted from Blackwell et al. (2007)), and failure mindsets (sample item: "My ECE peers seem to believe that failure is bad and should be avoided"; α = 0.79; adapted from Haimovitz and Dweck (2016)) on a scale from 1 = Strongly disagree to 6 = Strongly agree. Higher scores indicated stronger perceived unproductive mindsets about intelligence, effort, and failure. Items were averaged to form composite scores.

Motivation. Participants responded to two items measuring their self-efficacy ("How good at electrical and computer engineering are you?" on a scale from 1 = Not very good to 7 = Very good and "If you were to list all of the students from best to worst in electrical and computer engineering, where are you?" from 1 = One of the worst to 7 = One of the best; adapted from Jacobs et al. (2002)), which were averaged to form a composite score (α = 0.79). Participants also responded to one item each measuring their utility value ("How useful is what you learn in electrical and computer engineering?" from 1 = Not at all useful to 7 = Very useful), attainment value ("For me being good in electrical and computer engineering is … " from 1 = Unimportant to 7 = Important), and interest value ("I find working on electrical and computer engineering assignments … " from 1 = Boring to 7 = Interesting), all adapted from Jacobs et al. (2002). Finally, participants responded to one item each measuring their mastery goals ("In my ECE classes, I want to learn as much as possible"), performance-approach goals ("In my ECE classes, my goal is to get a better grade than most of the other students"), and performance-avoidance goals ("In my ECE classes, my goal is to avoid performing poorly"), on a scale from 1 = Not at all true of me to 6 = Very true of me, all adapted from Elliot and McGregor (2001).

Belonging. Participants responded to three items measuring their sense of belonging (sample item: "How much do you feel like you belong as a student in electrical and computer engineering (ECE)?") on a scale from 1 = Not at all to 7 = Completely, adapted from Murphy and Zirkel (2015). Items were averaged to form a composite score (α = 0.91).

Academic choices. Participants were asked two forced-choice questions. The first question was: "For one of your required courses, you have the option of two different instructors. Who would you choose?" with the response options: Instructor A, who is known to create challenging assignments and gives out few A-grades, but who students learn a lot from; or Instructor B, who is known to have easier assignments and give out more A-grades, but students learn less from. The second question was: "If you had a choice between one of two assignments, which would you choose?" with the response options: one that was harder and would probably lead to a lower grade, but where you would learn more; or one that was easier and would probably lead to a higher grade, but where you would learn less. Both items were coded such that 0 = choice of the easier instructor/assignment, whereas 1 = choice of the harder instructor/assignment.

SAT scores. We asked participants to report either their SAT or ACT scores. If they took the SAT, we also asked them whether their score was out of 1,600 or 2,400. We then converted all scores to an SAT score between 0 and 1,600.

Demographics. Participants reported their age, sex (coded 0 = male, 1 = female), race/ethnicity, and year in college.

Procedure

In Fall 2019 and Spring 2020, all Electrical and Computer Engineering undergraduate students at a large, public southwestern university in the United States were sent an email inviting them to participate in a 15 min survey from a faculty member in their department, in exchange for being entered into a raffle to win $25 or $50 Amazon gift cards. The sample reported in the present study (N = 304) includes participants from both waves of data collection (N = 242 from Fall 2019 and N = 62 from Spring 2020); because of this, wave (coded 0 = Fall 2019, 1 = Spring 2020) was included as a control variable in all analyses. Sixty-six participants completed the survey at both waves, but only their data from wave 1 (Fall 2019) was included.

Analysis Plan

To answer Research Question 1 (What are the mean-level differences in students' perceptions of their and professors' and peers' unproductive mindsets about intelligence, effort, and failure?), we conducted three paired samples t-tests using SPSS Version 25.

To answer Research Question 2 (How do students' perceptions of their professors' and peers' unproductive mindsets about intelligence, effort, and failure predict students' motivation (self-efficacy, value, goal orientations), belonging, and academic choices, above and beyond their own mindsets?), we conducted hierarchical regression analyses using SPSS Version 25. For all continuous outcome variables (self-efficacy, utility value, attainment value, intrinsic value, mastery goals, performance-approach goals, performance-avoidance goals, and belonging), we conducted hierarchical linear regression analyses. In Step 1, we entered in our three control variables, gender (coded 0 = male, 1 = female) SAT scores (which were z-scored), and wave (coded 0 = Fall 2019, 1 = Spring 2020). In Step 2, we entered students' own mindsets about intelligence, effort, and failure. In Step 3, we entered students' perceptions of their professors' mindsets about intelligence, effort, and failure. Finally, in Step 4, we entered students' perceptions of their peers' mindsets about intelligence, effort, and failure. We then examined the change in R^2 at each step to determine whether each set of variables explained a significant amount of variance in the outcome, above and beyond the variables included in the previous steps. Specifically, the change in R^2 at Step 2 allowed us to determine whether students' own mindsets predicted their motivation and belonging above and beyond the control variables (gender, SAT scores, and wave), the change in R^2 at Step 3 allowed us to determine whether students' perceptions of their professors' mindsets predicted their motivation and belonging above and beyond their own implicit beliefs, and the change in R^2 at Step 4 allowed us to determine whether students' perceptions of their peers' mindsets predicted their motivation and belonging above

TABLE 1 | Descriptives and correlations of all variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Self-intelligence																					
2. Self-effort	0.47**																				
3. Self-failure	0.25**	0.37**																			
4. Prof-intelligence	0.45**	0.35**	0.20**																		
5. Prof-effort	0.33**	0.50**	0.29**	0.66**																	
6. Prof-failure	0.23**	0.26**	0.35**	0.34**	0.51**																
7. Peer-intelligence	0.25**	0.24**	0.20**	0.43**	0.35**	0.09															
8. Peer-effort	0.16**	0.34**	0.23**	0.42**	0.55**	0.18**	0.61**														
9. Peer-failure	0.07	0.13*	0.26**	0.21**	0.21**	0.17**	0.51**	0.51**													
10. Self-efficacy	−0.06	−0.09	−0.20**	−0.10	−0.12*	−0.07	−0.12*	−0.14*	−0.12*												
11. Utility value	−0.08	−0.22**	−0.14*	−0.23**	−0.25**	−0.10	−0.12*	−0.20**	−0.12*	0.20**											
12. Attainment value	−0.04	−0.07	−0.07	−0.22**	−0.20**	−0.05	−0.05	−0.13*	−0.10	0.26**	0.51**										
13. Intrinsic value	−0.11*	−0.14*	−0.21**	−0.26**	−0.15**	−0.01	−0.23**	−0.25**	−0.31**	0.31**	0.61**	0.46**									
14. Mastery	−0.04	−0.15*	−0.20**	−0.15*	−0.14*	−0.03	−0.19**	−0.17**	−0.26**	0.18**	0.47**	0.42**	0.47**								
15. Perf approach	0.13*	0.13*	0.06	0.03	0.07	0.09	0.02	0.09	0.06	0.34**	0.05	0.23**	0.12*	0.14*							
16. Perf avoidance	0.04	0.03	0.17**	0.07	0.06	0.12*	−0.01	0.10	0.07	−0.16**	−0.01	0.11	−0.17**	0.10	0.09						
17. Belonging	−0.07	−0.14*	−0.32**	−0.28**	−0.27**	−0.14*	−0.28**	−0.39**	−0.28**	0.47**	0.41**	0.29**	0.48**	0.33*	0.09	−0.13*					
18. Choice-instructor	−0.06	−0.08	−0.16**	−0.06	−0.04	−0.08	−0.07	−0.03	−0.11	0.12	0.21**	0.13*	0.25**	0.39**	−0.07	−0.06	0.17**				
19. Choice-assignment	−0.11	−0.17**	−0.15**	−0.04	0.001	−0.003	−0.04	−0.04	−0.18**	0.10	0.12*	0.09	0.21**	0.30**	−0.05	−0.04	0.08	0.48**			
20. SAT	0.01	0.04	−0.05	−0.04	0.09	−0.08	−0.01	0.03	−0.08	0.24**	−0.07	−0.04	−0.003	−0.03	0.22**	−0.11*	0.10	−0.04	0.03		
21. Female	−0.07	−0.11	−0.03	0.01	0.02	−0.06	0.09	0.12*	0.03	−0.18**	−0.01	0.001	0.03	0.01	−0.07	0.06	−0.22**	0.01	0.09	−0.07	
Mean	2.83	2.23	3.05	2.43	1.89	2.14	3.35	2.83	3.79	4.46	5.55	6.03	5.13	5.02	4.09	4.83	4.80	N/A	N/A	1,466.91	N/A
SD	1.27	1.17	1.12	1.06	0.89	0.94	1.31	1.24	1.22	1.22	1.40	1.19	1.46	1.16	1.53	1.31	1.51	N/A	N/A	86.38	N/A
Range	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–7	1–7	1–7	1–6	1–6	1–6	1–7	0–1	0–1	0–1,600	0–1

Note. $N = 304$. *$p < 0.05$, **$p < 0.01$. All variables that begin with "self" are students' own mindsets; all variables that begin with "prof" are students' perceptions of their professors' mindsets; and all variables that begin with "peer" are students' perceptions of their peers' mindsets. Mindsets about intelligence, effort, and failure and coded such that higher values indicate more unproductive mindsets (or perceived mindsets). Choice variables are coded 0 = easier instructor/assignment, 1 = harder instructor/assignment. Female is coded 0 = male, 1 = female. Perf = performance.

TABLE 2 | Perceived professor and peer mindsets predicting motivation and belonging: R-square change at each step.

	Self-efficacy	Utility value	Attainment value	Intrinsic value	Mastery goals	Performance approach goals	Performance avoidance goals	Belonging
Step 1: Controls	0.08***	0.01	0.01	0.001	0.001	0.05**	0.02	0.06**
Step 2: Self mindsets	0.04**	0.05**	0.01	0.05**	0.05**	0.02	0.03*	0.11***
Step 3: Perceived professor mindsets	0.01	0.04*	0.06**	0.06***	0.02	0.01	0.01	0.05***
Step 4: Perceived peer mindsets	0.003	0.01	0.01	0.06***	0.05**	0.01	0.02	0.05***

Note. *p < 0.05, **p < 0.01, ***p < 0.001.

TABLE 3 | Perceived professor and peer mindsets predicting student choices: Nagelkerke R square at each step.

	Choice of more difficult instructor	Choice of more difficult assignment
Step 1: Controls	0.01	0.02
Step 2: Self mindsets	0.04*	0.06*
Step 3: Perceived professor mindsets	0.05	0.08
Step 4: Perceived peer mindsets	0.06	0.13*

Note. *p < 0.05, **p < 0.01, ***p < 0.001. p-values correspond to the chi-square test of model coefficients at each step.

and beyond their own mindsets and their perceptions of their professors' mindsets.

For the two dichotomous outcome variables (choice of professor and choice of assignment), we conducted hierarchical logistic regression analyses. We followed the same procedure as with the continuous outcome variables, but examined the Nagelkerke R^2 and the chi-square value at each step of the model in order to examine whether each set of variables explained a significant amount of variance in the outcome, above and beyond the variables included in the previous steps.

RESULTS

Descriptives and Correlations

See **Table 1** for descriptives (means, standard deviations, ranges) and correlations for all variables.

Research Question 1: What are the mean-level differences in students' perceptions of their and professors' and peers' unproductive mindsets about intelligence, effort, and failure?

We found that participants perceived their peers to have significantly stronger fixed mindset beliefs ($M = 3.34$) than their professors ($M = 2.43$), $t(302) = -12.41$, $p < 0.001$, Cohen's $d = 0.71$, significantly more negative beliefs about effort ($M = 2.83$) than their professors ($M = 1.89$), $t(303) = -15.42$, $p < 0.001$, Cohen's $d = 0.86$, and significantly more negative beliefs about failure ($M = 3.79$) than their professors ($M = 2.14$), $t(303) = -20.44$, $p < 0.001$, Cohen's $d = 1.18$. That is, students perceived their peers to have more unproductive mindsets than their professors.

Research Question 2: How do students' perceptions of their professors' and peers' unproductive mindsets about intelligence,

effort, and failure predict students' motivation (self-efficacy, value, goal orientations), belonging, and academic choices, above and beyond their own mindsets?

See **Table 2** for a summary of results of R^2 change from the motivation (self-efficacy, values, and goals) and belonging outcomes, and **Table 3** for a summary of results of chi-square at each step from the choice outcomes. See **Supplementary Tables S1–S10** in the Supplemental Materials for all individual models including coefficients for each variable at each step.

Motivation

We explored three broad categories of motivation: self-efficacy, value, and achievement goal orientation.

Self-Efficacy. For self-efficacy, the change in R^2 was only significant at Step 2, $F(3, 296) = 4.35$, $p = 0.005$, indicating that students' own mindsets predicted their self-efficacy above and beyond the control variables (gender, SAT score, and wave). The change in R^2 was not significant at Step 3 or Step 4, indicating that students' perceptions of their professors' and peers' mindsets did not predict their self-efficacy above and beyond their own mindsets.

Value. For utility value, the change in R^2 was significant at Step 2, $F(3, 296) = 5.43$, $p = 0.001$, and Step 3, $F(3, 293) = 3.75$, $p = 0.01$, indicating that students' own mindsets predicted their utility value above and beyond the control variables, and students' perceptions of their professors' mindsets predicted their utility value above and beyond their own mindsets.

For attainment value, the change in R^2 was only significant at Step 3, $F(3, 293) = 5.95$, $p = 0.001$, indicating that students' perceptions of their professors' mindsets predicted their attainment value above and beyond their own mindsets.

For intrinsic value, the change in R^2 was significant at Step 2, $F(3, 296) = 5.06$, $p = 0.002$, Step 3, $F(3, 293) = 7.02$, $p < 0.001$, and Step 4, $F(3, 290) = 6.89$, $p < 0.001$, indicating that students' own mindsets predicted intrinsic value above and beyond the control variables, students' perceptions of their professors' mindsets predicted their intrinsic value above and beyond their own mindsets, and students' perceptions of their peers' mindsets predicted their intrinsic value above and beyond their own mindsets and their perceptions of their professors' mindsets.

Goal orientation. For mastery goals, the change in R^2 was significant at Step 2, $F(3, 296) = 4.76$, $p = 0.003$, and Step 4, $F(3, 290) = 4.85$, $p = 0.003$, indicating that students' own mindsets predicted their mastery goals above and beyond the control variables, and students' perceptions of their peers' mindsets

predicted their mastery goals above and beyond their own mindsets and their perceptions of their professors' mindsets.

For performance-approach goals, the change in R^2 was only significant at Step 1, $F (3, 299) = 5.41$, $p = 0.001$, indicating that none of the mindset or perceived mindset variables predicted students' performance-approach goals above and beyond the control variables.

For performance-avoidance goals, the change in R^2 was only significant at Step 2, $F (3, 296) = 2.93$, $p = 0.03$, indicating that students' own mindsets predicted their performance-avoidance goals above and beyond the control variables. The change in R^2 was not significant at Step 3 or Step 4, indicating that students' perceptions of their professors' and peers' mindsets did not predict their performance-avoidance goals above and beyond their own mindsets.

Belonging

For students' sense of belonging, the change in R^2 was significant at Step 1, $F (3, 299) = 5.91$, $p = 0.001$, Step 2, $F (3, 296) = 12.38$, $p < 0.001$, Step 3, $F (3, 293) = 6.76$, $p < 0.001$, and Step 4, $F (3, 290) = 6.91$, $p < 0.001$. That is, each set of variables at each step predicted students' sense of belonging above and beyond the sets of variables at the lower steps. Of particular interest to the present study, students' perceptions of their professors' mindsets predicted students' sense of belonging above and beyond their own mindsets, and students' perceptions of their peers' mindsets predicted students' sense of belonging above and beyond their own mindsets and their perceptions of their professors' mindsets.

Choices

For choice of a more difficult instructor who students learn more from (over an easier instructor who students learn less from), the Nagelkerke R^2 was only significant at Step 2, $\chi^2 = 8.26$, $p = 0.04$, indicating that students' own mindsets predicted their choice of instructor above and beyond the control variables (gender and SAT score). The Nagelkerke R^2 was not significant at Step 3 or Step 4, indicating that students' perceptions of their professors' and peers' mindsets did not predict their choice of instructor above and beyond their own mindsets.

For choice of a more difficult assignment that students get a worse grade on but learn more from (over an assignment that students get a better grade on but learn less from), the Nagelkerke R^2 was significant at Step 2, $\chi^2 = 10.20$, $p = 0.02$, and Step 4, $\chi^2 = 10.89$, $p = 0.01$. That is, students' own mindsets predicted their choice of a more difficult assignment above and beyond the control variables, and students' perceptions of their peers' mindsets predicted their choice of a more difficult assignment above and beyond their own mindsets and their perceptions of their professors' mindsets.[2]

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[2]In exploratory analyses, we also examined whether gender moderated the association between students' perceptions of their professors' and peers' implicit beliefs and students' motivation, belonging, and choices. We only found one gender x perceived peer beliefs interaction effect on performance-approach goals, such that the more women (but not men) perceived their peers to have fixed beliefs, the more likely they were to report performance-approach goals (see **Supplementary Table S11** in the Supplemental Materials).

DISCUSSION

The overall purpose of the present study was to examine how undergraduate engineering students' perceptions of their professors' and peers' mindsets predicted their motivation, belonging, and academic choices in engineering. We found, consistent with prior research (e.g., Tabernero and Wood, 1999; Robins and Pals, 2002; Bråten and Strømsø, 2006; Payne et al., 2007; Chen and Pajares, 2010; Degol et al., 2018; Lee and Seo, 2019; Bai and Wang, 2020; Lytle and Shin, 2020), that students' own mindsets predicted their motivation (self-efficacy, utility value, intrinsic value, mastery goals, performance-avoidance goals), belonging, and choices of difficult (over easy) tasks, even controlling for gender and prior achievement (i.e., SAT scores). Specifically, students' unproductive mindsets were negatively associated with students' self-efficacy, utility value, intrinsic value, and mastery goals, and positively associated with their performance-avoidance goals. However, extending this research and consistent with other recent work (e.g., Rattan et al., 2018; LaCosse et al., 2020; Muenks et al., 2020), we found that the perceived mindset *context* of the classroom, as operationalized by students' perceptions of their professors' and peers' mindsets, also predicted their motivation, belonging, and academic choices. Specifically, students who perceived their engineering professors to have more *unproductive mindsets* about intelligence, effort, and failure—that is, perceived their professors to believe that intelligence is fixed, effort is a sign of low ability, and failure is debilitating—reported less utility value, attainment value, and intrinsic value, and lower belonging in engineering. Further, students who perceived their engineering peers to have more unproductive mindsets reported lower intrinsic value, mastery goals, and belonging in engineering, and were less likely to choose a difficult engineering assignment where they would learn a lot over an easy assignment where they would learn very little.

Our findings regarding students' perceptions of their professors' mindsets predicting their motivation and belonging are consistent with prior research (e.g., Rattan et al., 2018; LaCosse et al., 2020; Muenks et al., 2020). In our study, just as in these previous studies, we controlled for students' own mindsets, demonstrating that perceived mindset *contexts* (here, operationalized as students' perceptions of their professors' mindsets) predict students' psychological and motivational outcomes above and beyond students' own mindsets (e.g., Murphy and Dweck, 2010). We note, however, that it would be interesting to further explore (perhaps with qualitative methods) the extent to which students' own mindsets shape how they interpret others' mindsets, as well as whether there may be self-enhancement or self-improvement effects in how people view themselves vs. others (e.g., Heckhausen and Krueger, 1993). We also controlled for prior achievement (i.e., SAT scores), which suggests that these effects are not simply a function of students' prior academic performance. We extended prior studies that measured students' motivation, interest, or engagement in more general ways (e.g., Canning et al., 2019; LaCosse et al., 2020; Muenks

et al., 2020) by examining how students' perceptions of their professors' mindsets predicted specific motivational beliefs, values, and goals, using situated expectancy-value theory (Eccles and Wigfield, 2020) and goal orientation theory (Urdan and Kaplan, 2020) as theoretical frameworks. Interestingly, we found that students' perceptions of their engineering professors' mindsets were particularly strongly predictive of their *value* of engineering, as well as their belonging. That is, when students perceived their engineering professors to have unproductive mindsets about intelligence, effort, and failure, they reported that engineering was less useful, important, and interesting to them, and felt less like they belonged in engineering, even controlling for their own mindset beliefs. Perhaps professor messages that communicate to students that only the smartest students can succeed, that effort is a sign of low ability, and that failure is debilitating, lead students to place less emphasis on the value or importance of those classes in order to protect their self-concept (e.g., Harter, 1986). The results for belonging are consistent with prior literature and suggest that professors' communication of unproductive mindsets can undermine students' feelings of comfort and fit in those professors' classes (e.g., Rattan et al., 2018; LaCosse et al., 2020; Muenks et al., 2020). This is especially concerning given that students' value and feelings of belonging in STEM courses are very strong predictors of whether they remain in the STEM pipeline or drop out of it (Wang and Degol, 2013; Cromley et al., 2016).

Thus far, most of the work examining mindset contexts in academic settings has focused on the role of professors' or teachers' mindsets, as professors have the power to shape the classroom structure, policies, and culture (e.g., Schmidt et al., 2015; Canning et al., 2019; LaCosse et al., 2020; Muenks et al., 2020). However, the professor is not the only person who makes up the context of a classroom; peers also play a critical role (e.g., Song et al., 2015; Wentzel, 2017; Yeager et al., 2019; King, 2020). A major contribution of the present study is that we examined whether students' perceptions of their *peers'* mindsets predicted their motivation, belonging, and academic choices above and beyond their perceptions of their professors' mindsets (and their own mindsets). We hypothesized that even if students perceived their professors to have more productive mindsets about intelligence, effort and failure (i.e., having stronger growth mindsets, believing that effort and failure are important and useful), they may still experience decreased motivation or a sense of belonging if they perceive that their peers have unproductive mindsets. Indeed, we found that, on average, students did perceive their peers to have more unproductive mindsets than their professors—that is, to have stronger fixed mindsets about intelligence, to believe more strongly that effort is useless, and to believe more strongly that failure is debilitating. Further, when engineering students perceived their peers to have more unproductive beliefs about intelligence, effort, and failure, they reported lower intrinsic value, mastery goals, and belonging in engineering; they were also less likely to choose a difficult over an easy task, even after controlling for students'

own mindsets and perceptions of professors' mindsets. These findings suggest that peers play a unique role in the mindset context of a classroom, particularly when it comes to how much students enjoy and feel like they "fit in" in their engineering classes, the extent to which they are oriented toward learning or mastery, and their willingness to choose challenging (yet useful) assignments. More research is needed to build a theoretical model of how perceptions of teachers' and peers' unproductive mindsets may be related to specific motivational beliefs, values, and goals.

Another contribution of the present study is a broader operationalization of students', professors', and peers' mindsets that extends beyond intelligence mindsets, which has been a major focus of previous research (e.g., Canning et al., 2019; LaCosse et al., 2020; Muenks et al., 2020). In this study, we not only examined mindsets about intelligence (i.e., whether intelligence is fixed or malleable; Dweck, 1999) but also mindsets about effort (e.g., Blackwell et al., 2007) and failure (e.g., Haimovitz and Dweck, 2016). Previous research by Haimovitz and Dweck, 2016; suggests that failure mindsets of parents and teachers may be more proximal to the learning context and thus more visible to students than intelligence mindsets; we expected that this may be the case for mindsets about effort as well. Though not a central focus of the present study, we did find some differences in which mindsets (or perceived mindsets) were most predictive of different outcomes. For example, when examining how students' perceptions of their professors' mindsets predict their value and belonging, intelligence mindsets seemed to play a key role. In contrast, when examining how students' perceptions of their peers' mindsets predict their intrinsic value, mastery goals, and academic choices, failure mindsets seemed to play a key role; and when examining how students' perceptions of their peers' mindsets predict their belonging, effort mindsets play a key role. These findings suggest that future researchers should consider the role of multiple mindsets, not just intelligence mindsets, on students' outcomes, particularly when examining students' perceptions of others' mindsets.

There were several aspects of motivation that were not predicted by students' perceptions of their professors' and peers' mindsets. Specifically, neither perceptions of professors nor peers predicted students' self-efficacy, performance goals (approach or avoidance), or choice of a difficult instructor. These results were somewhat surprising, as we expected that perceiving unproductive mindset contexts would undermine students' confidence and willingness to pursue difficult tasks. Further, previous research has found that goal structures of classrooms—which are conceptually similar to perceived mindset contexts—are predictive of students' own goal orientations (e.g., Meece et al., 2006). Perhaps there may be more complex associations between one's own mindsets, perceptions of professors' and peers' mindsets, and self-efficacy, such that perceived unproductive mindset contexts only negatively affect students' self-efficacy when students hold a fixed mindset themselves (e.g., Chen and Tutwiler, 2017). With respect to performance goal orientations, perhaps these are less affected by students' perceptions of mindset contexts in a major

that is already highly competitive, such as engineering (e.g., Goubeaud, 2010); however, future research should explore this further.

Several limitations of this study should be noted. First, this study is a cross-sectional, correlational study so we are unable to make any causal or directional claims about our effects. It is possible that students' feelings of motivation and belonging predict their perceptions of the mindset context around them, instead of the other way around. Though theory, prior experimental work (e.g., LaCosse et al., 2020), and prior longitudinal work (e.g., Muenks et al., 2020) have found that perceived mindset contexts (operationalized as students' perceptions of their professors' mindsets) influence or predict students' motivation and belonging, future research should further explore the directionality of these effects, specifically when it comes to students' perceptions of their peers' mindsets. Future researchers could also examine more complex process models, for example examining how students' perceptions of their professors' and peers' mindsets predict their self-efficacy and belonging, which then predict their goal orientations. Second, some of our motivation variables are measured with single items, due in part to the need for short surveys. Though research suggests that single-item measures can be appropriate for unidimensional constructs (e.g., Gogol et al., 2014), future researchers should use more robust measures of these constructs. Third, all of our measures asked about students' perceptions of their mindset context and their motivation and belonging in their Electrical and Computer Engineering classes in general, rather than about specific Electrical and Computer Engineering classes. These perceptions, though not specific to any one class, may nevertheless be important for predicting students' persistence and success within the field (e.g., Rainey et al., 2019). However, because we did not measure these perceptions in specific classrooms, we were unable to model contextual effects at the classroom level (e.g., Marsh et al., 2012). Future research should explore contextual effects using these methods to gain a more complete picture of how different mindset contexts could impact students' motivation and belonging. Finally, it is important to note that this study was conducted in a very particular context of Electrical and Computer Engineering, which is highly competitive (Goubeaud, 2010), male-dominated, and not particularly diverse with respect to gender and race/ethnicity. Our sample was largely male (78.6%), and Asian (51.8%) or White (28.1%), which, although representative of the specific department from which the sample was drawn, should not be generalized to all students. Future research should explore whether students also perceive their peers to have more unproductive mindsets than their professors in contexts that are less competitive, more cooperative, and/or more diverse. Further, although we examined whether gender moderated any of our effects and only found one interaction (see **Supplementary Table S11** in the Appendix), it is important to note that we had limited power to explore these interactions. Future research should examine, in more diverse samples, the extent to which these associations may

look different for marginalized or minoritized students—that is, whether unproductive mindset contexts may be particularly harmful for students who are already negatively stereotyped in a domain such as engineering (e.g., Canning et al., 2020; LaCosse et al., 2020).

In sum, our findings emphasize the important role of the perceived mindset context in students' motivation, belonging, and willingness to choose difficult tasks. Our findings support and extend prior research that found that professors are an important part of the perceived mindset context, demonstrating that perceiving unproductive mindsets in engineering professors predict lower value and belonging in engineering. Importantly, we also find that peers are a critical part of the perceived mindset context, that students perceive their peers to have more unproductive mindsets than their professors, and that students' perceptions of their peers' unproductive mindsets uniquely predict their intrinsic value, mastery goals, belonging, and willingness to choose difficult assignments. Although future researchers should continue to explore this, these findings support a broader literature (e.g., Ames, 1992; Meece et al., 2006; Patrick and Ryan, 2008; Murayama and Elliot, 2009; Murphy and Dweck, 2010; Gasiewski et al., 2012; Schmidt et al., 2015; Canning et al., 2019; Fuesting et al., 2019; Yeager et al., 2019; King, 2020; LaCosse et al., 2020; Muenks et al., 2020) that emphasize the key role of perceived mindset contexts, and suggest that future interventions aimed to increase students' motivation, sense of belonging, and retention in STEM should focus on creating a more productive mindset context for students rather than simply focusing on changing students' own mindsets. Further, interventions at the teacher level should not only focus on changing teachers' own mindsets but also how to create productive mindsets among peers.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Office of Research Support and Compliance at the University of Texas at Austin. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

KM, VY, and NT conceptualized the idea for the manuscript and assisted with data collection. KM conducted analyses and wrote the manuscript with assistance from VY.

FUNDING

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2021.633570/full#supplementary-material.

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