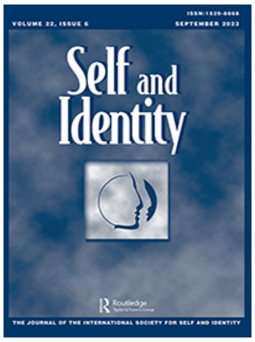

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"That's a great question!" instructors' positive responses to students' questions improve STEM-related outcomes

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ABSTRACT

How instructors respond to students' questions may serve as an important cue that shapes students' self-perceptions and motivation. Across five studies, when participants imagined asking questions in a STEM context and receiving a positive (vs. neutral or negative) response from instructors, they felt greater self-efficacy and belonging, which predicted greater intentions to join the lab and to recruit other students. Positive verbal responses were effective regardless of whether they were directed toward participants or other students, occurred in public or private, in STEM or non-STEM settings, and when they came from warm/friendly versus cold/critical professors. Women especially benefitted from receiving positive instructor responses. Instructors' positive responses to students' questions may thus be a powerful cue that boosts students' academic-related outcomes.

KEYWORDS

STEM; belonging; self-efficacy; motivation; teaching practices

Asking questions is a fundamental feature of science and scientific inquiry. Posing questions helps to fill knowledge gaps, promotes critical thinking and problem-solving, and increases students' self-efficacy and independence in learning (Chin & Osborne, 2008; Lemke, 1990; Marbach-Ad & Sokolove, 2000). Past research has often focused on the types of questions that students and teachers ask in classroom settings, the benefits of asking questions, and ways to improve the quality of questions asked (Carr, 1998; Meyer & Turner, 2002; Pedaste et al., 2015; Watts et al., 1997). While much is known about the process of asking questions, less is known about how instructors' *responses* to questions – as a minimal yet potentially powerful situational cue in academic settings – shape students' self-perceptions and motivation.

How instructors respond to students' questions may be especially important in Science, Technology, Engineering, and Mathematics (STEM) contexts, because negative learning experiences in STEM can contribute to students' decision to leave these fields. Indeed, college students report dropping out of STEM majors due to poor quality of instruction, lack of direct contact with faculty, or perceptions that STEM faculty prioritize research over teaching (Mervis, 2011; Seymour & Hewitt, 1997; Vogt et al., 2007). In the present studies, we examine how instructors' verbal responses to students' questions in hypothetical STEM settings may serve as an important situational cue that affects

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students' self-efficacy, belonging, motivation to pursue research in STEM, and intentions to recruit others to join in their endeavors.

Instructors' responses to students as a situational cue

According to the cues hypothesis (Murphy et al., 2007; Walton & Brady, 2017), individuals attend to cues in the environment that signal who or what is valued in that context. Cues can include features of the physical or social environment, such as objects associated with certain fields of study (Cheryan et al., 2009; Master et al., 2016), the presence of ingroup and outgroup members (Dennehy & Dasgupta, 2017; Murphy et al., 2007), and beliefs conveyed by individuals in positions of power (Canning et al., 2019; Muenks et al., 2020; Rattan et al., 2012).

Instructors provide salient cues in academic environments that can shape students' learning and interest in STEM. Not only do demographic characteristics of instructors (e.g., their gender, race, academic rank) relate to students' course performance, choice of major, and persistence (Carrell et al., 2010; Fairlie et al., 2013; Hoffmann & Oreopoulos, 2009), but a large body of research has documented how instructors' beliefs, expectations, and instructional practices can serve as cues that influence students' motivation. For example, a longitudinal study of college students found that those who took STEM courses taught by professors with a fixed mind-set (i.e., the belief that intelligence is innate and unchanging) versus a growth mind-set (i.e., the belief that intelligence is malleable) reported more negative experiences in their courses (Canning et al., 2019).

Using experimental methods, Muenks et al. (2020) found that students who watched a videoclip of a male professor conveying a fixed mind-set (vs. a growth mind-set) reported less belonging and engagement in their STEM course. In another study, when students imagined performing poorly on a calculus test and receiving comfort-oriented feedback from their instructor (i.e., being told "It's ok – not everyone can be good at math"), they perceived the instructor to hold an entity theory of math ability and subsequently felt less supported and motivated, compared to students who imagined receiving strategy-focused feedback or control feedback (Rattan et al., 2012). Together, these findings suggest that perceptions of instructors' beliefs about intelligence can serve as a situational cue that affects students' self-perceptions and motivation.

In addition to beliefs, the way that instructors *respond* to students' questions in academic contexts is an important situational cue that conveys meaningful information about students' performance or understanding (Hattie & Timperley, 2007). In the present research, we examine how positive verbal statements from instructors – in response to students' questions in STEM settings – can serve as a situational cue that affects students' self-perceptions and motivation. We hypothesize that students who imagine asking a question in a STEM lab seminar and receive a positive (vs. negative or neutral) response from their instructor will show greater interest and motivation in STEM, as indicated by their increased intention to join the STEM lab and to recruit other students to join. A positive statement in response to a student's question may buffer students against threat, whereas a negative or neutral response to a question may serve as a cue that triggers social identity threat.

According to the cues hypothesis, social identity threat could pertain to a decreased sense of belonging and desire to participate in the environment (Murphy et al., 2007; see

Park et al., in press, for a review). We therefore chose to examine intentions to participate in STEM environments via intentions to become involved in a STEM lab. Furthermore, we chose to focus on a STEM lab context, because research labs have been described as *microcultures* that expose students to the norms, practices, and values of science and scientists (Thoman et al., 2017). Thus, instructors' positive verbal responses to students' questions in lab settings may play a key role in boosting students' self-efficacy, belonging, motivation to pursue STEM, and desire to recruit others to pursue STEM.

Effects of positive verbal statements

Research on the effects of positive verbal statements (i.e., verbal rewards) on motivation are mixed. On one hand, studies suggest that verbal rewards increase intrinsic motivation (Cameron & Pierce, 1994; Eisenberger & Cameron, 1996; Henderlong & Lepper, 2002). For example, a meta-analysis by Deci et al. (1999) found that receiving positive feedback from others increased self-reported interest and free-choice behavior among college students. Experimental studies also support this idea. Verbal reinforcement from an experimenter improved adults' performance on a mirror tracing task compared to a control group (Catano, 1975, 1976), and participants who received positive (vs. negative) verbal comments from an experimenter during a motor task reported higher perceived competence, which predicted greater interest and motivation to pursue the task (Vallerand & Reid, 1988). Verbal rewards also boost outcomes compared to the absence of rewards; in one study, participants who received positive verbal reinforcement on a puzzle task (i.e., being told, "That's very good") spent more time on the task when given the option to, compared to those who received no feedback (Deci, 1971).

Research on teacher confirmation behaviors further suggests that instructors who display confirming behaviors – i.e., show responsiveness to students' questions and comments, express interest in students' learning, and use a teaching style that conveys to students that they are valuable members of the classroom (Ellis, 2000, 2004) – have students who perceive greater emotional support, report a more positive classroom experience (Goldman & Goodboy, 2014), and show increased effort and interest in the course (Campbell et al., 2009). In one study, college-level communications instructors followed a teaching script that used not confirming, somewhat confirming, or highly confirming behaviors (i.e., encouraged student questions, demonstrated interest, used an interactive teaching style). Compared to the not confirming condition, students in the confirming and somewhat confirming conditions showed increased learning and motivation (Goodboy & Myers, 2008).

Other studies, however, find that verbal rewards can sometimes diminish motivation by increasing awareness of the controlling behavior of others or exacerbating pressure to perform (Deci & Ryan, 1985). For instance, verbal rewards can heighten self-focused attention, contingent self-worth, and fixed beliefs about intelligence, leading to feelings of helplessness when individuals encounter setbacks or difficulties (Baumeister et al., 1990; Deci & Ryan, 1985; Kamins & Dweck, 1999; Mueller & Dweck, 1998). Using the cues hypothesis framework (Murphy et al., 2007), we seek to investigate how even *imagined* verbal responses from instructors can serve as powerful situational cues. In particular, perceiving instructors' verbal responses as positive is likely to act as a situational cue that boosts students' perceptions of self-efficacy and belonging.

Mediators: self-efficacy and belonging

Two potential routes through which students' interest and motivation in STEM may increase is through self-efficacy and belonging. Self-efficacy is the belief that one has the ability to achieve desired end-states (Bandura, 1977, 1986); belonging is the feeling that one is accepted and fits in within a given environment, such as in STEM contexts (Cheryan et al., 2009; Good et al., 2012; Murphy et al., 2007). One mechanism by which verbal rewards increase motivation is by boosting one's perceived ability to achieve desired goals (Bandura & Cervone, 1983; Harackiewicz, 1979). For example, adults who worked on a puzzle in the lab and were told, "Your strategies are among the best I've seen so far" (Pretty & Seligman, 1984, p. 1244) showed higher intrinsic motivation compared to a control group who received no praise. The experimenter's comment is likely to have conveyed positive information about participants' competence at solving puzzles, thereby increasing their motivation. Indeed, students' perceptions of the feedback they receive from instructors play a key role in shaping their self-efficacy (Fong et al., 2018). Together, these and other studies suggest that when individuals receive verbal rewards, they feel competent and efficacious, thus boosting their motivation (see Henderlong & Lepper, 2002, for a review).

In addition to self-efficacy, students' sense of belonging is likely to contribute to their motivation and interest. For example, for both men and women, feelings of belonging in math have been shown to predict greater intentions to take future math classes (Good et al., 2012). In another study, women who watched a video of a math/science/engineering conference with a balanced ratio of men to women reported greater anticipated belonging at the conference and greater interest in participating in the conference compared to women who watched a gender-imbalanced video (Murphy et al., 2007). Likewise, a reduced sense of belonging is one component of identity threat according to the cues hypothesis (Murphy et al., 2007).

Given the importance of self-efficacy and belonging in shaping motivation and interest, we predict that when students imagine asking a question in a STEM lab seminar and receive a positive (vs. neutral or negative) response from their instructor, they will feel greater self-efficacy and belonging in that environment, and show greater intentions to join the lab and to recruit others to join. In contrast, students who receive a negative response from instructors when asking a question in a STEM context are expected to show lower self-efficacy and belonging and less desire to join the lab or to recruit others to join. Indeed, past research found that when STEM instructors conveyed that students might not have the intelligence or ability to succeed in a domain, students reported negative psychological experiences and became demotivated in their courses (Canning et al., 2019; Good et al., 2012). Thus, whereas negative responses from instructors ought to lower students' interest and engagement, positive verbal responses from instructors may be a promising situational cue to improve students' academic self-perceptions and motivation.

Moderating effects of gender

One way to promote psychological safety in STEM is to provide cues to members of underrepresented or negatively stereotyped groups that they belong and have the ability to succeed in a given environment. In STEM contexts, women often feel uncertain about their belonging (Cheryan et al., 2009; Good et al., 2012; Murphy et al., 2007), show worse performance when negative gender stereotypes about women's quantitative abilities are activated (Spencer et al., 1999), and experience social identity threat during negative or sexist interactions with men (Hall et al., 2019; Logel et al., 2009). Thus, asking questions in STEM contexts may be a highly visible, vulnerable situation that women are especially attuned to.

Consistent with this idea, female college students who received positive written feedback (i.e., their score plus the handwritten comment "Good job!") versus objective feedback (i.e., their score only) on an evaluative math test reported higher self-efficacy and belonging in math, especially when this information came from a perceived gatekeeper in math (i.e., a male authority figure; Park et al., 2018). Similarly, meta-analyses revealed that students who received written comments from instructors (vs. those who just received grades) showed greater perceived competence, interest and motivation, and better academic performance (Koenka et al., 2021). Whereas past work examined the effects of written feedback, we investigate whether instructors' positive verbal responses to students' questions in STEM settings can act as a minimal cue to improve STEM outcomes, especially for women.

Preliminary studies

An assumption underlying the current research is that students in STEM settings will benefit from receiving positive responses from instructors when asking questions. But why might this be? One reason is that academic STEM settings have often been described as having a "chilly climate" characterized by a competitive, intimidating culture and impersonal teaching style (Seymour & Hewitt, 1997; Vogt et al., 2007). If so, then it might be the case that students are less likely to receive (and instructors less likely to give) positive verbal responses when asking questions in academic STEM settings versus other settings.

To test these ideas, we conducted two preliminary studies. In **Study A**, we recruited students who had taken math and English courses at their university. Participants were mostly first- (38%) and second-year (46%) students, non-STEM majors (55%) and had taken their courses either in-person (math: 46%; English: 47%), online (math: 47%, English: 43%), or a combination of both modes (math: 7%; English: 10%) (see Table 1 for full demographics of sample).

For **Study A**, participants reported how frequently they and other students asked questions in their math course (2 items, $r(132)=.48$, $p < .001$) and English course (2 items, $r(130)=.50$, $p < .001$)[1] from 1=*never* to 5=*very often*. They reported how often their instructors responded to students' questions in each course with positive statements[2] (e.g., "That's a great question," "I'm glad you brought that up" or something similar), negative statements (e.g., "I'm not sure why you're asking this question," "We went over this already"), and neutral statements (e.g., "We're actually out of time today," "Please hold your question till next time") from 1=*never* to 5=*very often*.

In **Study B**, we emailed the Chairpersons of Math and English departments at universities across the U.S. and asked them to forward the survey link to instructors who taught under-graduate courses in their department. Instructors from over 20 colleges and

Table 1. Descriptive statistics for participant demographics across studies.

	Final Sample	Age (Mean and SD)	Ethnicity	Currently Enrolled in a STEM course	STEM Major
Preliminary Study A	*N*=134 (68 men, 64 women,2 prefer not to answer)	Mage=19.07 (1.13)	53% White, 22% Asian, 11% Black, 5% Latinx, 9% other	All students took a college STEM (e.g., math) and non-STEM (e.g., English) course	55% non-STEM majors
Preliminary Study B	*N*=81 (33 men, 44 women, 3 unknown)	Mage=43.34 (14.13)	82% White, 6% Asian, 4% Black, 1% Latinx, 7% other	N/A	N/A
Study 1	*N*=471 (220 men, 251 women)	Mage=19.11 (1.63)	50% White, 27% Asian, 10% Black, 6% Latinx, 7% other	72% enrolled	63% non-STEM majors
Study 2	*N*=326 (169 men, 154 women, 3 non-binary)	Mage=19.32 (1.58)	46% White, 32% Asian, 11% Black, 6% Latinx, 5% other	55% enrolled	72% non-STEM majors
Study 3	*N*=243 (122 men, 121 women)	Mage=19.18, (1.65)	50% White, 28% Asian, 10% Black, 6% Latinx, 6% other	58% enrolled	71% non-STEM majors
Study 4	*N*=415 (194 men, 221 women)	Mage=19.77 (2.96)	54% White, 29% Asian, 9% Black, 4% Latinx, 4% other	53% enrolled	67% non-STEM majors
Study 5	*N*=539 (276 men, 258 women,) 5 non-binary	Mage=19.07 (2.11)	57% White, 22% Asian, 10% Black, 8% Latinx, 3% other	50% enrolled	78% non-STEM majors

universities responded to the online survey; 59% were math instructors, 41% were English instructors (see Table 1 for full demographics).

Instructors consisted of tenured or tenure-track faculty (29%), teaching/clinical faculty (26%), lecturer/adjunct instructors (25%), and other categories (e.g., post-doc, etc., 20%). They taught undergraduate courses an average of 5.32 years ($SD = 1.83$) with a median class size of 30 students. Instructors were asked to think of the last time they taught an introductory course in their department; these classes were taught in-person (math: 34%; English: 39%), online (math: 57%, 40%), or a combination of both modes (math: 9%, English: 21%). Instructors reported how often they responded to students' questions in their course with the same positive, negative, and neutral statements and scales as in Study A.

Study A results

Results of paired sample *t*-tests and descriptive statistics are shown in Table 2. A sensitivity analysis indicated that our analyzed sample size provided adequate power (>.80) to detect an effect size of approximately d_z=.245. Students asked fewer questions in their math versus English courses and perceived instructors to give less frequent positive responses to students' questions in their math versus English courses. In fact, students reported that instructors gave more frequent negative verbal comments in response to students' questions in math versus English courses. There was no evidence of a significant difference in frequency of receiving neutral instructor responses in math versus English courses.

A mixed ANOVA – with participants' reports of math and English course experiences as the within-subjects variable and participants' gender as the between-subjects variable – revealed no evidence of significant moderating effects of gender in predicting frequency of questions asked in STEM versus non-STEM courses, $F(2, 129)=.03$, $p = .975$, $\eta_p^2 = .00$, or in the frequency of instructor responses in STEM versus non-STEM courses that were positive, $F(2, 129)=.82$, $p = .441$, $\eta_p^2=.01$, neutral, $F(2, 129)=.89$, $p = .415$, $\eta_p^2= .01$, or negative, $F(2, 129) = 1.27$, $p = .284$, $\eta_p^2= .02$.

Table 2. Results of paired t-tests and descriptive statistics (study A: students' reports).

Outcome Variable	Math Course	English Course			
	M (SD)	M (SD)	t (131)	p	Cohen's d
How often did you/students in your introductory math/English course ask questions?	2.51 (.87)	2.94 (.92)	−4.05	<.001	.48
In your introductory math/English course, when students asked a question to the instructor, how often did the instructor respond with these kinds of statements:					
"That's a great question," "I'm glad you brought that up" or something similar?	3.02 (1.23)	3.71 (1.07)	−4.96	<.001	.60
"I'm not sure why you're asking this question" "We went over that already" or something similar?	2.23 (1.25)	1.93 (1.10)	2.45	016	25
"We're actually out of time today," "Please hold your question till next time" or something similar?	1.95 (1.07)	2.02 (1.15)	−.76	447	06

Study B results

Results of independent sample *t*-tests and descriptive statistics are shown in Table 3. A sensitivity analysis indicated that our analyzed sample size provided adequate power (>.80) to detect an effect size of approximately d_z=.638. Mirroring the findings of Study A, instructors reported lower frequency of giving positive verbal responses to students' questions in math versus English courses. There was no evidence of a significant difference in negative or neutral instructor responses based on course type.

An ANOVA further showed that instructors gave less frequent positive verbal responses to students' questions in math courses, even after controlling for instructors' gender, age, number of students in the course, and mode of teaching, $F(1, 68) = 5.57$, $p = .021$, η_p^2=.076. There was no evidence of a significant difference in negative, $F(1, 68)$=.01, $p = .930$, η_p^2=.000, or neutral, $F(1, 68)$=.39, $p = .534$, η_p^2=.006, instructor responses based on course type.

Current research

Our preliminary studies indicate that in the real-world, students are less likely to ask questions in their math versus English courses. When students do ask questions, they are less likely to receive (and instructors less likely to give) positive verbal responses. In fact, students reported that instructors gave more negative verbal responses, such as, "I'm not sure why you're asking this question, we went over this already" in their math versus English courses.

Building upon these initial findings, we conducted five experiments to systematically investigate how instructors' responses to students' questions, in the context of a weekly seminar for students considering STEM research opportunities, shaped students' self-perceptions and motivation. We first tested whether different types of instructor responses predicted intentions to join the lab and to recruit other students to join the lab via increases in self-efficacy and/or belonging in the lab (Study 1). Next, Studies 2–5 tested potential boundary conditions to see if it mattered whether the instructor's positive verbal response was directed toward the participant versus another student (Study 2), occurred in a public or private setting (Study 3), in a STEM or non-STEM context (Study 4), and came from a

Table 3. Results of independent sample t-tests and descriptive statistics (study B: instructors' reports).

Outcome Variable	Math Course	English Cours			
	M (SD)	M (SD)	t(78)	p	Cohen's d
In your course, when students asked a question, how often did you respond with these kinds of statements:					
"That's a great question," "I'm glad you brought that up" or something similar?	3.64 (.97)	4.18 (.68)	2.78	007	64
"I'm not sure why you're asking this question" "We went over that already," or something similar?	1.53 (.78)	1.45 (.62)	1.53 (.78) 1.45 (.62) .48 .635 .11	48	11
"We're actually out of time today," "Please hold your question till next time" or something similar?	1.79 (.88)	1.55 (.62)	1.36	.179	.32

warm/friendly versus cold/critical professor (Study 5). Across studies, we also examined whether women benefitted more from receiving a positive verbal response from their instructor than men, based on past work suggesting that women in particular are affected by situational cues in STEM environments (e.g., Cheryan et al., 2017; Murphy et al., 2007).

Study 1

Study 1 examined effects of receiving different types of verbal responses from a professor on students' self-perceptions and motivation in a STEM context. We predicted that students who imagined receiving a positive (vs. neutral or negative) verbal response from their instructor when asking a question in a STEM lab seminar would report greater self-efficacy and belonging and show greater interest in getting involved in a STEM research lab and recruiting others to do the same. Additionally, we examined whether the effects of positive instructor responses extended to self-perceptions in STEM in general and whether women differed from men in the outcomes. In all the present studies, the professor in the scenario was male given that college STEM professors tend to be male (Li & Koedel, 2017) and students are likely to think that college STEM professors are male (Park et al., 2018).

Methods

Participants

In the current study and in all subsequent studies, participants were recruited from the Introductory Psychology Subject Pool at a large public university in the U.S. and completed the study online in exchange for partial course credit. In the present studies, students imagined attending a STEM lab seminar that provided an introductory orientation to STEM research. We therefore opened up recruitment to students from the general subject pool, rather than recruiting students who were already committed to being STEM majors. Table 1 (shown earlier) summarizes demographics and Table 4 reports sensitivity analyses across Studies 1–5. A series of Monte Carlo power simulations revealed that the present studies had between 0.90 and 0.99 power to detect an indirect effect of lab belonging, and between 0.76 and 0.99 power to detect an indirect effect of lab self-efficacy (Schoemann et al., 2017).

For all studies in this paper, we report all manipulations, measures, and participant exclusions. No manipulations other than the ones reported in this paper were used in the present studies. Additional measures that were assessed but not directly relevant to this paper appear in the Methodology File. All data, scripts, study materials and manipulations are available in the Open Science Framework at: https://osf.io/bzke6/?view_only=d4db6741c43b42ea8fa0fab03734235b. No analyses were conducted until each study was completed.

Table 4. Sensitivity analyses.

Study 1	Our analyzed sample size provided adequate power (>.80) to detect a small to medium effect size of approximately $F = .14$ for manipulated instructor response condition, and $F = .16$ for the interaction between instructor response and participant gender
Study 2	Our analyzed sample size provided adequate power (>.80) to detect a small to medium effect size of approximately $F = .20$ for manipulated instructor response condition and target of instructor response, and $F = .23$ for the interaction between instructor response, target of instructor response, and participant gender
Study 3	Our analyzed sample size provided adequate power (>.80) to detect a small to medium effect of approximately $F = .23$ for manipulated instructor response condition and public versus private setting, and $F = .26$ for the interaction between instructor response, setting of instructor response, and participant gender.
Study 4	Our analyzed sample size provided adequate power (>.80) to detect a small to medium effect of approximately F= 18 for manipulated instructor response condition and STEM versus non-STEM academic domain, and $F = .20$ for the interaction between instructor response, academic domain, and participant gender.
Study 5	Our analyzed sample size provided adequate power (>.80) to detect a small effect of approximately $F = .15$ for manipulated instructor response condition and instructor warmth condition, and $F = .18$ for the interaction between instructor response, instructor warmth condition, and participant gender

Materials and procedure

Instructor response condition

Participants read a scenario where they imagined being enrolled in a weekly lab seminar for students considering STEM research opportunities and asked a question to their male professor:

> *Imagine you are in a lab seminar for undergraduate students who are considering joining a research lab at UB in Science, Technology, Engineering, and Math (STEM). During one of the weekly seminar meetings, you ask a question to the professor about the material being presented and he says to you . . .*

Participants were randomly assigned to one of three conditions. In the **positive response condition**, participants imagined the professor responding to their question with, *"That's a great question, I'm glad you brought that up."* In the **neutral response condition**, the professor said, *"We're actually out of time today, so please hold your question till next time."* In the **negative response condition**, the professor said, *"I'm not sure why you're asking this question, we went over this already."* Participants then completed the following measures, embedded among other questionnaires not relevant to the present research. For each measure listed below, scale items were averaged after reverse-scoring relevant items.

Lab self-efficacy

Thinking of the scenario they read, participants reported their perceived self-efficacy in the lab seminar (e.g., "I expect to do well in this lab;" "I'm confident I can understand the basic concepts taught in this lab") from 1=*strongly disagree* to 7=*strongly agree* (4 items, α = .94, adapted from McKeachie et al., 1986).

STEM self-efficacy

Participants reported their general self-efficacy in STEM (e.g., "How confident are you about your STEM abilities right now?") from 1=*not at all confident* to 7=*extremely confident* (3 items, α = .87, adapted from Stout et al., 2011).

Lab belonging

Participants reported their perceived belonging in the lab by responding to items such as, "How much would you feel like you fit in in this lab?" from 1=*not at all* to 7=*very much* (3 items, α = .94, adapted from Kirby et al., 2020; Muenks et al., 2020).

STEM belonging

Participants reported their general belonging in STEM (e.g., "In STEM, I feel like I belong to a group") from 1=*not at all* to 7=*very much* (4 items, α = .90, adapted from Kirby et al., 2020; Muenks et al., 2020).

Intentions to join the lab

Participants reported their intentions to join the lab (e.g., "How likely are you to join this lab?") from 1=*extremely unlikely* to 7=*extremely likely* (3 items, α = .93).

Intentions to recruit others to the lab

Participants reported their intentions to recruit other students to join the lab (e.g., "How likely are you to talk to other students about joining this lab?") from 1=*not at all likely* to 7=*very likely* (4 items, α = .67).

Demographics

Participants reported their gender, age, ethnicity, whether or not they were currently enrolled in a STEM course and were a STEM major.

Results

Table 5 reports zero-order correlations.

We first conducted ANOVAs examining the effect of Instructor Response Condition (see Table 6 for ANOVA results, descriptive statistics, and pairwise comparisons). Supporting hypotheses, participants who imagined receiving positive (vs. neutral or negative) responses from their instructor after asking a question reported greater self-efficacy and belonging in the lab and in STEM more generally. There was no evidence for significant differences in general self-efficacy and belonging in STEM, however, between participants who received a neutral versus negative instructor response. In sum, participants who imagined receiving a positive (vs. negative or neutral) response from their STEM professor reported greater intentions to join the lab and to recruit other students to join, and this was partially accounted for by increased self-efficacy and belonging in the lab, but not by STEM self-efficacy or STEM belonging in general (see Table 7).

Mediation analyses

Next, we conducted mediation analyses, using Hayes (2018) PROCESS macro version 3.5.3 (model 4) with 5,000 resamples for 95% bootstrapped percentile confidence intervals, to test whether self-efficacy and belonging in the STEM lab and/or in STEM in general predicted behavioral intentions.[3] Figure 1 depicts the basic mediation model tested across studies.

Table 5. Zero-order correlations among variables (study 1).

	1	2	3	4	5	6	7
1. Lab self-efficacy	–						
2. STEM self-efficacy	.50***	–					
3. Lab belonging	.65***	.64***	–				
4. STEM belonging	.37***	.59***	.62***	–			
5. Intentions to join lab	.62**	.48***	.75***	.49***	–		
6. Intentions to recruit other students to join lab	.50***	.45***	.60***	.48***	.71***	–	
7. Gender	.00	.10*	.09	.18**	.02	−.03	–

Note. For correlations, degrees of freedom (*df*)=469. Gender: 1=female, 2=male. *$p<.05$, **$p<.01$, ***$p<.001$.

We entered Instructor Response Condition as the independent variable (positive vs. neutral and negative response conditions, respectively), self-efficacy and belonging in the lab and in STEM in general as simultaneous mediators, and intentions to join the lab and to recruit others, respectively, as dependent variables. Participants who imagined receiving a positive (vs. negative or neutral) response from their STEM professor reported greater intentions to join the lab and to recruit other students to join, and this was partially accounted for by increased self-efficacy and belonging in the lab, but not by STEM self-efficacy or STEM belonging in general (see Table 7).

Moderation by gender

Finally, we conducted ANOVAs to test for moderating effects of gender. There were significant main effects of gender for general STEM self-efficacy, belonging, and belonging in the STEM lab. Consistent with past work (Cheryan et al., 2017; Good et al., 2012), women reported lower self-efficacy in STEM and lower belonging both in STEM and in the STEM lab compared to men. All other effects of gender, including the Gender × Instructor Response Condition interaction, were non-significant (see Table 1 in Supplemental Materials for full results of all effects).[4]

Discussion

Study 1 found that participants who imagined receiving a positive verbal response from their instructor after asking a question in a STEM lab seminar felt greater self-efficacy and belonging in the lab, which was related to greater interest in joining the lab and recruiting others to join. Although positive instructor responses also boosted self-efficacy and belonging in STEM in general, these broader self-perceptions were unrelated to participants' specific intentions to join the lab or to recruit other students to join.

Although women reported lower STEM self-efficacy and belonging than men, there was no evidence of significant gender differences in the outcomes based on instructor responses. In past work, women showed better STEM outcomes when they received positive (vs. objective) written feedback from a male authority figure (Park et al., 2018). Whereas this prior work varied the source of feedback (i.e., male vs. female authority figure), we did not manipulate the source in the present study because our primary interest was in examining effects of different *types* of instructor responses on student outcomes. Finally, even though most of the students in this study were non-STEM majors,

Table 6. Results of ANOVAs, descriptive statistics, and pairwise comparisons (study 1).

Instructor Response Condition	Lab Self-Efficacy	STEM Self-Efficacy	Lab Belonging	STEM Belonging	Intentions to Join Lab	Intentions to Recruit
Results of ANOVAs	$F(2, 468)=45.84$ $p < .001$, $\eta_p^2=.16$	$F(2, 468)=3.59$ $p=.028$, $\eta_p^2=.02$	$F(2, 468)=22.78$ $p<.001$, $\eta_p^2=.09$	$F(2, 468)=3.96$ $p=.020$, $\eta_p^2=.02$	$F(2, 468)=29.35$ $p < .001$, $\eta_p^2=.11$	$F(2, 468)=20.13$ $p < .001$, $\eta_p^2=.08$
Means (*SDs*)						
Positive Response ($N=157$)	5.31 (.93)	4.70 (1.24)	4.68 (1.29)	4.73 (1.50)	4.55 (1.39)	4.64 (1.04)
Neutral Response ($N=151$)	4.53 (1.32)	4.44 (1.42)	4.19 (1.41)	4.43 (1.41)	3.85 (1.39)	4.32 (1.07)
Negative Response ($N=163$)	3.98 (1.42)	4.29 (1.44)	3.68 (1.30)	4.28 (1.39)	3.34 (1.46)	3.89 (1.06)
Results of Pairwise Comparisons						
Positive vs. Neutral	$M_{diff}=0.78$, $SE=.14$ [.50, 1.06], $p < .001$ $d=.68$	$M_{diff}=0.26$, $SE=.15$ [−.05, .57], $p=.098$ $d=.13$	$M_{diff}=0.50$, $SE=.15$ [.20, .79], $p=.001$ $d=.36$	$M_{diff}=0.30$, $SE=.16$ [−.03, .62], $p=.072$ $d=.21$	$M_{diff}=0.70$, $SE=.16$ [.38, 1.01], $p < .001$ $d=.50$	$M_{diff}=0.32$, $SE=.12$ [.08, .55], $p=.009$ $d=.30$
Positive vs. Negative	$M_{diff}=1.33$, $SE=.14$ [1.05, 1.60], $p < .001$ $d=1.11$	$M_{diff}=0.41$, $SE=.15$ [.11, .71], $p=.008$ $d=.30$	$M_{diff}=1.00$, $SE=.15$ [.71, 1.30], $p < .001$ $d=.77$	$M_{diff}=0.45$, $SE=.16$ [.13, .76], $p=.006$ $d=.31$	$M_{diff}=1.21$, $SE=.16$ [.90, 1.52], $p < .001$ $d=.85$	$M_{diff}=0.75$, $SE=.12$ [.52, .98], $p < .001$ $d=.07$
Negative vs. Neutral	$M_{diff}=-0.55$, $SE=.14$ [−.83, −.27], $p < .001$ $d=.40$	$M_{diff}=-0.15$, $SE=.16$ [−.45, .16], $p=.343$ $d=.10$	$M_{diff}=-0.51$, $SE=.15$ [−.80, −.21], $p < .001$ $d=.38$	$M_{diff}=-0.15$, $SE=.16$ [−.47, .17], $p=.356$ $d=.11$	$M_{diff}=-0.51$, $SE=.16$ [−.83, −.20], $p=.001$ $d=.36$	$M_{diff}=-0.43$, $SE=.12$ [−.67, −.20], $p < .001$ $d=.40$

Note. Intentions to recruit=intentions to recruit other students to join the lab. For pairwise comparisons, 95% confidence intervals for mean differences appear in [brackets] next to *p*-values.

Table 7. Results of mediation analyses (study 1).

Mediators				
IV: Instructor Response	Lab Self-Efficacy (a_1 path)	STEM Self-Efficacy (a_3 path)	Lab Belonging (a_2 path)	STEM Belonging (a_4 path
Positive Response vs. Negative Response	1.33 [1.05, 1.60] $p < .001$	.41 [.11, .71] p=.008	1.00 [.71, 1.29] $p < .001$	.45 [.13, .76] p=.006
Positive Response vs. Neutral Response	.78 [.50, 1.06] $p < .001$	.26 [−.05, .57] p=.098	.50 [.20, .79] p=.001	.30 [−.03, .62] p=.072
Mediators	DV: Intentions to Join Lab		DV: Intentions to Recruit Others to Join Lab	
Lab Self-Efficacy (b_1 path)	.23 [.14, .32], $p < .001$		.13 [.05, .21], p=.001	
STEM Self-Efficacy (b_3 path)	−.05 [−.14, .04], p=.249		.03 [−.05, .11], p=.475	
Lab Belonging (b_2 path)	.63 [.53, .73], $p < .001$		.27 [.18, .36], $p < .001$	
STEM Belonging (b_4 path)	.07 [−.02 .15], p=.094		.15 [.08, .22], $p < .001$	
	DV: Intentions to Join Lab		DV: Intentions to Recruit Others to Join Lab	
	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response
Direct Effect (c′ path)	.26 [.03, .50], p=.025	.20 [−.02, .42], p=.076	.23 [.03, .44], p=.028	.03 [−.17, .23], p=.749
Indirect Effects				
Lab Self-Efficacy	**.30 [.15, .47]**	**.18 [.08, .30]**	**.18 [.06, .30]**	**.10 [.03, .19]**
STEM Self-Efficacy	−.02 [−.07, .02]	−.01 [−.05, .01]	.01 [−.02, .05]	.01 [−.01, .04]
Lab Belonging	**.63 [.42, .86]**	**.31 [.12, .53]**	**.27 [.15, .40]**	**.13 [.05, .24]**
STEM Belonging	.03 [−.02, .09]	.02 [−.01, .07]	**.06 [.01, .13]**	.04 [−.00, .10]

Note. IV=*X* or independent variable, DV=*Y* or dependent variable. Betas reflect unstandardized coefficients. Values within brackets reflect lower and upper level 95% confidence intervals. For indirect effects, values within brackets that exclude zero are significant as indicated in bold. STEM self-efficacy and STEM belonging were not assessed in Studies 2–4 so the a_3, a_4, b_3 and b_4 paths are not shown in Figure 1 but appear in this table since they were assessed in Study 1.

they still expressed interest in joining a STEM lab and recruiting others to join when they imagined receiving positive responses from instructors in a STEM context.

Study 2

Study 2 sought to replicate the findings of Study 1 and examine whether the target of instructors' responses mattered. Past research found that exposure to negative cues, even if participants were not the direct recipients of such cues, had detrimental effects. For example, women who overheard that a male instructor was sexist performed worse on a logic test and reported a less favorable experience than those who were not exposed to a suggestion of sexism (Adams et al., 2006). If cues of psychological threat can be readily activated and affect mere witnesses of such cues, then signaling psychological safety through positive instructor responses may be beneficial even when such cues are not directed toward oneself. We therefore manipulated whether participants imagined themselves or a classmate asking a question in a STEM lab seminar and whether the professor's response was positive, negative, or neutral. In the present studies and in all subsequent studies, we did not assess general STEM self-efficacy or belonging because we did not find significant effects of instructor response condition on these variables in Study 1.

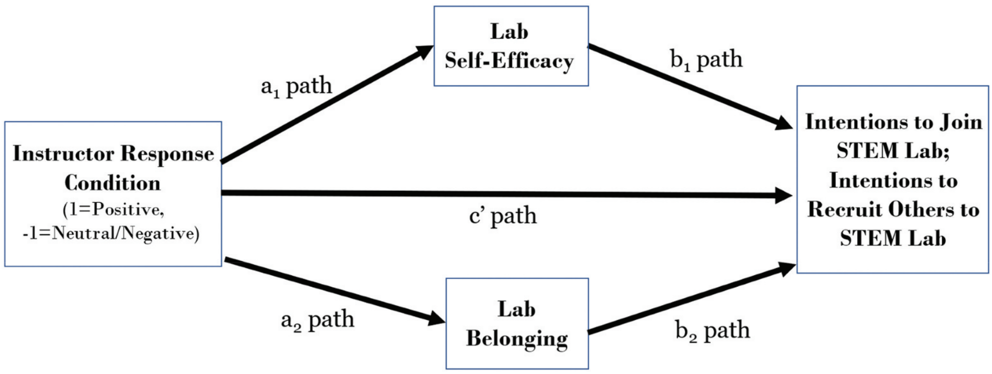

Figure 1. Proposed mediation model across studies.
Note: The c′ path=direct effect. In Study 1, STEM sefficacy amd STEM belonging were also included as simultaneous mediators in the model. These variables were not included in subsequent studies, however, because they to be significant mediators in Study 1.

Participants

See Table 1 for demographics and Table 4 for sensitivity analyses.

Materials and procedure

Instructor response condition

Same as in Study 1.

Target condition

In addition to receiving positive, negative, or neutral instructor responses, participants imagined that they (or another student) asked a question to the professor:

> *"Imagine you are in a lab seminar for students who are considering joining a research lab at UB in Science, Technology, Engineering, and Math (STEM). During one of the seminar meetings, [**you/a student] ask/s a question to the professor about the material being presented and he says to [you/them] . . . "***

Participants then completed the same questionnaires as in Study 1 including STEM lab self-efficacy (α=.95), belonging (α=.96), intentions to join the lab (α=.95), intentions to recruit other students to the lab (α=.70), and demographics. We did not assess general STEM self-efficacy or belonging in Studies 2–4.

Results

Table 8 reports zero-order correlations.

We first conducted ANOVAs examining Instructor Response Condition, Target Condition, and their interaction in predicting the dependent variables (see Table 9). Results replicated Study 1, but there was no evidence of significant main effects of target condition or interaction between instructor response and target condition for any outcomes. Participants who imagined receiving – or witnessed another student in the

Table 8. Zero-order correlations among variables (study 2).

	1	2	3	4	5
1. Lab self-efficacy	–				
2. Lab belonging	.80***	–			
3. Intentions to join lab	.75***	.82***	–		
4. Intentions to recruit other students to join lab	.68***	.70***	.72***	–	
5. Gender	.09	.07	.04	−.02	–

Note. For correlations with gender, *df*=321; for all other correlations, *df*=324. Gender: 1=female, 2=male.
*p<.05, **p<.01, ***p<.001.

seminar receiving – a positive (vs. neutral or negative) instructor response after asking a question – reported greater self-efficacy and belonging in the lab, greater desire to join the lab, and to recruit other students to join the lab. As in Study 1, neutral instructor responses did not differ significantly from negative instructor responses in predicting the outcomes.

Mediation analyses

We next conducted mediation analyses to test the model shown in Figure 1, to see whether positive (vs. neutral or negative) instructor responses predicted intentions to join the lab and to recruit other students to join the lab via increased lab self-efficacy and

Table 9. Results of ANOVAs, descriptive statistics, and pairwise comparisons (study 2).

Instructor Response Condition	Lab Self-Efficacy	Lab Belonging	Intentions to Join Lab	Intentions to Recruit Others to Join Lab
Results of ANOVAs	$F(2, 320)=38.67$ $p < .001$, $\eta_p^2=.20$	$F(2, 320)=47.91$ $p < .001$, $\eta_p^2=.23$	$F(2, 320)=48.18$ $p < .001$, $\eta_p^2=.23$	$F(2, 320)=36.11$ $p < .001$, $\eta_p^2=.18$
Target Condition	$F(1, 320)=.56$ $p=.456$, $\eta_p^2=.00$	$F(1, 320)=.80$ $p=.373$, $\eta_p^2=.00$	$F(1, 320)=3.05$ $p=.082$, $\eta_p^2=.01$	$F(1, 320)=.44$ $p=.506$, $\eta_p^2=.00$
Instructor Response × Target Condition	$F(2, 320)=.63$ $p=.533$, $\eta_p^2=.00$	$F(2, 320)=1.53$ $p=.217$, $\eta_p^2=.01$	$F(2, 320)=.37$ $p=.688$, $\eta_p^2=.00$	$F(2, 320)=.70$ $p=.496$, $\eta_p^2=.00$
Means (*SDs*)				
Positive Response (*N*=107)	5.39 (.93)	5.17 (1.07)	4.91 (1.28)	4.87 (.96)
Neutral Response (*N*=109)	4.10 (1.25)	3.68 (1.38)	3.31 (1.53)	3.86 (1.01)
Negative Response (*N*=110)	4.03 (1.56)	3.54 (1.55)	3.09 (1.62)	3.74 (1.21)
Results of Pairwise Comparisons				
Positive vs. Neutral	M_{diff}=1.29, SE=.17 [.95, 1.63], $p < .001$ d=1.17	M_{diff}=1.49, SE=.18 [1.12, 1.85], $p < .001$ d=1.21	M_{diff}=1.60, SE=.20 [1.20, 1.99], $p < .001$ d=1.13	M_{diff}=1.01, SE=.15 [.72, 1.29], $p < .001$ d=1.02
Positive vs. Negative	M_{diff}=1.36, SE=.17 [1.05, 1.60], $p < .001$ d=1.06	M_{diff}=1.63, SE=.18 [1.27, 1.99], $p < .001$ d=1.22	M_{diff}=1.00, SE=.20 [1.42, 2.21], $p < .001$ d=1.25	M_{diff}=1.13, SE=.15 [.84, 1.41], $p < .001$ d=1.03
Negative vs. Neutral	M_{diff}=-0.07, SE=.17 [−.83, −.27], p=.694 d=.05	M_{diff}=-0.14, SE=.18 [−.50, .22], p=.445 d=.09	M_{diff}=-0.22, SE=.20 [−.61, .17], p=.273 d=.14	M_{diff}=-0.12, SE=.15 [−.41, .16], p=.401 d=.11

For pairwise comparisons, 95% confidence intervals for mean differences appear in [brackets] next to p-values.

belonging (see Table 10). Given that target condition did not interact with instructor response condition, we controlled for this variable in the analyses.[5] Replicating Study 1, participants who imagined receiving positive (vs. negative or neutral) responses from their professor reported greater lab self-efficacy and belonging, which was related to greater interest in joining the lab and recruiting other students to join.

Moderation by gender

Finally, we ran ANOVAs examining moderating effects of gender (see Table 2 in Supplemental Materials for full results). There were no significant Gender × Instructor Response Condition × Target Condition interactions, but there was a significant main effect of gender, qualified by a Gender × Instructor Response Condition interaction for lab self-efficacy. Women reported lower lab self-efficacy than men when they imagined receiving a neutral response from the instructor; no evidence of other significant gender differences emerged in the other instructor response conditions.

Discussion

Replicating Study 1, Study 2 found that participants who imagined asking a question in a STEM context and receiving a positive verbal response from their professor felt greater self-efficacy and belonging, which was related to greater interest in joining – and recruiting others to join – the STEM lab. There were no observed differences in these outcomes based on whether participants imagined themselves or a classmate receiving this

Table 10. Results of mediation analyses (study 2).

Mediators				
IV: Instructor Response Condition	Lab Self-Efficacy (a_1 path)		Lab Belonging (a_2 path)	
Positive Response vs. Negative Response	1.35 [1.01, 1.70] $p < .001$		1.62 [1.26, 1.99] $p < .001$	
Positive Response vs. Neutral Response	1.29 [.94, 1.63] $p < .001$		1.49 [1.12, 1.85] $p < .001$	
Mediators	DV: Intentions to Join Lab		DV: Intentions to Recruit Others to Join Lab	
Lab Self-Efficacy (b_1 path)	.30 [.18, .42], $p < .001$		.28 [.12, .38], $p < .001$	
Lab Belonging (b_2 path)	.63 [.51, .74], $p < .001$		.30 [.20, .39], $p < .001$	
	DV: Intentions to Join Lab		DV: Intentions to Recruit Others to Join Lab	
	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response
Direct Effect (c′ path)	.39 [.12, .67], p=.005	.28 [.01, .55], p=.043	.27 [.03, .51], p=.028	.21 [−.03, .45], p=.084
Indirect Effects				
Lab Self-Efficacy	.41 [.17, .66]	.39 [.16, .64]	.37 [.21, .56]	.36 [.20, .53]
Lab Belonging	1.02 [.69, 1.39]	.93 [.61, 1.29]	.48 [.29, .71]	.44 [.27, .64]

IV=X or independent variable, DV=Y or dependent variable. Betas are unstandardized coefficients. Values within brackets reflect lower and upper level 95% confidence intervals. For indirect effects, values within brackets that exclude zero are significant as indicated in bold.

response. Instructors' positive verbal responses to students' questions may therefore serve as a powerful situational cue that boosts students' self-perceptions and motivation, even when individuals are not themselves the direct recipients.

As in Study 1, neutral responses from instructors did not differ significantly from negative responses. Although instructors in the neutral condition simply asked participants to hold their question due to a lack of time, participants appeared to interpret this response in a way that was similar to a negative response. Students may be hesitant to ask questions, especially in the presence of peers, because doing so risks criticism, ridicule, or being brushed off by the teacher (Chin & Osborne, 2008). Thus, it seems possible that participants in the neutral response condition might have interpreted the instructor's response as being dismissive.

Although there were a few significant results with regard to gender, such as women reporting lower lab self-efficacy than men in the neutral instructor response condition, gender differences did not consistently emerge across the outcome variables. One possible reason for this is that we did not vary the source of the response (i.e., who responded to students). Although we used the pronoun "he" in the scenario, this was only mentioned once and may have been too subtle of a cue to be impactful. In past work, women showed better STEM-related outcomes after receiving positive written feedback on a math test from a male authority figure, but in that case, the gender of the feedback provider was more salient – i.e., participants took a math test in the presence of a male versus female experimenter (Park et al., 2018).

Study 3

Studies 1 and 2 found that participants who imagined receiving a positive verbal response from their instructor after asking a question in a STEM lab seminar felt greater self-efficacy and belonging, which was related to greater intentions to join the lab and to recruit other students to join. An alternative explanation is that positive instructor responses boosted students' interest in joining the lab and recruiting other students to join because the instructor giving positive responses was perceived as caring, or the response was perceived as polite versus rude. To test these alternative explanations, we assessed perceptions of the instructor's care and politeness of the response to see whether these perceptions better accounted for the relationship between instructor responses and intentions to join and recruit other students to the STEM lab.

We also investigated an important potential boundary condition in the present study to determine whether the setting – public versus private – amplifies the impact of instructors' responses to students' questions. While some studies suggest that unexpected public recognition increases performance (Bradler et al., 2016), other studies show that individuals who are privately (vs. publicly) acknowledged for their performance do not differ in their responses to feedback (Gerhards & Siemer, 2016). Still other studies suggest that individuals with impostor syndrome – who doubt their achievements and fear being exposed as a fraud – are uncomfortable with being singled out for praise (Clance & Imes, 1978) and report lower expectations for success when their responses are made public (Leary et al., 2000). It therefore remains to be seen whether the effects of positive instructor responses might be magnified or attenuated in a public versus private setting and whether this effect differs for women versus men.

Methods

Participants

See Table 1 for demographics and Table 4 for sensitivity analyses.

Materials and procedure

Instructor response condition

Same as in Study 1.

Public versus private setting

Participants were randomly assigned to imagine receiving a response from their instructor in a public or private setting. For example, in the public (vs. private) and positive instructor response condition, they read:

> *"Imagine you are in a lab seminar for students who are considering joining a research lab at UB in Science, Technology, Engineering, and Math (STEM).* ***During one of the seminar meetings, you raise your hand and ask a question to the professor, in front of everyone [After one of the seminar meetings, after all the other students have left, you stay a little after the meeting to privately ask the professor a question]*** *about the material being presented and he responds with "That's a great question, I'm glad you brought that up."*

Using the same measures as before, participants reported their lab self-efficacy (α=.96), belonging (α=.94), intentions to join the lab (α=.96), and to recruit others to the lab (α=.67).

They also reported their perceptions of the instructor's care with items such as, "How much does the instructor … Care about whether or not I do well in school?" "Be available when I need to talk to them?" from 1=*not at all* to 7=*a great deal* (6 items, α = .97). Finally, participants rated the politeness versus rudeness of the instructor's response from 1=*very polite* to 7=*very rude* and then reported demographics.

Results

Table 11 reports zero-order correlations. First, we conducted ANOVAs examining Instructor Response Condition, Public versus Private Condition, and their interaction in predicting the dependent variables (see Table 12). Replicating Studies 1 and 2, participants who imagined receiving a positive (vs. neutral or negative) response after asking a question to their STEM professor reported greater self-efficacy, belonging, and greater desire to join the lab and recruit other students to join. Participants who imagined receiving positive (vs. neutral or negative) responses also perceived the instructor to be more caring and the response to be more polite/less rude. Neutral and negative instructor responses did not differ significantly from each other and there was no evidence of significant effects of public versus private condition for any outcomes.

Table 11. Zero-order correlations among variables (study 3).

	1	2	3	4	5	6	7
1. Lab self-efficacy	–						
2. Lab belonging	.80***	–					
3. Intentions to join lab	.73***	.76***	–				
4. Intentions to recruit other students to join lab	.60***	.59***	.68***	–			
5. Perceptions of the instructor's care	.72**	.68***	.66***	.48***	–		
6. Perceptions of instructor response being rude	−.68**	−.67***	−.65***	−.53***	−.73***	–	
7. Gender	.10	.11	.11	.07	.07	−.01	–

Note. For all correlations, *df*=241. Gender: 1=female, 2=male. For perceptions of rudeness, higher values =. instructor response was rated as being more rude than polite. *p<.05, **p<.01, ***p<.001.

Mediation analyses

We next conducted mediation analyses to examine whether positive (vs. neutral or negative instructor responses, respectively) were related to increased intentions to join the lab and to recruit other students to join the lab via increased self-efficacy and belonging (see Figure 1; Table 13). To test alternative explanations, we included perceptions of the instructor's care and politeness of the instructors' response as simultaneous mediators in the model. Given that public versus private setting did not interact with instructor response condition, we controlled for this variable in the analyses.[6] Participants who imagined receiving a positive (vs. negative or neutral) instructor response reported greater lab self-efficacy and belonging, which was related to greater desire to join the lab and to recruit others to join. Although instructor response condition affected perceptions of the instructor's care and politeness of the response, these variables did not account for the relationship between response received and the outcomes.

Moderation by gender

Finally, we conducted ANOVAs examining moderating effects of gender (see Table 3 in Supplemental Materials for full results). There were only significant Gender × Instructor Response Condition interactions for lab belonging and intentions to join the lab; no other two- way or three-way interactions with gender were significant. Women (vs. men) reported lower lab belonging and less intentions to join the lab in the neutral instructor response condition, but not in the other response conditions.

Discussion

Consistent with Studies 1 and 2, participants who imagined receiving a positive (vs. neutral or negative) response after asking a question to their STEM professor felt greater self-efficacy and belonging, which was associated with greater intentions to join the lab and recruit others to join. The were no observed differences in the beneficial effects of positive responses based on whether the instructor responded to participants' questions in a public or private setting. Perhaps in this particular context – in which students asked a question without the suggestion that their performance was being heavily scrutinized by instructors – the distinction between public versus private setting did not matter. We also did not find support for two alternative explanations; positive instructor responses were related to greater intentions to join the lab and to recruit other students to join via

Table 12. Results of ANOVAs, descriptive statistics, and pairwise comparisons (study 3).

Instructor Response Condition	Lab Self-Efficacy	Lab Belonging	Intentions to Join Lab	Intentions to Recruit Others to Join Lab	Perceptions of Instructor's Care	Perceptions of Rudeness
Results of ANOVAs	$F(2, 237)=31.54$ $p < .001$, $\eta_p^2=.21$	$F(2, 237)=35.77$ $p < .001$, $\eta_p^2=.23$	$F(2, 237)=31.55$ $p < .001$, $\eta_p^2=.21$	$F(2, 237)=20.52$ $p < .001$, $\eta_p^2=.15$	$F(2, 237)=77.56$ $p < .001$, $\eta_p^2=.40$	$F(2, 237)=64.92$ $p < .001$, $\eta_p^2=.35$
Public vs. Private Condition	$F(1, 237)=.58$ $p=.608$, $\eta_p^2=.00$	$F(1, 237)=.58$ $p=.447$, $\eta_p^2=.00$	$F(1, 237)=.12$ $p=.735$, $\eta_p^2=.00$	$F(1, 237)=1.72$ $p=.191$, $\eta_p^2=.01$	$F(1, 237)=1.44$ $p=.231$, $\eta_p^2=.01$	$F(1, 237)=.38$ $p=.536$, $\eta_p^2=.00$
Instructor Response × Public vs. Private	$F(2, 237)=.56$ $p=.573$, $\eta_p^2=.01$	$F(2, 237)=.79$ $p=.455$, $\eta_p^2=.01$	$F(2, 237)=2.18$ $p=.115$, $\eta_p^2=.02$	$F(2, 237)=.33$ $p=.721$, $\eta_p^2=.00$	$F(2, 237)=.09$ $p=.197$ $\eta_p^2=.00$	$F(2, 237)=.48$ $p=.167$ $\eta_p^2=.00$
Means (*SDs*)						
Positive Response (*N*=78)	5.35 (1.05)	5.06 (1.06)	4.61 (1.30)	4.60 (1.07)	5.67 (.97)	2.49 (1.39)
Neutral Response (*N*=84)	3.87 (1.13)	3.39 (1.52)	3.01 (1.53)	3.64 (1.06)	2.96(1.62)	4.64(1.34)
Negative Response (*N*=81)	3.89 (1.50)	3.56 (1.44)	3.03 (1.56)	3.61 (1.18)	3.12 (1.85)	4.84 (1.58)
Results of Pairwise Comparisons						
Positive vs. Neutral	$M_{diff}=1.48$, $SE=.21$ [1.06, 1.90], $p<.001$ $d=1.36$	$M_{diff}=1.68$, $SE=.22$ [1.26, 2.11], $p<.001$ $d=1.27$	$M_{diff}=1.60$, $SE=.23$ [1.15, 2.06], $p<.001$ $d=1.13$	$M_{diff}=0.96$, $SE=.17$ [.62, 1.31], $p<.001$ $d=.90$	$M_{diff}=2.71$, $SE=.24$ [2.24, 3.19], $p<.001$ $d=2.03$	$M_{diff}=-2.16$, $SE=.23$ [−2.61, −1.71], $p<.001$ $d=1.57$
Positive vs. Negative	$M_{diff}=1.46$, $SE=.21$ [1.04, 1.89], $p<.001$ $d=1.36$	$M_{diff}=1.50$, $SE=.22$ [1.07, 1.94], $p<.001$ $d=1.19$	$M_{diff}=1.59$, $SE=.23$ [1.13, 2.05], $p<.001$ $d=1.10$	$M_{diff}=0.99$, $SE=.18$ [.64, 1.33], $p <.001$ $d=.88$	$M_{diff}=2.54$, $SE=.24$ [2.06, 3.03], $p<.001$ $d=1.73$	$M_{diff}=-2.36$, $SE=.23$ [−2.81, −1.90], $p<.001$ $d=1.58$
Negative vs. Neutral	$M_{diff}=0.02$, $SE=.21$ [−.40, .43], $p=.934$ $d=.00$	$M_{diff}=0.18$, $SE=.22$ [−.24, .60], $p=.403$ $d=.11$	$M_{diff}=0.01$, $SE=.23$ [−.44, .46], $p=.951$ $d=.01$	$M_{diff}=-0.02$, $SE=.17$ [−.36, .32], $p=.897$ $d=.03$	$M_{diff}=0.17$, $SE=.24$ [−.30, .64], $p=.481$ $d=.09$	$M_{diff}=0.19$, $SE=.22$ [−.25, .64], $p=.388$ $d=.14$

Note. For pairwise comparisons, 95% confidence intervals for mean differences appear in [brackets] next to *p*-values.

Table 13. Results of mediation analyses (study 3).

Mediators				
IV: Instructor Response Condition	Lab Self-Efficacy (a_1 path)	Lab Belonging (a_2 path)	Perceptions of Instructor's Care (a_3 path)	Perceptions of Rudeness (a_4 path)
Positive Response vs. Negative Response	1.46 [1.04, 1.88] $p < .001$	1.50 [1.07, 1.93] $p < .001$	2.54 [2.06, 3.02] $p < .001$	−2.35 [−2.80, −1.90] $p < .001$
Positive Response vs. Neutral Response	1.48 [1.06, 1.90] $p < .001$	1.68 [1.25, 2.10] $p < .001$	2.71 [2.24, 3.19] $p < .001$	−2.16 [−2.60, −1.71] $p < .001$

Mediators	DV: Intentions to Join Lab	DV: Intentions to Recruit Others to Join Lab
Lab Self-Efficacy (b_1 path)	.24 [.09, .40], *p*=.002	.25 [.10, .39], $p < .001$
Lab Belonging (b_2 path)	.44 [.30, .58], $p < .001$	.19 [.06, .32], *p*=.005
Perceptions of Instructor's Care (b_3 path)	.10 [−.01, .22], *p*=.078	−.06 [−.16, .05], *p*=.303
Perceptions of Rudeness (b_4 path)	−.12 [−.23, −.00], *p*=.047	−.11 [−.22, −.00], *p*=.047

	DV: Intentions to Join Lab		DV: Intentions to Recruit Others to Join Lab	
	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response
Direct Effect (c′ path)	.03 [−.36, .42], *p*=.861	−.03 [−.42, .36], *p*=.889	.22 [−.14, .59], *p*=.232	.20 [−.17, .56], *p*=.293
Indirect Effects				
Lab Self-Efficacy	**.35 [.08, .65]**	**.36 [.09, .63]**	**.36 [.10, .66]**	**.36 [.11, .65]**
Lab Belonging	**.66 [.40, 1.00]**	**.73 [.44, 1.10]**	**.28 [.05, .56]**	**.32 [.06, .61]**
Perceptions of Instructor's Care	.26 [−.07, .60]	.28 [−.08, .62]	−.14 [−.42, .14]	−.15 [−.45, .15]
Perceptions of Rudeness	.28 [−.04, .60]	.25 [−.04, .55]	.26 [−.02, .54]	.24 [−.02, .49]

Note. IV=*X* or independent variable, DV=*Y* or dependent variable. Betas reflect unstandardized coefficients. Values within brackets reflect lower and upper level 95% confidence intervals. For indirect effects, values within brackets that exclude zero are significant as indicated in bold.

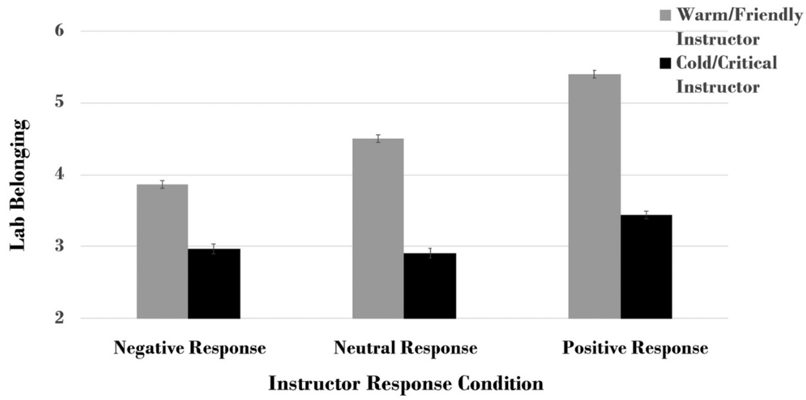

Figure 2. Lab belonging (study 5).
Note. Error bars represent the standard error around the mean of each condition.

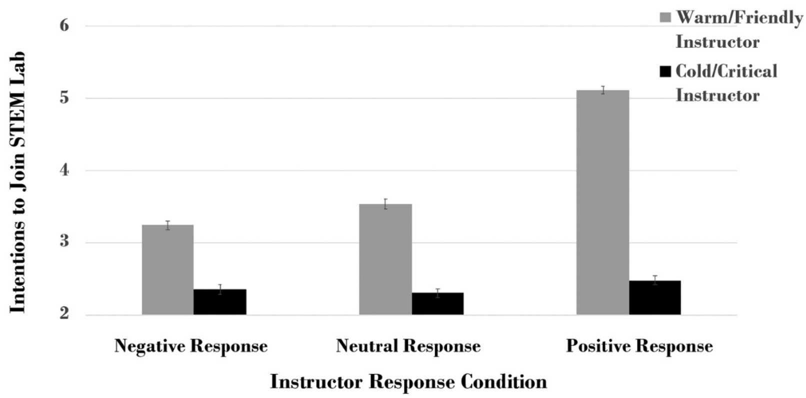

Figure 3. Intentions to join STEM lab (study 5).
Note. Error bars represent the standard error around the mean of each condition.

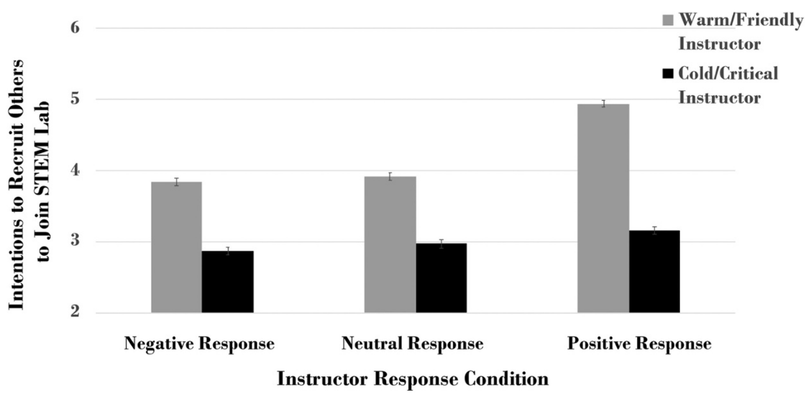

Figure 4. Intentions to recruit others to join STEM lab (study 5).
Note. Error bars represent the standard error around the mean of each condition.

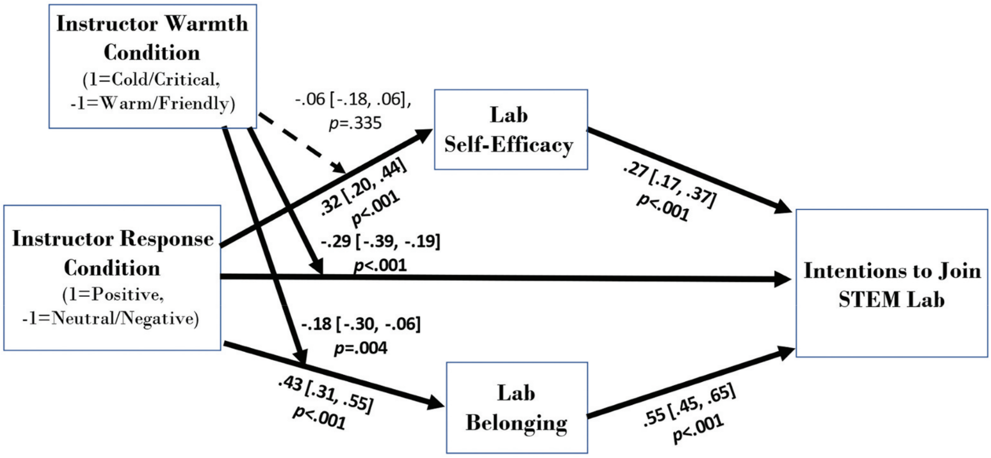

Figure 5. Moderated mediation results predicting intentions to join STEM lab (study 5).
Note. Bolded paths are significant

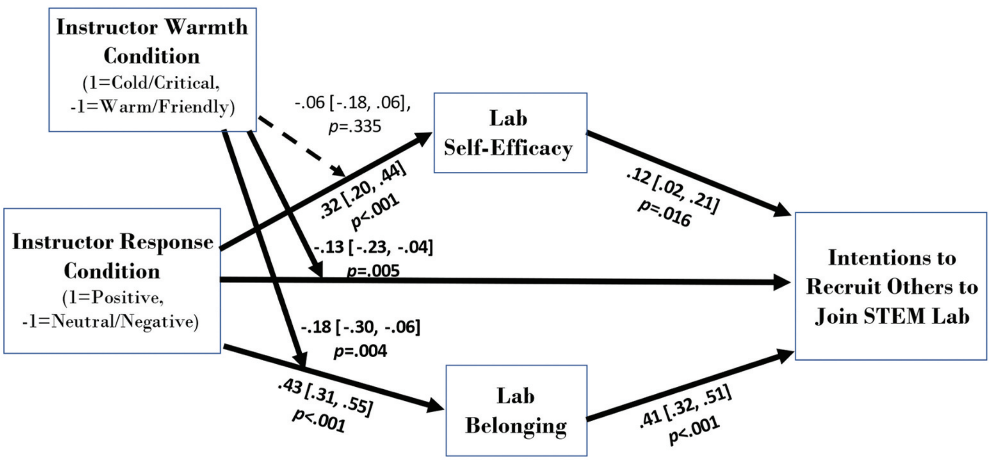

Figure 6. Moderated mediation results predicting intentions to recruit others to join STEM lab (study 5).
Note. Bolded paths are significant

increased self-efficacy and belonging in the lab, rather than perceptions of the instructor's care or perceived politeness of the response. Thus, the findings overall suggest that imagining positive instructor responses when asking questions – whether publicly or privately – improves students' self-efficacy and belonging in STEM contexts.

Whereas Study 1 showed that women reported lower lab self-efficacy than men in the neutral instructor response condition, women in the current study reported lower lab belonging and less intentions to join the lab when they received such responses. As in Study 2, we also found no evidence that neutral instructor responses differed significantly from negative responses. Indeed, the two conditions were viewed as equally rude and low in perceptions of instructor caring. Such findings suggest that even if professors run out of time during a class to answer a query, it may be better to respond positively to students for asking a question in the first place.

In sum, Study 3 provided additional support for the idea that positive instructor responses to students' questions increase participants' self-efficacy and belonging in that environment, which were related to increased intentions to join the lab and to recruit others to join. In the next study, we examine whether the academic context – STEM versus non-STEM – matters in shaping students' self-perceptions and motivation.

Study 4

The studies thus far demonstrate that positive verbal responses from instructors benefit students regardless of who the recipient is or how it is given. These findings underscore the importance of instructors and suggest that positive instructor cues can boost self-efficacy and belonging for students in a variety of classroom settings. However, past research also suggests that positive cues may be especially beneficial for members of certain groups, such as women in STEM contexts, who may doubt their abilities or belonging in academic domains where they are underrepresented or negatively stereotyped (Hall et al., 2019; Logel et al., 2009; Murphy et al., 2007). With these ideas in mind, Study 4 examines whether the academic domain matters and whether women benefit more when they imagine receiving positive instructor responses in STEM versus non-STEM contexts. Additionally, we sought to further investigate whether the neutral instructor response condition differed from the negative instructor response condition in terms of how rude the neutral response seemed, given that Study 3 showed no significant difference between these two conditions in perceptions of rudeness.

Participants

See Table 1 for demographics and Table 4 for sensitivity analyses.

Materials and procedure

Instructor response condition

Same as in Study 1.

Academic domain condition

In addition to instructor response condition, participants were randomly assigned to a STEM or non-STEM context. For example, in the STEM (vs. non-STEM) setting and positive instructor response condition, they read:

> *"Imagine you are in a lab seminar for undergraduate students who are considering joining a research lab at UB in* ***STEM (e.g., Science, Technology, Engineering, Math) [the Humanities (e.g., English, Comparative Literature, Languages, History, Philosophy)]****. During one of the weekly seminar meetings, you ask a question to the professor about the material being presented and he says to you: "That's a great question, I'm glad you brought that up."*

Using the same items as before, but adapted to reflect a STEM lab or a Humanities lab, participants reported their lab self-efficacy (α=.94), belonging (α=.96), intentions to join the lab (α=.96), to recruit other students to join the lab (α=.74), perceptions of the instructor's response as rude versus polite, and demographics.

Results

Table 14 reports zero-order correlations. First, we conducted ANOVAs examining Instructor Response Condition, Academic Domain Condition, and their interaction in predicting the dependent variables (see Table 15). Replicating our previous studies, participants who imagined asking a question and receiving a positive (vs. neutral or negative) instructor response reported greater self-efficacy and belonging and greater desire to join the lab and to recruit other students to join. In contrast to our earlier studies, neutral instructor responses differed significantly from negative responses: participants reported lower lab self-efficacy and belonging, and less intentions to join the lab or to recruit other students to join, when they imagined receiving a negative (vs. neutral) response from the professor. These findings make sense, given that neutral and negative instructor responses differed significantly from each other in perceptions of rudeness in the present study, such that neutral responses were perceived as less rude than negative instructor responses.

Mediation analyses

We next conducted mediation analyses to examine whether positive (vs. neutral or negative instructor responses, respectively) predicted intentions to join the lab and to recruit others to join via increased self-efficacy and belonging in the lab. Because domain did not interact with instructor response condition, we controlled for this variable in the analyses. Consistent with the previous studies, participants who imagined receiving a positive (vs. negative or neutral) instructor response reported greater self-efficacy and belonging, which was related to greater intentions to join the lab and to recruit other students to join (see Figure 1; Table 16).

Moderation by gender

Finally, we conducted ANOVAs to examine moderating effects of gender (see Table 4 in Supplemental Materials for full results). There were no significant three-way interactions between Gender, Instructor Response Condition, and Academic Domain Condition in predicting any of the outcomes. However, there were significant main effects of gender for lab self-efficacy and belonging, qualified by significant Gender × Instructor Response

Table 14. Zero-order correlations among variables (study 4).

	1	2	3	4	5	6
1. Lab self-efficacy	–					
2. Lab belonging	.83***	–				
3. Intentions to join lab	.77***	.84***	–			
4. Intentions to recruit other students to join lab	.66***	72***	.79***	–		
5. Perceptions of instructor response being rude	−.42***	−.42***	−.42***	−.42***	–	
6. Gender	.06	.05	−.01	.01	.08	–

Note. For all correlations, *df*=413. Gender: 1=female, 2=male. *p<.05, **p<.01, ***p<.001.

Table 15. Results of ANOVAs, descriptive statistics, and pairwise comparisons (study 4).

Instructor Response Condition	Lab Self-Efficacy	Lab Belonging	Intentions to Join Lab	Intentions to Recruit Others to Join Lab	Perceptions of Rudeness
Results of ANOVAs	$F(2, 409)=75.12$ $p < .001$, $\eta_p^2=.27$	$F(2, 409)=117.88$ $p < .001$, $\eta_p^2=.37$	$F(2, 409)=112.37$ $p < .001$, $\eta_p^2=.36$	$F(2, 409)=83.02$ $p < .001$, $\eta_p^2=.29$	$F(2, 409)=113.93$ $p < .001$, $\eta_p^2=.36$
Academic Domain Condition	$F(1, 409)=.01$ $p=.919$, $\eta_p^2=.00$	$F(1, 409)=.16$ $p=.685$, $\eta_p^2=.00$	$F(1, 409)=.41$ $p=.521$, $\eta_p^2=.00$	$F(1, 409)=1.25$ $p=.264$, $\eta_p^2=.00$	$F(1, 409)=.87$ $p=.350$, $\eta_p^2=.00$
Instructor Response × Academic Domain Condition	$F(2, 409)=.99$ $p=.374$, $\eta_p^2=.00$	$F(2, 409)=2.60$ $p=.076$, $\eta_p^2=.01$	$F(2, 409)=2.87$ $p=.058$, $\eta_p^2=.01$	$F(2, 409)=83.02$ $p=.205$, $\eta_p^2=.01$	$F(2, 409)=2.54$ $p=.080$, $\eta_p^2=.01$
Means (*SDs*)					
Positive Response ($N=140$)	5.43 (.91)	5.46 (1.02)	5.18 (1.12)	4.95 (1.05)	2.53 (1.39)
Neutral Response ($N=138$)	4.05 (1.18)	3.68 (1.17)	3.29 (1.41)	3.57 (1.17)	4.31 (1.43)
Negative Response ($N=137$)	3.86 (1.36)	3.35 (1.49)	2.86 (1.55)	3.24 (1.28)	5.02 (1.46)
Results of Pairwise Comparisons					
Positive vs. Neutral	$M_{diff}=1.38$, $SE=.14$ [1.10, 1.65], $p<.001$ $d=1.31$	$M_{diff}=1.78$, $SE=.15$ [1.49, 2.07], $p<.001$ $d=1.62$	$M_{diff}=1.88$, $SE=.16$ [1.20, 1.99], $p<.001$ $d=1.48$	$M_{diff}=1.01$, $SE=.15$ [.72, 1.29], $p<.001$ $d=1.24$	$M_{diff}=-1.78$, $SE=.17$ [−2.11, −1.45], $p<.001$ $d=1.26$
Positive vs. Negative	$M_{diff}=1.57$, $SE=.14$ [1.30, 1.85], $p<.001$ $d=1.36$	$M_{diff}=2.12$, $SE=.15$ [1.83, 2.41], $p<.001$ $d=1.65$	$M_{diff}=2.32$, $SE=.16$ [1.99, 2.64], $p<.001$ $d=1.72$	$M_{diff}=1.13$, $SE=.15$ [.84, 1.41], $p<.001$ $d=1.46$	$M_{diff}=-2.49$, $SE=.17$ [−2.83, −2.16], $p<.001$ $d=1.75$
Negative vs. Neutral	$M_{diff}=-0.20$, $SE=.14$ [−.47, .08], $p=.164$ $d=.15$	$M_{diff}=-0.34$, $SE=.15$ [−.63, −.04], $p=.024$ $d=.25$	$M_{diff}=-0.44$, $SE=.16$ [−.76, −.11], $p=.008$ $d=.29$	$M_{diff}=-.12$, $SE=.15$ [−.41, .16], $p=.401$ $d=.27$	$M_{diff}=.71$, $SE=.17$ [.38, 1.05], $p<.001$ $d=.49$

Note. For pairwise comparisons, 95% confidence intervals for mean differences appear in [brackets] next to *p*-values.

Table 16. Results of mediation analyses (study 4).

Mediators				
IV: Instructor Response Condition	Lab Self-Efficacy (a_1 path)		Lab Belonging (a_2 path)	
Positive Response vs. Negative Response	1.57 [1.30, 1.85] $p < .001$		2.12 [1.83, 2.41] $p < .001$	
Positive Response vs. Neutral Response	1.38 [1.10, 1.65] $p < .001$		1.79 [1.49, 2.08] $p < .001$	
Mediators	DV: Intentions to Join Lab		DV: Intentions to Recruit Others to Join Lab	
Lab Self-Efficacy (b_1 path)	.31 [.19, .42], $p < .001$		.18 [.06, .30], $p = .004$	
Lab Belonging (b_2 path)	.61 [.50, .71], $p < .001$		.43 [.32, .54], $p < .001$	
	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response	IV: Positive Response vs. Negative Response	IV: Positive Response vs. Neutral Response
Direct Effect (c′ path)	.54 [.29, .80], $p < .001$	.37 [.13, .62], $p = .003$	.51 [.24, .78], $p < .001$	.36 [.10, .62], $p = .006$
Indirect Effects				
Lab Self-Efficacy	**.48 [.24, .73]**	**.42 [.22, .63]**	**.28 [.05, .51]**	**.25 [.04, .46]**
Lab Belonging	**1.29 [.98, 1.62]**	**1.08 [.81, 1.38]**	**.91 [.62, 1.23]**	**.77 [.51, 1.07]**

Notes. IV=*X* or independent variable, DV=*Y* or dependent variable. Betas are unstandardized coefficients. Values within brackets reflect lower and upper level 95% confidence intervals. For indirect effects, values within brackets that exclude zero are significant as indicated in bold.

Condition interactions for lab self-efficacy, belonging, intentions to join the lab, and to recruit others to join.Women (vs. men) reported lower lab self-efficacy, belonging, less intentions to join the lab, and tended to have lower intentions to recruit others to join the lab when they received neutral or negative responses from their instructor. However, after receiving a positive instructor response, women (vs. men) tended to report greater belonging, and greater intentions to both join the lab and recruit others to join the lab.

Discussion

Consistent with the findings of our previous studies, participants who imagined receiving a positive (vs. neutral or negative) instructor response after asking a question in a lab seminar reported greater self-efficacy and belonging, which was related to greater desire to join the lab and to recruit other students to join. Although women overall reported lower lab self-efficacy and belonging than men, there was no evidence that the impact of instructor responses varied by academic domain. In past work, women who received positive written feedback from authority figures on a math (vs. verbal) test showed better domain-related outcomes (Park et al., 2018). One possible reason for the discrepancy across findings is that we did not manipulate the gender of the instructor in the present study, nor did we create a highly evaluative performance-based situation as in previous work (Park et al., 2018). Also, whereas the present scenario involved an orientation-like seminar for students potentially interested in STEM research, women might benefit more from positive instructor responses when concerns about gender stereotypes or performance are made highly salient.

Whereas Studies 2 and 3 found no differences comparing the neutral and negative response conditions, participants in the current study reported lower lab self-efficacy, belonging, and less intentions to join the lab and to recruit other students to join when they imagined receiving a negative (vs. neutral) response from their instructor. In the present study, participants perceived the instructor's response in the neutral condition to be significantly less rude than the negative response condition.

We also found moderating effects of gender in the present study: women (vs. men) reported lower lab self-efficacy, belonging, and less intentions to recruit others to the lab when they received neutral or negative instructor responses. However, after a positive instructor response, women (vs. men) tended to report greater belonging, greater intentions to join the lab, and to recruit others to join.

In sum, Study 4 provided further converging evidence that positive instructor responses to students' questions boost students' self-efficacy, belonging, intentions to join the lab, and to recruit other students to join. Furthermore, positive instructor responses were more beneficial than receiving neutral or negative responses across both STEM and non-STEM contexts.

Study 5

The final study examined whether the impact of instructors' responses to students' questions may be amplified depending on whether instructors were portrayed as warm/friendly versus cold/critical. Interpersonal warmth and coldness reflect two core dimensions of person perception, especially when forming impressions of novel targets (Asch, 1946). In a classic study by Kelley (Kelley, 1950), students first read about a professor who was described as being warm or cold in demeanor and then interacted with the professor during a discussion session. Compared to students who expected a cold professor, those who expected a warm professor participated more in the discussion and rated the instructor as being more sociable and good-natured, even though the professor acted the same way toward both groups of students. Research on the primacy effect further suggests that exposure to positive versus negative traits of a target can subsequently shape perceivers' expectancies and judgments (Asch, 1946).

Applying these ideas to the present study, if perceptions of warmth amplify subsequent information through an assimilative process, then participants who initially read about a warm instructor and then imagine receiving a positive response from them may show higher self-efficacy, belonging, and greater intentions to join the lab and to recruit others to join. If, however, participants are initially exposed to information suggesting negative traits of the instructor (i.e., being cold/critical), then even positive instructor responses may be discounted and its impact diminished, because such behaviors violate existing schemas and expectancies. Along these lines, research suggests that praise that is perceived as insincere – for example, because it is inconsistent with other words or actions from a target – can have negative effects on motivation (Henderlong & Lepper, 2002).

Alternatively, if a cold/critical instructor responds positively to a student's question, this cue might be especially meaningful to students, because expectancy violations can sometimes magnify judgments more extremely than expectancy confirming behaviors (Biernat et al., 1999). In this way, a positive instructor response might be viewed as more diagnostic of one's abilities or belonging when such feedback is not typically given. Indeed, this may better reflect students' actual classroom experiences as our preliminary studies found that students reported receiving less frequent positive responses from instructors when asking questions in their STEM courses, and instructors corroborated this perception through their own self-reports. Thus, in the present study we varied how warm (vs. cold) the professor acted toward students to see whether these portrayals differentially affected the impact of instructor responses to students' questions in STEM contexts. In addition, we again assessed perceptions of rudeness of the instructor's response to ensure that the neutral response condition was viewed as less rude than the negative response condition.

Participants

Table 1 summarizes demographics; Table 4 reports sensitivity analyses.

Materials and procedure

Instructor response condition

Same as in Study 1.

Instructor warmth condition

Participants were randomly assigned to imagine having a professor who was warm/ friendly or cold/critical. For example, in the instructor warm (vs. cold) positive response condition, they read:

> *"Imagine you are in a lab seminar for students who are considering joining a research lab at UB in Science, Technology, Engineering, and Math (STEM). The professor of this class is typically* ***warm and friendly [cold and critical]*** *towards students. The professor* ***holds [does not hold]*** *regular office hours with students, and* ***often will offer extended office hours before exams [and the professor instead tells students to go to the TA or tutors if questions emerge outside of class]****. They are also* ***very quick in responding to students' emails personally, and provide personalized, detailed feedback to their students on assignments and exams [They take a long time to respond to emails, and when they do it is minimal. The professor also does not provide feedback on assignments and exams]. [Despite these experiences]****, one day during one of the seminar meetings, you ask a question to the professor about the material being presented and he says to you: "That's a great question, I'm glad you brought that up."*

Participants then completed the same items as before including lab self-efficacy (α=.96), belonging (α=.96), intentions to join the lab (α=.96), to recruit others (α=.67), ratings of the instructor's response as being rude versus polite, and demographics.

Results

Table 17 reports zero-order correlations. For our primary analyses, we conducted ANOVAs examining Instructor Response Condition, Instructor Warmth Condition, and their interaction in predicting the dependent variables (see Table 18). Replicating our previous studies, participants who imagined receiving a positive (vs. neutral or negative) instructor response reported higher self-efficacy, belonging, intentions to join the STEM lab, and to recruit other students to join. Participants who received neutral instructor responses showed marginally higher self-efficacy and significantly higher belonging than those who received negative responses. No other significant differences emerged between neutral and negative response conditions.

Replicating Study 4, participants rated negative instructor responses as significantly more rude compared to neutral responses, M_{diff}=.54, $p < .001$, 95% CI=[.24, .84], $d = .35$, and positive responses were perceived as less rude than both neutral responses, M_{diff}=-1.53, $p < .001$, 95% CI=[−1.83, −1.23], $d = 1.01$, and negative responses, M_{diff}=-2.08, $p < .001$, 95% CI=[−2.38, −1.78], $d = 1.34$. Participants reported higher self-efficacy, belonging, intentions to join the lab, and to recruit others to join the lab when they imagined having a warm/friendly versus cold/critical STEM professor. In addition, warm instructors

Table 17. Zero-order correlations among variables (study 5).

	1	2	3	4	5	6
1. Lab self-efficacy	–					
2. Lab belonging	.79***	–				
3. Intentions to join lab	.70***	.76***	–			
4. Intentions to recruit other students to join lab	.59***	.67***	.76***	–		
5. Perceptions of instructor response being rude	.29***	.32***	.33***	.29***	–	
6. Gender	−.00	.05	.07	−.02	.06	–

For all correlations with gender, *df*=532; for all other correlations, *df*=537. Gender: 1=female, 2=male. **p*<.05, ***p*<.01, ****p*<.001.

Table 18. Results of ANOVAs, descriptive statistics, and pairwise comparisons (study 5).

Instructor Response Condition	Lab Self-Efficacy	Lab Belonging	Intentions to Join Lab	Intentions to Recruit Others	Perceptions of Rudeness
Results of ANOVAs	$F(2, 533)=15.45$ $p<.001$, $\eta_p^2=.06$	$F(2, 533)=26.12$ $p<.001$, $\eta_p^2=.09$	$F(2, 533)=24.17$ $p<.001$, $\eta_p^2=.08$	$F(2, 533)=16.29$ $p<.001$, $\eta_p^2=.06$	$F(2, 533)=99.80$ $p<.001$, $\eta_p^2=.27$
Instructor Warmth Condition	$F(1, 533)=181.91$ $p<.001$, $\eta_p^2=.25$	$F(1, 533)=163.09$ $p<.001$, $\eta_p^2=.23$	$F(1, 533)=155.51$ $p<.001$, $\eta_p^2=.23$	$F(1, 533)=136.23$ $p<.001$, $\eta_p^2=.20$	$F(1, 533)=68.23$ $p<.001$, $\eta_p^2=.11$
Instructor Response × Warmth Condition	$F(2, 533)=1.02$ $p=.363$, $\eta_{p_2}=.00$	$F(2, 533)=7.19$ $p<.001$, $\eta_{p_2}=.03$	$F(2, 533)=18.10$ $p<.001$, $\eta_{p_2}=.06$	$F(2, 533)=7.18$ $p<.001$, $\eta_{p_2}=.03$	$F(2, 533)=2.57$ $p=.078$, $\eta_{p_2}=.01$
Means (*SDs*)					
Positive Response (*N*=179)	4.68(1.42)	4.43 (1.58)	3.81 (1.91)	4.05 (1.51)	3.03 (1.54)
Neutral Response (*N*=180)	4.17 (1.56)	3.71 (1.62)	2.92 (1.67)	3.44 (1.39)	4.57 (1.52)
Negative Response (*N*=180)	3.92 (1.60)	3.42 (1.48)	2.79 (1.62)	3.36 (1.31)	5.11 (1.56)
Instructor Warmth Condition					
Warm Instructor (*N*=270)	5.02 (1.20)	4.60 (1.37)	3.97 (1.69)	4.24 (1.30)	3.72 (1.79)
Cold Instructor (*N*=269)	3.49 (1.50)	3.11 (1.49)	2.37 (1.51)	2.99 (1.28)	4.75 (1.59)

	Instructor Warmth Condition (Means, *SDs*)							
	Lab Self-Efficacy		Lab Belonging		Intentions to Join Lab		Intentions to Recruit Others	
Instructor Response Condition	Warm	Cold	Warm	Cold	Warm	Cold	Warm	Cold
Positive Response (*N*=90, *N*=89)	5.53 (.85)	3.83 (1.37)	5.41 (1.11)	3.44 (1.35)	5.14 (1.29)	2.46 (1.42)	4.96 (1.16)	3.13 (1.24)
Neutral Response (*N*=90, *N*=90)	4.97 (1.10)	3.37 (1.55)	4.51 (1.24)	2.91 (1.56)	3.54 (1.63)	2.30 (1.47)	3.92 (1.29)	2.97 (1.32)
Negative Response (*N*=90, *N*=90)	4.58 (1.38)	3.26 (1.53)	3.87 (1.30)	2.97 (1.52)	3.24 (1.49)	2.35 (1.63)	3.85 (1.16)	2.87 (1.27)
Results of Pairwise Comparisons								
Positive vs. Neutral	M_{diff}=0.56 (.20) [.17, .94], p=.005 d=.57	M_{diff}=0.47 (.20) [.08, .86], p=.018 d=.31	M_{diff}=0.89 (.20) [.50, 1.29], p<.001 d=.76	M_{diff}=0.53 (.20) [.13, .92], p=.009 d=.36	M_{diff}=1.60 (.22) [1.16, 2.03], p<.001 d=1.09	M_{diff}=0.16 (.22) [−.27, .60], p=.462 d=.11	M_{diff}=1.04 (.18) [.68, 1.40], p<.001 d=.85	M_{diff}=0.17 (.19) [−.20, .53], p=.366 d=.12
Positive vs. Negative	M_{diff}=.95 (.20) [.56, 1.34], p<.001 d=.83	M_{diff}=.57 (.20) [.18, .96], p=.004 d=.39	M_{diff}=1.54 (.20) [1.14, 1.93], p<.001 d=1.27	M_{diff}=0.47 (.20) [.07, .87], p=.020 d=.33	M_{diff}=1.90 (.22) [1.47, 2.34], p<.001 d=1.36	M_{diff}=0.11 (.22) [−.33, .55], p=.626 d=.07	M_{diff}=1.11 (.18) [.75, 1.47], p<.001 d=.96	M_{diff}=0.26 (.19) [−.10, .63], p=.161 d=.21
Negative vs. Neutral	M_{diff}=-0.39 (.20) [−.78, −.01], p=.046 d=.00	M_{diff}=-0.10 (.20) [−.49, .28], p=.602 d=.07	M_{diff}=-0.64 (.20) [−1.04, −.25], p=.001 d=.50	M_{diff}=0.06 (.20) [−.34, .45], p=.783 d=.04	M_{diff}=-0.31 (.22) [−.74, .13], p=.168 d=.19	M_{diff}=0.06 (.22) [−.38, .49], p=.803 d=.03	M_{diff}=-0.07 (.18) [−.43, .29], p=.704 d=.06	M_{diff}=-0.09 (.19) [−.46, .27], p=.618 d=.08

For pairwise comparisons, standard errors appear in (parentheses) and 95% confidence intervals for mean differences appear in [brackets] next to p-values.

were perceived as less rude than cold instructors, M_{diff}=-1.03, $p < .001$, 95% CI=[−1.27, −.78], $d = .61$ (see Table 18).

These effects were qualified by significant Instructor Response × Instructor Warmth Condition interactions for belonging, intentions to join the lab, and to recruit other students to join (see Table 18 and Figures 2–4). Participants imagining a warm/friendly STEM professor who responded with a positive (vs. neutral or negative response) to their question reported higher belonging, intentions to join the lab, and to recruit other students to join the lab. Participants who imagined a warm instructor also felt greater belonging in the lab when they received a neutral versus negative response from them. For those who imagined a cold/critical professor, receiving a positive response boosting feelings of belonging compared to receiving a neutral or negative response. However, there was no evidence of differences in desire to join the lab or to recruit others to join between participants who imagined receiving neutral versus negative responses from a cold instructor.

Moderated mediation analyses

Given that there were significant interactions between the experimental conditions, we conducted moderated mediation analyses using Hayes (2018) PROCESS macro version 3.5.3 (model 8) with 5,000 resamples for 95% bootstrapped percentile confidence intervals.[7] We entered Instructor Response Condition as the independent variable, Instructor Warmth Condition as the moderator, self-efficacy and belonging as the mediators, and the dependent variables (i.e., intentions to join the STEM lab and to recruit other students to join the lab, respectively) into each model (see Table 19; Figures 5–6).

Bootstrapping analyses showed that the indirect effects excluded zero and the index of moderated mediation was significant for the models with belonging as the mediator. Participants who imagined having a warm/friendly instructor and receiving a positive (vs. neutral/negative) response from them reported greater belonging in the lab, which predicted greater intentions to join the STEM lab and to recruit others to join. When participants imagined having a cold/critical instructor, belonging still mediated the relationship between positive instructor responses and these outcomes, but the effects were not as strong. Notably, only belonging mediated the effects, not self-efficacy.[8]

Moderation by gender

Finally, we conducted ANOVAs to examine moderating effects of gender (see Table 5 in Supplemental Materials for full results). There were no significant three-way interactions between Gender, Instructor Response Condition, and Instructor Warmth Condition in predicting any of the outcomes. However, there were significant main effects of gender for belonging and intentions to join the lab, qualified by significant Gender × Instructor Response Condition interactions for lab self-efficacy, belonging, intentions to join the lab, and to recruit others to join the lab. There was also a significant Gender × Instructor Warmth Condition interaction for lab self-efficacy. Simple effects are reported in Table 5 of Supplemental Materials.

Compared to men, women reported lower lab self-efficacy, belonging, and intentions to join the STEM lab when they imagined receiving a neutral response from the instructor,

Table 19. Results of moderated mediation analyses (study 5).

	Conditional Direct Effects of Instructor Response Condition on Dependent Variables at Values of the Moderator	
	Intentions to Join STEM Lab	Intentions to Recruit Others to Join Lab
Warm/Friendly Instructor	.44 [.30, .58], p<.001	.24 [.11, .38], p<.001
Cold/Critical Instructor	−.14 [−.28, .00], p=.051	−.03 [−.1611], p=.699
	Conditional Indirect Effects of Instructor Response Condition on Dependent Variables	
	Intentions to Join STEM Lab	Intentions to Recruit Others to Join Lab
Warm/Friendly Instructor		
With Lab Self-Efficacy as Mediator	**.10 [.05, .16]**	**.04 [.01, .09]**
With Lab Belonging as Mediator	**.33 [.24, .44]**	**.25 [.17, .34]**
Cold/Critical Instructor		
With Lab Self-Efficacy as Mediator	**.07 [.02, .13]**	**.03 [.00, .07]**
With Lab Belonging as Mediator	**.14 [.04, .24]**	**.10 [.03, .19]**
	Index of Moderated Mediation	
	Intentions to Join STEM Lab	Intentions to Recruit Others to Join Lab
Instructor Warmth Condition		
With Lab Self-Efficacy as Mediator	−.03 [−.10, .03]	−.01 [−.05, .01]
With Lab Belonging as Mediator	**-.20 [−.33, −.07]**	**-.15 [−.26, −.05]**

Paths reflect unstandardized coefficients with 95% confidence intervals. Instructor Condition was coded as 1=positive, −1=neutral and negative response conditions. For indirect effects and index of moderated mediation, values within brackets that exclude zero are significant as indicated in bold.

but greater intentions to recruit other students to join the lab when they received a positive instructor response. Also, women who imagined having a cold/critical STEM instructor tended to report lower self-efficacy than men. However, this gender difference became non-significant in the warm/friendly instructor condition.

Discussion

Replicating our previous studies, participants benefited from having an instructor who responded positively to them when they imagined asking a question in a STEM seminar. Furthermore, having an instructor who was warm/friendly *and* who responded positively to participants' questions led to greater reports of self-efficacy, belonging, intentions to join the lab, and to recruit others to join the lab. Receiving a positive response from a warm/friendly instructor increased participants' sense of belonging in particular, which predicted their intentions to join the lab and to recruit others to join. Thus, feelings of belonging played a key role in shaping participants' intentions to pursue STEM opportunities by wanting to join the lab and recruiting others to join.

Internal meta-analyses

Given that the significance of the negative (vs. neutral) instructor response conditions varied across studies, we conducted an internal meta-analysis to obtain a more precise estimate of the results (Braver et al., 2014; Goh et al., 2016). For brevity's sake, full details of the meta-analytic approach and results appear in Supplemental Materials. Results of the meta-analysis revealed that participants reported lower self-efficacy, belonging, and less intentions to join the lab and to recruit others to join when they imagined receiving a negative (vs. neutral) instructor response when asking a question in a STEM lab seminar. We also conducted an internal meta-analysis of Studies 3, 4 and 5 to see whether instructors' responses in the neutral condition differed significantly from the negative response condition in terms of perceptions of the instructor's rudeness. The meta-analysis indicated that the neutral instructor response (*"We're actually out of time today, so please hold your question till next time"*) was rated as being significantly less rude than the negative instructor response condition (*"I'm not sure why you're asking this question, we went over this already"*).

Additionally, because the results differed across studies, we also conducted an internal meta-analysis to better estimate gender effects (see Supplemental Materials for full details). Compared to men, women who imagined receiving a positive instructor response when asking a question in a STEM lab context reported greater self-efficacy, belonging, intentions to join the lab and to recruit other students to join the lab. In contrast, women who received a negative instructor response reported lower self-efficacy, belonging, less intentions to join the lab and to recruit others to join the lab than men. If women experience more self-doubts than men, it seems reasonable that they would benefit more from receiving positive responses. Along these lines, research shows a significant gender gap in self-esteem, such that women generally report lower self-esteem than men (Bleidorn et al., 2016), which could be attributed to factors such as more frequent experiences of sexism among women that may erode self-esteem (Schmitt et al., 2002).

Furthermore, the internal meta-analysis revealed that, compared to men, women who imagined asking a question and receiving a neutral instructor response reported lower lab self-efficacy, lower lab belonging, less intentions to join the lab, and less desire to recruit other students to join the lab (see Supplemental Materials for full details). The gender difference that emerged in this condition suggests that women might perceive neutral responses from instructors as more similar to negative instructor responses than men do. That is, women may interpret neutral responses from instructors to be more negative or dismissive than men, because women may already be hypervigilant to noticing cues of threat in STEM contexts relative to men (Cheryan et al., 2009; Murphy et al., 2007; Park et al., in press).

Overall, the meta-analyses demonstrate that negative instructor responses are perceived as ruder and are more detrimental than neutral responses, and women show worse outcomes than men when they imagine receiving negative or neutral instructor responses. However, when women imagined asking a question in a STEM context and received a positive instructor response, they reported greater sense of self-efficacy, belonging, intentions to join the lab, and to recruit other students to join the lab, relative to men.

General discussion

The present studies suggest that instructors' verbal responses to students' questions serve as a powerful situational cue that shapes students' academic self-perceptions and motivation. Colleges and universities in the U.S. pride themselves on cultivating critical thinking and learning, which often involve students expressing, clarifying, and articulating their thoughts (Kim, 2002; Tweed & Lehman, 2002). While the importance of asking questions is a hallmark of the Western educational system and scientific thought, instructors may respond in ways that inadvertently undermine students' self-efficacy and belonging. For instance, although instructors sometimes perceive students' questions in a positive light, they also sometimes perceive questions to be disruptive if they detract from the goal to be efficient, maintain control over the classroom, or cover required curriculum (Rop, 2002). In addition, instructors may sometimes give feedback to students that inadvertently conveys low expectations and undermines students' motivation and engagement (e.g., Rattan et al., 2012).

When students imagined asking a question in a seminar designed to introduce them to STEM research opportunities and received positive (vs. neutral or negative) verbal responses from the instructor, they reported greater self-efficacy and belonging in the lab, which was tied to greater intentions to join the lab and to recruit other students to join the lab (Studies 1–5). Participants benefitted from imagining positive instructor responses not only when it was directed at them, but also when such responses were given to a classmate, occurred in a public or private setting, or in a STEM versus non-STEM context. Moreover, receiving a positive response from a warm (vs. cold) instructor led participants to report greater self-efficacy, which predicted greater intentions to join the STEM lab and to recruit other students to join the lab. Overall, these findings suggest that responding positively to students' questions may be an important situational cue of psychological safety that bolsters students' confidence, belonging, and interest in an academic setting.

We chose to focus on the STEM context in the present studies because students often doubt their abilities and inclusion in STEM, and are at increased risk of dropping out of STEM majors compared to other fields (Seymour & Hewitt, 1997). Research also suggests that positive responses and feedback from others are especially helpful in the early stages of goal pursuit, when individuals may be less skilled or have not yet committed to pursuing a domain (Fishbach et al., 2010). Indeed, while many participants in the current studies were enrolled in a STEM course, most were non-STEM majors. Given that most students taking introductory psychology courses are first- or second-year students, their choice of major may not yet be solidified. Students starting out in STEM fields may encounter new information that is challenging and necessitates asking questions to improve comprehension. Thus, for students beginning college who are exploring different classes, receiving positive responses from instructors in STEM contexts could be highly beneficial in facilitating their interest and engagement in STEM. Furthermore, results of our internal meta-analysis revealed that women, who often doubt their ability and belonging in STEM contexts (Cheryan et al., 2009; Good et al., 2012; Murphy et al., 2007; Walton & Brady, 2017), benefitted the most from imagining positive responses from instructors.

The present findings align with the broader idea that cues in the environment can signal psychological safety to enhance feelings of belonging and motivation among students with diverse social identities (Howansky et al., 2021). Along these lines, past research found that female college students who imagined (or actually received) positive versus objective written feedback on a math test reported higher self-efficacy, belonging, and more favorable attitudes toward, identification with, and interest in STEM (Park et al., 2018).

Other studies have shown that wise feedback – feedback that is critical yet reassures students they can meet high standards – increases institutional trust and academic performance among racially minoritized students (Cohen et al., 1999; Yeager et al., 2014). Wise feedback conveys that students' ability and belonging are evident, rather than in doubt. Whereas wise feedback has typically been studied in formal assessment situations (e.g., giving written feedback on essays), positive verbal responses may be a low-cost, efficient way to convey cues of psychological safety in real-time in the classroom. In fact, research suggests that for underachieving students, experiences of mastery in the classroom are key to developing self-efficacy (Fong & Krause, 2014). Accordingly, instructors' positive verbal responses to students' questions may signal to students that they have the capacity to succeed at mastering the material they learn in academic STEM environments.

Although the current studies focused on how instructors' positive responses to students'

questions improved student outcomes, instructors may benefit from this process as well. Encouraging and instilling the value of asking questions is likely to promote generative ideas, reveal gaps or contradictions in existing literatures or theories, and provide fruitful avenues for future research. Indeed, participants who received positive (vs. neutral or negative) instructor responses when asking questions not only reported greater intentions to join the lab, but to recruit other students to join. Having a lab that garners interest from a variety of students could lead to a strong lab culture that facilitates faculty members' research productivity and develops students' skills. Aside from career benefits, faculty may also reap personal and emotional benefits from mentoring students in their lab, such as feeling fulfilled, inspired, and a sense that they are making a difference (McKinsey, 2016). Students' questions may also demonstrate active listening and engagement (e.g., grappling with course content, repetition to encode material), so responding positively to students' questions could help to further strengthen students' learning and critical thinking skills.

Previous research examining the role of instructors in student outcomes focused on demographic characteristics of instructors (Carrell et al., 2010; Fairlie et al., 2013; Hoffmann & Oreopoulos, 2009), instructors' fixed versus growth mind-set beliefs (Canning et al., 2019; Muenks et al., 2020; Rattan et al., 2012), teacher confirmation behaviors (Ellis, 2000, 2004), and perceptions of feedback (Deci et al., 1999; Fong et al., 2018; Henderlong & Lepper, 2002; Koenka et al., 2021; Rattan et al., 2012). The present research adds to this literature by showing that merely imagining positive verbal responses from instructors when asking questions boosts students' academic self-perceptions and motivation. Further, there was no evidence that the benefits of positive instructor responses were limited to those who imagined receiving such cues themselves; imagining another student receiving positive responses also boosted participants' own self-efficacy and belonging in that environment. Likewise, positive instructor responses were beneficial across both public and private settings and in STEM and non-STEM contexts.

Positive verbal comments from warm instructors – who conveyed friendliness and concern – also led to better student outcomes than positive comments from a cold/critical instructor who appeared uninvolved. Such findings dovetail with qualitative studies showing that students who perceive feedback givers to be caring and supportive of their ability to learn view the feedback as more constructive (Fong et al., 2018), and experimental work showing that students put in more academic effort when they receive feedback from instructors that conveys high expectations and reassurance that they can succeed (Yeager et al., 2014). Receiving positive verbal responses from instructors, especially from instructors who show warmth and concern toward students, may thus have far-reaching consequences for students' self-perceptions and motivation.

Limitations and future directions

A limitation of the present studies is that they involved scenarios, which may not fully capture the experiences that students have in the classroom. Indeed, research on affective forecasting suggests that people's responses to hypothetical scenarios do not always correspond to how they actually feel or behave when they experience such events in the real-world (Wilson & Gilbert, 2003). For example, people often underestimate the positive impact of interacting with strangers (Epley & Schroeder, 2014), talking to close others (Kumar & Epley, 2021), giving compliments to others (Zhao & Epley, 2021a, 2021b), receiving social support (Dungan et al., 2022), learning from others through conversation (Atir et al., 2022), engaging in deep conversation (Kardas et al., 2022), and performing random acts of kindness (Kumar & Epley, 2023). Based on such findings, it seems possible that instructors may underestimate the beneficial impact of responding positively to students' questions. Furthermore, when students receive positive responses from instructors, they might benefit even more from this experience than they or their instructors expect.

Considering the present studies were cross-sectional in nature, future research could examine the effects of receiving positive feedback in an actual classroom setting across a given semester. Such real-world studies could be conducted by doing an intervention in which instructors in a course are advised to give positive or neutral responses to students' questions. Future work could also utilize a daily diary methodology, whereby students could indicate if they asked a question in a particular class on a given day, how their instructor responded, and their feelings of belonging and self-efficacy. Interventions or the use of daily diaries may capture students' experiences in a more naturalistic way.

It is also plausible that the effect of instructor responses to questions could potentially be *less* robust in the real-world. For instance, other contextual factors and additional information about the instructor may potentially weaken our hypothesized effects. For example, past work has shown that even brief exposure to instructors' nonverbal cues affects students' experience and persistence in the classroom (Ambady & Rosenthal, 1993). In real-life interactions, subtle nonverbal cues might further influence how certain content is processed and interpreted. For instance, an instructor who responds with an unenthused tone, impatient tapping of their foot, or an unpleasant facial expression may detract from positive message content.

In contrast, when positive statements are paired with encouraging head nods or validation while students ask their question (e.g., "mhm," "yeah"), such cues may signal to students that the instructor is actively engaged, listening, and interested in their question. Along these lines, a growing body of research suggests that high-quality listening can be beneficial for both the speaker and the listener by creating a sense of togetherness that promotes a wide range of positive outcomes (see Kluger & Itzchakov, 2022, for a review). Future work could thus examine how nonverbal and paraverbal cues, paired with different verbal content, shape students' self-efficacy and belonging in STEM settings.

In our preliminary studies, students reported receiving less positive verbal responses from instructors when asking questions in their math versus English courses; instructors, too, reported giving less frequent positive responses to students' questions in math versus English courses. In fact, students reported receiving more negative verbal responses from instructors when asking questions in their math courses. Such findings suggest that in the real-world, positive verbal comments from instructors may be less common in STEM-related courses such as math, compared to courses in the Humanities, such as English. On a related note, in the real-world, instructors are not always male, as they were portrayed in the current studies. Future research could thus investigate whether the effects of receiving positive instructor responses differ for students, especially for women, depending on whether instructors are male versus female.

Given that the negative and neutral instructor response conditions functioned similarly in some of the current studies, it could be that participants interpreted their question as being either welcomed or unwelcomed by the instructor. Future work could identify a truer neutral condition, whereby a students' question is answered without any cues as to whether the question was welcomed or not. Alternatively, although the present studies were sufficiently powered to detect small-to-medium effects (see Table 4), it is possible that meaningful differences between conditions were too small to be observed in some cases. In addition, whereas the current studies did not specify whether the question that students asked was content-based and substantive, or more procedural and logistical regarding the lab, future studies could examine whether the effects of instructors' responses to students' questions depend on the type of question asked.

Another limitation of the present research is that the mediation analyses we conducted were correlational in nature, so we cannot draw firm causal conclusions about the links between type of instructor response, the mediators of self-efficacy and belonging, and the outcomes of intentions to join the STEM lab and to recruit others to join the lab. For example, it could be the case that instructor responses predict greater intentions to join the STEM research lab, which in turn, increases perceptions of self-efficacy and belonging. We think this reverse pathway is less likely, however, based on past work suggesting that self-efficacy and belonging precede motivation and behavioral intentions (Bandura, 1977, 1986; Good et al., 2012). To help address issues of temporal precedence, future studies could use longitudinal methods to examine the impact of instructors' responses on students' self-perceptions and subsequent behaviors over time. For example, one possibility is that positive instructor responses boost students' self-efficacy and belonging, which guide their behavioral choices, which then serve to further strengthen their perceptions of ability and belonging via recursive processes.

Researchers could also examine how long boosts to self-perceptions and motivation last after receiving positive instructor responses, and investigate additional boundary conditions of these effects. For example, researchers could study the effects of receiving positive responses from individuals with differing degrees of social power, such as faculty versus peers. For instance, when peers give a classroom presentation and students ask them a question, would peers' responses to questions similarly boost students' self-efficacy, belonging, and motivation in that context? And while the current research found that asking a question in a public or private setting did not differentially affect outcomes, the size of the classroom was not specified. Thus, it is unclear how many other students participants visualized in the hypothetical classroom, which could have affected the extent to which they felt public recognition or not. Future studies could therefore manipulate class size to examine effects of instructor responses on student outcomes.

The gender of other students who ask a question may also be important to consider in future work, especially in gender-dominated fields. While the current research examined broad domains (e.g., STEM and the Humanities), the gender proportions in subfields are more variable. For instance, women are still underrepresented in philosophy, computer science, and engineering (American Academy of Arts and Sciences, 2019; NSF, 2019). In such male-dominated fields, if female students see an instructor respond positively to a male student asking a question, this observation may not necessarily boost women's self-efficacy or belonging within the field.

Conversely, seeing a female student not understand a concept in class could increase feelings of threat if one perceives the group member to confirm negative stereotypes that women are not capable in the underrepresented field. However, if a female student sees an instructor respond positively to another female student, this could heighten the benefits of positive instructor responses on the witness. Seeing other underrepresented students receive positive instructor responses might signal to the student that they, too, are valued and capable of succeeding, leading to stronger transfer effects. Future work could consider such transfer effects, while also attempting to provide a deeper understanding of differences both across and within fields, such as in Philosophy or Engineering.

Finally, in the present studies, we did not ask participants who they were thinking of when they reported their intentions to recruit other students to the lab. It could be the case that women students were thinking about recruiting other women, while men were thinking about recruiting other men, which may have influenced their responses to this question. Perhaps women may be less inclined to have other women experience neutral or negative instructor responses in STEM contexts, especially when such environments are threatening due to cues of social identity threat or stereotype threat. Men, on the other hand, may be less worried about subjecting other men to STEM environments because they are less likely to experience threat in these settings.

Conclusion

The current studies show that positive verbal cues from instructors in STEM contexts can have a beneficial impact on student outcomes. Whereas the literature on academic interventions has often focused on students by having them engage in self-affirmation, social-belonging, or growth mind-set interventions (Rattan et al., 2015; Walton & Cohen, 2011; Yeager et al., 2014), the present studies point to the value of changing subtle cues in the environment, including how instructors respond to students' questions. Many students initially struggle in STEM courses and may be apprehensive about asking questions. Indeed, our preliminary studies revealed that in real-world settings, students are less likely to ask questions in their STEM courses and when they do, instructors respond less positively (and more negatively) to students' questions in math versus English courses.

Importantly, our findings advance previous work in this area by showing that positive instructor responses to students' questions are beneficial *even when* such responses are imagined and are especially impactful when they come from an instructor who conveys warmth toward their students. Moreover, our studies suggest that positive instructor responses are especially beneficial for women, who are often underrepresented and lack a sense of belonging in STEM settings. Future research could explore additional boundary conditions of these effects, examine the impact of this teaching practice in real-world settings, and seek to further understand why certain groups may differentially benefit from receiving positive verbal responses from instructors.

Notes

1. Degrees of freedom varied slightly because two participants did not complete the English class items in the survey.
2. When asking these items, we did not use the terms "positive," "negative," or "neutral" in describing the statements.
3. We used this same PROCESS macro and model to analyze the data in Studies 2–4.
4. When conducting moderating effects of gender analyses for these studies, we did not include data from participants who reported their gender as non-binary because there were not enough participants to examine differences between members of this group and other gender groups.
5. Mediation results stayed the same (i.e., the indirect effects remained significant) when target of the instructor response condition (self vs. another student) was not controlled for in Study 2.

6. Mediation results stayed the same (i.e., the indirect effects remained significant) when public versus private condition was not controlled for in Study 3.
7. Because the neutral and negative instructor response conditions did not differ significantly across the dependent variables in this study, we collapsed across these conditions to compare the positive instructor response condition to both of these conditions simultaneously.
8. In Study 5, results of moderation mediation analyses remained the same – i.e., the index of moderated mediation examining instructor warmth condition and lab belonging as the mediator remained significant in predicting the dependent variables – when the positive instructor response condition was compared to the negative response condition. When comparing positive versus *neutral* response conditions, the index of moderated mediation with lab belonging as the mediator was non-significant for intentions to join the lab, B=−.11, 95% CI [−.26, .06], and intentions to recruit other students to the lab, B=−.08, 95% CI [−.20, .04].."

Disclosure statement

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