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Growing STEM:

Perceived Faculty Mindset as an Indicator of Communal Affordances in STEM

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Abstract

As students explore science and engineering fields, they receive messages about what competencies are required in a particular field, as well as whether they can reach their goals by entering the field. Faculty members convey information both about whether students might *have the ability to succeed* in a particular field and also whether students might *want to succeed* in a particular field – is this career one that serves the values or goals of the student? We hypothesize a novel pathway through which growth vs. fixed mindset messages communicated by faculty affect students. Specifically, we explore whether emphasizing the potential for growth, rather than emphasizing fixed abilities, can indicate to students that STEM fields offer opportunities to fulfill their goals. Across 8 studies, we find that perceiving that faculty endorse growth vs. fixed mindset beliefs increases beliefs that STEM contexts afford communal and agentic goals; perceived communal affordances more strongly predict people’s interest in pursuing STEM education and careers.

Keywords: goals; motivation; growth mindset; STEM

Growing STEM: Perceived Faculty Mindset as an Indicator of Communal Affordances in STEM

The student sitting in the first-year chemistry lecture hall and the faculty member standing at the podium both engage in evaluative processes that are key to that student's decision to continue in science. The faculty member evaluates the student's abilities to perform the tasks of the discipline, certainly. However, the student also engages in evaluative processes, especially in determining whether this particular field offers opportunities to meet the goals that the student values. In this sense, the reach of faculty extends far beyond building and evaluating competency with the course material. Whether intended or not, faculty also communicate the values and opportunities of their fields. Faculty do not simply introduce students to the work of the field; they also introduce students to cues about whether that work is worth students' effort and talents.

Faculty Communicate Goal Affordances

Faculty convey information both about whether students might *have the ability to succeed* in a particular field and also whether students might *want to succeed* in a particular field – is this field one that serves the goals of the student? This distinction between the expectation of success and the value accorded to such success is central to expectancy-value models (Wigfield & Eccles, 2000). In particular, value will be accorded when a particular role provides opportunities to fulfill an individual's values. **We propose that faculty members provide information not only about whether a student possesses the capacity to succeed in a field, but also whether a particular field aligns with that student's values. In other words, can students meet their goals by investing in this particular field?**

As students consider their options in pursuing different academic paths, they assess whether entering into a particular social role will provide opportunities to meet their valued goals (Diekmann, Steinberg, Brown, Belanger, & Clark, 2017). Engaging in a specific behavior is both

a function of what an individual values as well as a function of what that individual perceives the situation to afford (Kruglanski, Chernikova, Rosenzweig, & Kopetz, 2014). In this sense, the construct of *affordances* – potential opportunities to fulfill one’s goals within particular roles – is central to the question of why students opt into some fields and out of others. When a career path offers opportunities that align with a student’s goals, the student is more likely to prefer that path to others that are seen as less likely to afford their goals.

Grounded in a rich history of research that examines behavior as a function of motivation and cognition (e.g., Atkinson, 1957; Bandura, 1986), the goal congruity framework might be applied to goal pursuit across many domains. Our analysis focuses on self-oriented or *agentic* goals (e.g., achievement, power), and other-oriented or *communal* goals (e.g., helping, prosociality, relatedness). Both agentic and communal dimensions are highly valued by people (Pöhlmann, 2001); however, some individuals may value one or the other more strongly. In explaining decisions to enter and persist in STEM, perceptions about the opportunities to pursue communal goals can exert special impact. People generally value communal goals, but STEM fields are often perceived to offer fewer communal opportunities than other career paths (Diekman, Brown, Johnston, & Clark, 2010). In short, career pathways are more attractive when they are viewed as providing opportunities to pursue these important dimensions of human experience.

Perceived Goal Affordances Influence Students’ STEM Motivation

Understanding perceived opportunities to pursue both agentic and communal goals can illuminate decisions to enter or opt out of STEM fields. Consistent with their focus on status, achievement, and financial success, agentic goals figure prominently in most professional pathways. Not surprisingly, then, agentic goal endorsement positively predicts interest in STEM

careers (Diekman et al., 2010), and perceived agentic opportunities in STEM classes predict positive memories of those classes (Fuesting, Diekman, & Hudiburgh, 2017). However, focusing solely on perceived agentic opportunities fails to explain why many STEM fields continue to struggle to recruit highly qualified and motivated students. To answer this question, the goal congruity model posited that STEM fields are perceived as uniquely lacking in communal opportunities, and thus highlighting those communal opportunities provides leverage in attracting and retaining students – particularly those who value communal goals (Diekman et al., 2017).

Consensual beliefs hold that STEM fields typically do not afford opportunities to connect to or help others. College students perceive STEM to provide less communal opportunity than career paths in business, law, medicine, or education (Diekman et al., 2010; Diekman, Clark, Johnston, Brown, & Steinberg, 2011). People perceive that scientists have fewer communal traits than the typical adult woman or man (Carli, Alawa, Lee, Zhao, & Kim, 2016), and they believe it is uniquely challenging to find a communal role model in STEM compared to other fields (Fuesting & Diekman, 2017). The stereotypical picture of STEM is thus unattractive to those who value communal goals, and therefore reduces motivation in these contexts. Put another way, opportunities for achievement are necessary, but not sufficient, for decisions to enter STEM pathways. Indeed, perceived opportunities to pursue communal goals more strongly predict interest in STEM careers than perceived opportunities to pursue agentic goals (e.g., Brown, Smith, Thoman, Allen, & Muragishi, 2015; Fuesting et al., 2017).

One consequence of consensual beliefs that STEM fields do not afford communal goals is that highlighting how STEM fields can provide such opportunities heightens attraction to these fields (Diekman et al., 2011; see also Boucher, Fuesting, Diekman, & Murphy, 2017, for a

review). Importantly, certain groups (e.g., women) are on average more likely to value communal opportunities, and thus can be particularly motivated by communal opportunities in STEM (e.g., Diekman et al., 2011; Thoman, Brown, Mason, Harmsen, & Smith, 2015; Thoman, Muragishi, & Smith, 2017). However, people across group memberships tend to highly value communal goals (e.g., Diekman et al., 2011; Pöhlmann, 2001) because relatedness and belonging constitute fundamental human drives (Baumeister & Leary, 1995; Ryan & Deci, 2000).

Experimental data illustrate the causal role of communal affordances in elevating STEM interest for individuals from a variety of group memberships. For instance, male and female students reported greater motivation after learning about biomedical labs whose research led to improved quality of life (Brown et al., 2015), or reading about scientist exemplars who collaborated with others (versus worked independently; Clark, Fuesting, & Diekman, 2016). Students (both women and men) also exhibited more interest in hypothetical engineering courses that integrated service learning than traditional courses (Belanger, Diekman, & Steinberg, 2017). This accumulating evidence suggests that understanding the perceived opportunities to pursue both communal and agentic goals within STEM is key to understanding students' STEM interest. But how do students learn whether a field offers opportunities to pursue communal or agentic goals?

Faculty Mindsets May Shape the Perceived Goal Affordances of Different Fields

This paper explores whether faculty mindsets shape students' perceptions about the goal opportunities that exist in a field. Mindsets refer to people's beliefs about the nature of ability (Dweck, 1999). People who endorse a fixed mindset believe that abilities are relatively fixed—"you either have them or you don't." People who endorse a growth mindset believe that ability

can be developed and improved through effort, help-seeking, and applying the right strategies (e.g., Dweck & Leggett, 1988; Yeager & Dweck, 2012).

Especially when entering a new role, understanding the mindsets of others in a context can be essential for success; however, not all mindsets are equally important. Newcomers look to the mindset beliefs of powerful people to determine the characteristics that are valued in a particular setting (Murphy & Dweck, 2010). In academic contexts, faculty hold power, and thus their mindset beliefs may be particularly important, consistent with previous research showing the impact of ability beliefs that emanate from powerful gatekeepers who represent the standard bearers of a field (Emerson & Murphy, 2014). The perceived mindsets of faculty reflect one component of *institutional mindset*, or the perceived mindset of a specific context (like a classroom) that is communicated by central features of that context, including its decision makers' verbal and nonverbal behavior, its reward structures, or its evaluation policies (Murphy & Dweck, 2010). Importantly, perceptions of an instructor's mindset that most students have scientific potential more strongly and consistently predict positive outcomes (e.g., belonging) in STEM settings than individuals' own beliefs about intelligence (Rattan, Savani, Komarraju, Morrison, Boggs, & Ambady, 2018, Study 4). Perceptions of powerful people's mindsets in a setting (e.g., teachers in a classroom, employers in a new job) shape the goals and behaviors of others (e.g., students, workers). For instance, when newcomers perceive that powerful people endorse more of a fixed mindset, they pursue performance goals in that setting— aiming to demonstrate their competence and individual performance by highlighting their past awards and achievements (Murphy & Dweck, 2010).

Indeed, fixed mindset environments may be particularly toxic for the pursuit of communal goals. At their core, fixed mindset environments focus on proving oneself through

performance: People strive to prove that they are “the best”—the most talented and skilled individual in the setting (Murphy & Dweck, 2010). In such contexts, there may be little benefit for people to work together because shared credit could mask individual performance. Further, performance-focused environments tend to foster zero-sum competition where another’s failure may be necessary for one’s success (Ames, 1992; Crocker & Canevello, 2008; Crocker, Olivier, & Nuer, 2009). This competition can dampen collaboration: Supporting this idea is experimental evidence that students who imagined working for a professor who emphasized outperforming other research interns (vs. building one’s skills) were less likely to help a fellow research intern (Poortvliet & Darnon, 2014). Similarly, endorsing self-image goals can lead individuals to view others as threatening because these others can disconfirm that one possesses desired traits (Crocker & Canevello, 2008; Crocker et al., 2009). On the whole, collaborating with or helping others may be seen as counterproductive in fixed mindset contexts, particularly when one’s success in demonstrating competence and superiority necessitates a classmate’s failure in the same.

Growth mindset environments, on the other hand, may encourage communal values and behaviors. At their core, growth mindset environments value learning and development (Murphy & Dweck, 2010); when one’s own success is determined by individual progress rather than outperforming others, individuals are more likely to offer help to others. Consistent with this claim is the finding that managers who were assigned to a growth mindset intervention (vs. control) were more willing to coach an employee who exhibited poor job performance, and they provided more constructive feedback to the employee (Heslin, Vandewalle, & Latham, 2006). Likewise, an ecosystem perspective sees the self as embedded within a community of others, and

compassionate goals are primary: Individuals who adopt compassionate goals tend to give and receive more social support (Crocker & Canevello, 2008).

Seeking help from others can be dampened in fixed mindset environments and enhanced in growth mindset environments. In a fixed environment, struggle is a sign of low ability, so people are likely to hide their mistakes and struggles in order to avoid being seen as lacking the ability necessary to succeed in that context (Dweck, Chiu, & Hong, 1995; Dweck & Leggett, 1988; Erdley & Dweck, 1993). Even offers of support from others might be met with suspicion: People who adopt self-image goals are more likely to mistrust others and assume that offering support serves another's self-interest (Crocker & Canevello, 2008; Crocker et al., 2009). In contrast, growth mindset environments value development and view struggle as integral to the building of ability. Thus, in growth mindset environments, students may be more likely to admit mistakes and seek help because these behaviors are seen as means to develop ability (Dweck & Leggett, 1988). In a growth environment, failure may be more likely to be construed as a challenge than a threat (e.g., Tomaka, Blascovitch, Kelsey, & Leitten, 1993), thus fostering academic success (e.g., Alter, Aronson, Darley, Rodriguez, & Ruble, 2010).

Finally, fixed mindset environments might engender less prosocial behavior than growth mindset environments. For instance, high school students randomly assigned to a growth mindset intervention demonstrated less aggression towards their peers and wrote more prosocial notes to someone who excluded them from an online game of catch. Indeed, these prosocial effects were long lasting: High school students assigned to the growth mindset intervention were nominated by their teachers as exhibiting fewer behavioral problems three months after the intervention (Yeager, Trzesniewski, & Dweck, 2013).

Although the prediction that fixed (vs. growth) mindset environments are less likely to support communal goals is clear, it is less clear how these environments will relate to agentic goals. Some evidence suggests that fixed mindset environments might increase perceived opportunities to pursue agentic goals, whereas other evidence suggests that fixed mindset environments might decrease perceived opportunities for agentic goals. As described above, the fixed mindset focuses students on displaying their abilities and achievements, which might motivate students who feel that they have strong abilities. However, these environments may leave many students apprehensive as to whether they can fulfill their agentic goals of power and status in these environments—especially if they are less sure about their abilities. Indeed, maintaining goals of demonstrating one’s intelligence and competence can deplete the cognitive resources necessary to perform well on academic tasks (Crouzevialle & Butera, 2013). Ironically, a goal to demonstrate achievement may prevent one from actually attaining this goal.

In contrast, the growth mindset focuses students on developing their abilities. Thus, growth mindset environments might elevate perceived opportunities to pursue a variety of goals—that is, both communal and agentic goals. A focus on the development of potential might be applied to achievement and independence (i.e., agentic goals), as well as to collaboration and altruism (i.e., communal goals). In sum, based on the prior literature, it is plausible to hypothesize that either fixed or growth mindset contexts will foster the perception of agentic opportunities. Given these competing hypotheses, empirical investigation of how faculty mindset influences agentic opportunities is needed.

Overview

Eight studies investigated how the perceived mindsets of STEM faculty relate to differential beliefs about the goal affordances of STEM fields, and how these goal affordances

influence students' interest in STEM fields. We explore these questions using multiple methods. First, we examine the naturally-occurring relationships between student perceptions of their STEM professors' mindsets, the perceived affordances in STEM majors, and student interest in pursuing a STEM major. We then employ experimental methods in Studies 2a, 2b, and 3 to demonstrate that perceived faculty mindset influences the goal affordances of academic settings and that communal affordances especially predict interest in STEM. Studies 4a and 4b further investigate the impact of perceived faculty mindset on STEM affordances within recalled educational experiences. Finally, Studies 5a and 5b examine how specific growth-oriented teaching practices influence students' beliefs about the communal opportunities in STEM careers and how these beliefs influence students' interest in pursuing STEM careers.

Throughout this work, we maximized power through a range of strategies. All studies relied on theoretically-derived measures, many of which had been used in previous research. Across the studies, we balance investigations of specific populations of interest (i.e., Study 1's sample of students highly identified with science and mathematics) with larger nonspecialized samples. For experimental studies, we report manipulation and attention checks and exclude respondents who do not meet criteria in order to maximize our signal-to-noise ratio (e.g., Oppenheimer, Meyvis, & Davidenko, 2009).

In addition, we report sensitivity analyses for each study. Sensitivity analyses provide an estimate of the smallest effect size that can be detected, given a sample size and several specified conditions. In this research, sensitivity analyses provide estimates of the smallest detectable effect size given the sample sizes in each study with power of .80, alpha of .05, and two-tailed tests (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). Sensitivity analyses may be particularly useful in research establishing new effects (here, the

effect of perceived faculty mindset on goal affordances) because they do not require an estimate of an unknown effect size. Thus, throughout this work, we use sensitivity analyses to report the minimum detectable f^2 adopting the effect size conventions from Cohen [1988; small = .02 (2% of variance explained), medium = .15 (13% of variance explained), and large = .35 (26% of variance explained)].

Study 1

Do students' impressions of STEM faculty mindset predict the goal opportunities that they perceive STEM fields to offer? Study 1 provided an initial examination of whether students' perceptions of STEM faculty mindsets relate to perceived goal affordances in the faculty's major, and whether these perceived goal affordances in turn related to students' interest in pursuing a STEM major. Study 1 explored these processes among students who reported being highly identified with math and science (that is, math and science were important to them and they believed themselves to be good at math and science tasks).

Participants and Procedure

All procedures were approved by the institutional review board. Eighty undergraduates at a large, public Midwestern university (36 men, 44 women, $M_{\text{age}} = 19.78$) responded to measures in the second year of a larger longitudinal study. Of these participants, 24 self-identified as White, 23 as Asian or Asian American, 12 as Hispanic or Latinx, 11 as Black or African American, and 10 as multi-racial or other. All participants were highly identified with math and science (see Steele & Aronson, 1995; Spencer, Steele, & Quinn, 1999); 37.5% reported that they were most interested in declaring a STEM major (e.g., biology, chemistry), 48.8% reported that they were most interested in declaring a major closely related to STEM (e.g., kinesiology, psychology, nursing), and the remainder were non-STEM majors (e.g., theatre, advertising). For

the purposes of this work, we refer to majors in engineering, technology (e.g., computer science), mathematics, or natural science disciplines (e.g., physics, biology, chemistry) as STEM majors; these participants do not include students majoring in social sciences (e.g., psychology).

Sensitivity analyses indicated that regressions with two predictors could detect a single regression coefficient with an effect size of $f^2 = .10$ (Faul et al., 2007, 2009).

Measures¹

Perceptions of STEM faculty mindset. Nine items, adapted from Dweck (1999), assessed student perceptions of their STEM professors' fixed or growth mindset (e.g., *In general, most of my math and hard science professors seemed to believe that students either "have it" or they don't*). Students responded on scales ranging from 1 (*strongly agree*) to 6 (*strongly disagree*). After reverse coding the fixed-phrased items, all items were averaged so that higher scores indicated more of a perceived growth mindset ($\alpha = .87$).

STEM major goal affordances. Nine items, adapted from the communal affordance scale in Diekmann and colleagues (2010) assessed students' beliefs that STEM majors at their institution allowed students to pursue different communal goals (e.g., working with people, serving humanity). Each item was rated on a scale from 1 (*not at all*) to 7 (*very much*) and items were averaged so that higher numbers indicated greater perceived communal affordances ($\alpha = .93$). In a similar fashion, 14 items adapted from the agentic affordance scale in Diekmann and colleagues (2010) assessed student beliefs that STEM majors at their institution allowed students to pursue different agentic goals (e.g., achievement, self-direction; $\alpha = .97$).

¹ All measures for all studies are available in the online supplement; the online supplement also includes additional procedural details for all studies.

STEM major interest. One item assessed the extent to which students were interested in pursuing a STEM (Science, Technology, Engineering, or Math) major. This item was rated on a scale from 0 (*not at all*) to 7 (*extremely*).

Results

Summary of gender and race/ethnicity effects. Neither participant gender (effect coded -1 = male, 1 = female) nor participant underrepresented race/ethnicity (effect coded -1 = white or Asian, 1 = Black, Hispanic or Latinx, or multiracial) moderated any of the analyses (interactions, $ps > .10$). Therefore, these factors are not included in the analyses below.

Does perceived faculty mindset predict STEM goal affordances? Two separate regression analyses examined whether students' perceptions of STEM faculty mindset predicted students' beliefs that STEM majors afforded communal and agentic goals. Results revealed that when respondents perceived STEM faculty to endorse more of a growth (vs. fixed) mindset, they perceived greater opportunities within STEM majors at their institution to pursue communal goals, $b = 0.44$, *Standard Error (SE)* = 0.20, $p = .03$, $\beta = .25$, and agentic goals, $b = 0.40$, *SE* = 0.18, $p = .03$, $\beta = .24$.

Indirect effects: Does perceived faculty mindset predict greater interest in STEM through perceived goal affordances? Next, we examined indirect effects of perceived faculty mindset on pursuing a STEM major through communal or agentic goal affordances. Because our measures of communal and agentic affordances were strongly correlated, $r(78) = .76$, $p < .0001$, we analyzed the indirect effects of communal and agentic affordances in separate models because of multicollinearity concerns.²

² When included in the same model, communal and agentic affordances were positive, but nonsignificant, predictors of major interest, $ps > .10$.

Using Hayes' (2013) PROCESS macro model 4 with 10,000 bootstrapped samples, we first investigated whether perceived faculty mindset predicted student beliefs that STEM majors afforded communal goals, which in turn predicted greater interest in pursuing a STEM major. As seen in Figure 1 (panel A), perceived faculty growth mindset was associated with greater interest in pursuing a STEM major via increased perceptions that STEM majors would offer communal goal opportunities [indirect effect = 0.18, $SE = 0.13$, 95% Confidence Interval (CI) [0.01, 0.57]. Similarly, as seen in Figure 1 (panel B), perceived faculty growth mindset was associated with greater interest in pursuing a STEM major via increased perceptions that STEM majors would offer agentic goal opportunities [indirect effect = 0.17, $SE = 0.13$, 95% CI [0.004, 0.56]. Considering both models, perceived faculty mindset did not directly predict STEM interest; instead, the perceived growth mindset context benefitted students' interest in majoring in STEM through perceived communal and agentic goal affordances.

Discussion

As hypothesized, perceived faculty mindset related to perceived communal goal affordances, as well as agentic goal affordances; these goal affordances predict interest in STEM. Students who perceived STEM faculty as more growth-oriented believed that pursuing STEM majors at their institution afforded more goals, and these perceived affordances predicted interest in pursuing a STEM major. This effect provides a novel demonstration of how growth vs. fixed mindset cues in the classroom environment influence students: Growth-oriented, more than fixed-oriented, instructors signaled that STEM fields afford communal and agentic goals, which, in turn, predict elevated interest in pursuing STEM.

Studies 2a-2b: Impact of Perceived Faculty Mindset on Educational Affordances

The initial demonstration in Study 1 captures naturalistic variability in students' perceptions of STEM faculty mindset and students' beliefs about the affordances available in STEM majors at their institution. Studies 2a and 2b provide two critical extensions. First, we employ experimental rather than correlational methods; second, we investigate whether communal or agentic affordances predict STEM interest when included in the same model.

Further, as an additional investigation of communality, we examine students' forecasts of whether helping behaviors will occur in an academic environment. In fixed mindset settings, students may focus on proving and performing, rather than learning and developing their own and others' skills. We, thus, hypothesize that growth mindset environments will be perceived as integrating helping behaviors, whereas fixed mindset environments will not.

Method

Studies 2a and 2b employ parallel methods but focus on different educational contexts: In Study 2a, participants considered a hypothetical STEM course taught by a faculty member who explicitly endorses a fixed or growth mindset, and in Study 2b, participants considered a STEM major headed by a faculty member who explicitly endorses a fixed or growth mindset.

Participants. We recruited 231 participants for Study 2a via Amazon's MechanicalTurk (MTurk). Participants were only able to participate if they were from the US and currently or recently enrolled in college courses. We excluded 22 respondents for failing the attention check, which asked them to recall two details from the article they read ($n = 11$ in each condition). Participants were screened on the basis of their ability to correctly choose correctly from 3 options that the research in the article compared twins who shared the same genes and were raised apart (vs. twins who did not share identical genes, or cousins who shared an environment). Participants also had to recall from 4 options that the article found that 88% (vs. 22%, 0%, or

100%) of intelligence was due to either the environment (growth mindset condition) or genetics (fixed mindset condition). Analyses including participants who failed the attention check had similar, but weaker, results. The final Study 2a sample included 209 participants (91 men, 114 women, 4 not reporting; $M_{age} = 26.16$), and 159 self-identified as White, 19 as Asian or Asian American, 14 as multiracial, 11 as African American or Black, and the remainder as other or preferred not to share; 25 participants identified as Hispanic or Latinx. Fifty-six percent of participants were STEM majors (e.g., computer science, biology), and the remainder were not (e.g., business, psychology).

We recruited 227 participants for Study 2b from the introductory psychology pool at a medium-sized Midwestern university who received partial fulfillment of a course requirement. Fifty-six respondents were excluded from analyses because they failed the attention check used in Study 2a ($n_{growth} = 30$ and $n_{fixed} = 26$). Analyses including participants who failed the attention check revealed an identical pattern of results. The final Study 2b sample consisted of 171 participants (66 men, 105 women; $M_{age} = 18.64$ years), and 144 identified as White, 13 identified as Asian or Asian American, 5 identified as Black or African American, 5 identified as multiracial, and the remainder identified as other or preferred not to share. Twenty-six percent of participants were STEM majors, and the remainder were other majors (e.g., business, kinesiology).

We conducted sensitivity analyses within each study that showed ability to detect small to medium effects: Regression analysis with 3 predictors yielded sensitivity to effect sizes of $f^2 = .05$ or smaller; mixed model ANOVA with 2 groups and 2 dependent variables could detect effects of $f^2 = .11$ or smaller.

Procedure. All procedures were approved by the institutional review board. Participants were randomly assigned to read about a faculty member who explicitly endorsed either fixed or growth mindset beliefs. These beliefs were embedded in an article adapted from Muenks and colleagues (2018) entitled “The Origins of Mathematical Abilities: Is the Nature-Nurture Controversy Resolved?” Both versions of the article described a large body of research that purportedly put to rest the question of whether mathematical abilities are due to heredity or the environment. The article quoted Dr. Rescorla, the director of a major university’s intelligence research lab, and featured her excitement about the evidence on the nature of mathematical ability. The fixed faculty mindset article presents information that a growing body of evidence suggests intelligence is fixed and mainly due to innate, genetic factors, and that environmental factors show little influence on mathematical ability and intelligence. The growth faculty mindset article presents information that a growing body of evidence suggests intelligence is malleable and mainly due to environmental factors.

Participants then read further about Dr. Rescorla, a prominent scientist who described the consensual fixed (or growth) mindset beliefs of her colleagues. She says:

Although we now know definitively, I think everyone in my department was excited about Eysenck’s and Knowles’ findings [on the nature of mathematical ability and intelligence] in part because we always believed that this is how intelligence worked. All of my colleagues were also happy to hear about their findings because they completely support how we have all approached teaching our students and designing our classes since we began our positions here.

Participants then responded to manipulation check measures that assessed their perceptions of the mindset beliefs of the faculty featured in the article. Next, participants imagined that Dr. Rescorla worked at their university. The Study 2a prompt read as follows:

Imagine that Dr. Rescorla and her like-minded colleagues work at your university, and that you are taking a science course taught by Dr. Rescorla. Take a moment to picture what you think taking a science course with her would be like. From understanding how Dr. Rescorla views intelligence, imagine how her course would be structured, what classes and labs would be like, and what course exams and quizzes would be like.

The Study 2b prompt read as follows:

Imagine that Dr. Rescorla and her like-minded colleagues work at your university. Dr. Rescorla is the head of one of the science departments, and she and her colleagues... teach all courses required in the science major. Take a moment to picture what you think majoring in this science department would be like. From understanding how Dr. Rescorla views intelligence, imagine how the major and its courses would be structured, including what classes and labs would be like, and what course exams and quizzes would be like.

Participants then responded to measures about specific helping behaviors and the goal affordances of the science course or major. Finally, students reported their interest in pursuing Dr. Rescorla's STEM course or major.

Measures.

Perceived faculty mindset (manipulation check). Eight items, adapted from Dweck (1999), assessed students' perceptions that the faculty believed that intelligence was fixed or malleable (e.g., "*these science professors seem to believe that no matter how much intelligence students have, they can always change it quite a bit*"). Responses were made on a scale from 1

(*strongly disagree*) to 7 (*strongly agree*) and fixed-phrased items were reverse-scored and averaged. Thus, higher values indicate greater perceived growth mindset among faculty ($\alpha_{\text{Study 2a}} = .95$; $\alpha_{\text{Study 2b}} = .94$).

Forecasted helping behaviors. In Study 2a, 7 items assessed the likelihood that participants would engage in different types of helping behavior if they were in a course taught by Dr. Rescorla (e.g., “I would offer to explain a course concept to a fellow student who did not initially grasp it”). Responses were made on a scale from 1 (*extremely unlikely*) to 7 (*extremely likely*) and were averaged to create an index of forecasted helping behaviors ($\alpha = .88$). Study 2b include these 7 items along with 7 additional items assessing the likelihood that fellow science majors would provide help to the participant. The 14 items were averaged into a measure of forecasted helping behavior in the major ($\alpha = .94$).

STEM goal affordances. Participants rated whether the course or major would fulfill each of several goals on scales from 1 (*not at all*) to 7 (*extremely*; adapted from Diekmann et al., 2010). For communal affordances, participants rated whether the course or major would fulfill the goals of *helping others*, *benefitting the community or society*, and *working with others*. These items were averaged to form a perceived communal goal affordance composite (Study 2a; $\alpha = .88$; Study 2b; $\alpha = .85$). For agentic goal affordances, participants rated whether the course or major would fulfill goals of *achievement* and *self-direction*. Items were averaged to form a perceived agentic goal affordance composite ($\alpha_{\text{Study 2a}} = .56$; $\alpha_{\text{Study 2b}} = .72$).³

STEM interest. Participants rated how *interested* and *likely* they were to take a course with Dr. Rescorla (Study 2a) or declare a major chaired by Dr. Rescorla (Study 2b). Items were

³ Although the reliability of the agentic affordances measure was low in Study 2a, the results were similar when items were analyzed separately or as a composite.

rated on scales from 1 (*not at all*) to 7 (*extremely*) and were averaged together to form a composite measure of interest ($\alpha_{\text{Study 2a}} = .92$; $\alpha_{\text{Study 2b}} = .90$).

Results

Gender. In Study 2a, the only effect of participant gender was that women ($M = 5.62$, $SD = 0.94$) were more willing to help fellow classmates in the hypothetical course than were men ($M = 5.30$, $SD = 1.02$), $F(1, 201) = 5.45$, $p = .02$, $d = 0.33$; however, this relationship was not qualified by perceived faculty mindset, $p = .30$. No other effects of gender were significant ($ps > .13$). In Study 2b, there were no significant effects of participant gender, $ps > .10$. Gender is omitted in models in Studies 2a and 2b.

Manipulation checks. Independent samples t-tests showed that students randomly assigned to the growth (vs. fixed) faculty mindset condition perceived that Dr. Rescorla and her colleagues endorsed the view that intelligence is malleable, [Study 2a: $t(207) = 16.27$, $p < .0001$, $d = 2.25$; $M_{\text{growth}} = 5.32$, $SD = 1.17$; $M_{\text{fixed}} = 2.86$, $SD = 1.01$; Study 2b: $t(169) = 14.60$, $p < .0001$, $d = 2.23$; $M_{\text{growth}} = 5.23$, $SD = 0.94$; $M_{\text{fixed}} = 3.06$, $SD = 0.99$]. Thus, the faculty mindset manipulation effectively shifted perceptions.

Does faculty mindset increase goal affordances? To investigate whether faculty mindset shaped students' beliefs about the goal affordances offered by Dr. Rescorla's course or major, we submitted affordance ratings to a 2 (Faculty Mindset: growth, fixed) \times 2 (Goal Affordance Type: communal, agentic) mixed model ANOVA with goal affordance (communal or agentic) as a within-subjects factor and faculty mindset as a between-subject factor. This analysis allowed us to examine how manipulated mindset affected perceptions of goal affordances of the course or major, and whether faculty mindset differentially affected communal and agentic affordances. Consistent with stereotypes about STEM, the goal

affordance main effect indicated that the contexts were perceived to offer more opportunities to pursue agentic goals than communal goals, Study 2a $F(1, 207) = 35.43, p < .0001, \eta_p^2 = .15$; Study 2b: $F(1, 169) = 58.15, p < .0001, \eta_p^2 = .25$.

More critical to predictions is that in both studies, students exposed to growth (vs. fixed) faculty mindset beliefs perceived that the science course and major would fulfill more goals overall [Study 2a: $F(1, 207) = 41.57, p < .0001, \eta_p^2 = .17$; Study 2b, $F(1, 169) = 58.15, p < .0001, \eta_p^2 = .26$]. Moreover, faculty mindset more strongly affected perceptions of communal (vs. agentic) goal affordances. The Faculty Mindset \times Goal Affordances interaction emerged in both Study 2a, $F(1, 207) = 38.49, p < .0001, \eta_p^2 = .16$, and Study 2b, $F(1, 169) = 3.80, p = .05, \eta_p^2 = 0.02$. We decomposed these interactions by considering the effects of mindset separately within communal affordances and agentic affordances. As shown in Figure 2, faculty mindset more strongly influenced students' perceptions about communal goal affordances [Study 2a: $F(1, 207) = 65.64, p < .0001, \eta_p^2 = .24, d = 1.12$; Study 2b: $F(1, 169) = 44.91, p < .0001, \eta_p^2 = .21, d = 1.03$] than agentic goal affordances [Study 2a: $F(1, 207) = 6.08, p = .01, \eta_p^2 = .03, d = 0.34$; Study 2b: $F(1, 169) = 34.78, p < .0001, \eta_p^2 = .17, d = 0.90$]. Overall, these patterns support the hypothesis that fixed mindset environments are perceived as dampening goal pursuit generally.

Forecasted helping behavior. We next investigated whether faculty mindset influenced forecasted helping behaviors. Independent samples t-tests revealed that participants expected greater helping behavior to occur in a context led by a growth mindset faculty member than a fixed mindset faculty member [Study 2a: $t(207) = 2.14, p = .03, d = 0.30$; $M_{\text{growth}} = 5.61, SD = 0.94$; $M_{\text{fixed}} = 5.31, SD = 1.06$; Study 2b: $t(169) = 4.83, p < .0001, d = 0.74$; $M_{\text{growth}} = 5.60, SD = 0.85$; $M_{\text{fixed}} = 4.82, SD = 1.21$].

Indirect effects: Perceived goal affordances mediate STEM interest. We next investigated whether faculty mindset indirectly predicted students' interest in the course and major through perceived goal affordances. In both studies, we used Hayes' (2013) PROCESS macro model 4 to test a parallel mediation model in which faculty mindset (dummy coded: 0 = fixed mindset, 1 = growth mindset) indirectly predicted increased STEM interest through beliefs that the course (Study 2a) or major (Study 2b) afforded communal and agentic goals (see Figure 3). In Study 2a, growth (vs. fixed) faculty mindset indirectly predicted greater course interest through student perceptions that the course afforded opportunities to pursue more communal goals, $b = 0.61$, $SE = 0.15$, 95% CI [0.36, 0.93], as well as more agentic goals, $b = 0.13$, $SE = 0.07$, 95% CI [0.03, 0.30]. In Study 2b, growth (vs. fixed) faculty mindset indirectly predicted greater interest in the science major through perceptions that the major afforded more opportunities to pursue communal goals, $b = 0.47$, $SE = 0.14$, 95% CI [0.23, 0.79], but not agentic goals, $b = 0.12$, $SE = 0.11$, 95% CI [-0.08, 0.37].⁴

As anticipated, growth (vs. fixed) faculty mindset indirectly predicted greater interest in STEM contexts through the belief that these growth mindset environments would afford more goals overall. In both studies, communal goal affordances, relative to agentic goal affordances, more strongly predicted students' STEM interest.

Discussion

⁴ We duplicated these analyses using the continuous measure of faculty mindset (i.e., the manipulation check) as the predictor. In Study 2a, the continuous measure of perceived faculty mindset indirectly predicted increased interest in the course through communal affordances, $b = 0.20$, $SE = 0.05$, 95% CI [0.11, 0.29], and agentic affordances, $b = 0.06$, $SE = 0.02$, 95% CI [0.02, 0.12]. In Study 2b, the continuous measure of perceived faculty mindset indirectly predicted increased interest in the major through communal affordances, $b = 0.19$, $SE = 0.07$, 95% CI [0.06, 0.33], but not agentic affordances, $b = 0.05$, $SE = 0.04$, 95% CI [-0.02, 0.13].

Studies 2a and 2b provide causal evidence that the mindset beliefs of science faculty can influence student perceptions about the goal opportunities that science courses and majors afford. When faculty endorsed a growth mindset, students expected more helping behaviors in the academic context led by the professor. Finally, faculty mindset indirectly predicted student interest in science through perceptions that these science classes and majors would afford more opportunities to pursue communal goals.

Study 3: Impact of Perceived Faculty Mindset on STEM Majors

Study 3 sought to replicate and extend Studies 2a and 2b in three ways: First, we adopted a more ecologically valid manipulation of faculty mindset involving videos of growth versus fixed mindset professors introducing their course on the first day of class. Second, we explored whether effects replicated among STEM majors. Finally, we investigated whether faculty mindset would influence participants' anticipated behavioral engagement in a course.

Method

Participants. We aimed to recruit 260 STEM majors via MTurk based on a-priori power analyses to detect small to medium effects with independent-samples t-tests (i.e., $d = 0.35$) and ANOVA interactions (i.e., $\eta_p^2 = .175$; Faul et al., 2007, 2009), and we continued data collection until participation ceased among the target population of STEM majors on MTurk. We stopped data collection with 199 U.S. college students majoring in STEM fields (e.g., computer science, biology). Further, 27 respondents ($n_{\text{growth}} = 10$; $n_{\text{fixed}} = 17$) failed the instructional manipulation attention check adapted from Oppenheimer and colleagues (2009); we excluded these participants. Results were similar, but weaker, when including participants who failed the attention check. Although the final sample of 171 participants was lower than the a priori goal, sensitivity analyses showed ability to detect small to medium effects: Regression analysis with 3

predictors yielded sensitivity to effect sizes of $f^2 = .05$ or smaller; mixed model ANOVA with 2 groups and 2 dependent variables could detect effects of $f^2 = .11$ or smaller.

The final sample included 84 men, 83 women, and 4 other or not reporting gender. Their mean age was 26.19 years, and 112 participants self-identified as White, 22 as Black or African American, 22 as Asian or Asian American, 7 as multiracial, and the remainder as other or preferred not to share. In addition to responding to measures regarding their race, 21 participants identified as Hispanic or Latinx in a separate ethnicity measure. Most (91%) attended 4-year colleges, and the remainder (9%) attended 2-year colleges. Most (92%) maintained a full-time class load during the normal semester. Participants represented a range of points in their education: 14 first years, 30 sophomores, 48 juniors, 52 seniors, and 27 5th-year seniors.

Procedure. All procedures were approved by the institutional review board. Participants learned that they were participating in research on students' opinions about different classes, and were told that, "First, you will watch a short video clip from the first day of class from a section of Introductory Chemistry recorded in the Spring 2018 semester. After watching this video clip you will be asked questions about your perceptions of the class." All participants viewed a video purportedly of a first day of a college chemistry course (i.e., Chemistry 101), and were randomly assigned to either a growth mindset version or a fixed mindset version. The videos were created by Muenks and colleagues (2018) as an experimental manipulation of faculty mindset, and were scripted and parallel except for key points. The videos both showed an older White male professor reading a syllabus and explaining his course policies. In the growth mindset video, the professor told his students that he thought that everyone could succeed in his class through effort, seeking help, and good strategies. In the fixed mindset video, the professor told his students that he thought that some people were just naturally good at the topic and would be able to

understand the course materials, and others would be unable to understand the course material. After viewing the video, participants rated the professor and his course, responded to demographic measures, and were debriefed.

Measures. Measures of perceived faculty mindset for the manipulation check were identical to Studies 2a and 2b except that they asked about the professor in the video ($\alpha = .93$). Measures of forecasted helping behaviors ($\alpha = .94$) were identical to Study 2b and STEM goal affordances ($\alpha_{\text{communal}} = .79$; $\alpha_{\text{agentic}} = .74$) were identical to Study 2a.

New to this study is a measure of *anticipated behavioral engagement*. Participants responded on a scale from 1 (*not at all*) to 6 (*very often*) how often they would perform 7 behaviors while taking the class (i.e., *ask questions during class*; *ask questions during lab or discussion section*; *answer questions during class*; *answer questions during lab or discussion section*; *raise your hand in class*; *raise your hand in lab or discussion section*; *attend the professor's office hours*). Items were averaged into a measure of anticipated behavioral engagement with the course ($\alpha = .90$).

Results

Gender. Unless otherwise noted, gender did not qualify any effects of condition ($ps > .05$), and thus we omitted gender from analyses.

Manipulation checks. Independent samples t-tests showed that students randomly assigned to the growth faculty mindset video ($M = 5.21$, $SD = 1.12$) perceived that the faculty member endorsed the view that intelligence is malleable to a greater extent than students assigned to the fixed faculty mindset video ($M = 3.63$, $SD = 1.04$), $t(169) = 9.50$, $p < .0001$, $d = 1.46$. The videos thus effectively manipulated perceptions of faculty mindset.

Does faculty mindset increase goal affordances? We investigated whether faculty mindset shaped students' beliefs about the goal affordances of the course by submitting affordance ratings to a 2 (Faculty Mindset: growth, fixed) \times 2 (Goal Affordance Type: communal, agentic) mixed model ANOVA with goal affordance (communal or agentic) as a within-subjects factor and faculty mindset as a between-subjects factor. A main effect of faculty mindset reflected that courses taught by the growth mindset faculty member were perceived as marginally but not significantly more likely to afford goals than courses taught by the fixed mindset faculty member, $F(1, 168) = 2.90, p = .09, \eta_p^2 = .02$. Courses were perceived to offer more opportunities to pursue agentic goals than communal goals, $F(1, 168) = 52.10, p < .0001, \eta_p^2 = .24$, but this was moderated by faculty mindset (see Figure 4).

The Faculty Mindset \times Goal Affordances interaction, $F(1, 168) = 3.78, p = .05, \eta_p^2 = .02$, reflected that the course taught by the growth mindset faculty member was viewed as affording more communal goals than the course taught by the fixed mindset faculty member, $F(1, 168) = 5.45, p = .02, d = 0.36$, but no significant difference emerged for agentic affordances, $F(1, 168) = 0.27, p = .60, d = 0.08$.

Forecasted helping behavior. The only measure to show a participant gender effect was forecasted helping behavior, which was examined in a 2 (Faculty Mindset: growth, fixed) \times 2 (Gender) ANOVA. No main effects arose, $ps > .17$, but a significant Faculty Mindset \times Gender interaction emerged, $F(1, 163) = 4.33, p = .04, \eta_p^2 = .03$. Women forecasted marginally more helping behavior in the course taught by the growth mindset faculty member ($M = 5.45, SD = 1.16$) than the fixed mindset faculty member ($M = 4.97, SD = 1.24$), $t(81) = 1.81, p = .07, d = 0.40$. Men's forecasted helping behavior did not differ by faculty mindset condition (growth faculty: $M = 5.03, SD = 1.15$; fixed faculty: $M = 5.26, SD = 0.80$), $t(82) = 1.08, p = .28, d = 0.24$.

Anticipated behavioral engagement. An independent-samples t-test demonstrated that participants viewing the growth mindset faculty member ($M = 3.73$, $SD = 1.10$) predicted more behavioral engagement in the course than participants viewing the fixed mindset faculty member ($M = 3.30$, $SD = 1.04$), $t(169) = 2.63$, $p = .01$, $d = 0.40$.

Indirect effects: Perceived goal affordances mediate anticipated STEM behavioral engagement. We next investigated whether faculty mindset indirectly predicted students' anticipated behavioral engagement with the course through perceived goal affordances. We used Hayes' (2013) PROCESS macro model 4 to test a parallel mediation model in which faculty mindset (dummy coded: 0 = fixed mindset, 1 = growth mindset) indirectly predicted increased anticipated behavioral engagement through beliefs that the course afforded communal and agentic goals (see Figure 5). Growth (vs. fixed) faculty mindset indirectly predicted greater anticipated behavioral engagement through student perceptions that the course afforded opportunities to pursue more communal goals, $b = 0.11$, $SE = 0.07$, 95% CI [0.02, 0.28], but not agentic goals, $b = 0.02$, $SE = 0.03$, 95% CI [-0.04, 0.10].⁵ Students exposed to a growth mindset STEM faculty member expected his class to offer more opportunities to fulfill communal goals, which in turn predicted greater anticipated behavioral engagement in the class.

Discussion

This study provides causal evidence that the perceived mindset beliefs of science faculty affect STEM student perceptions about whether they can pursue communal goals within a STEM course. Perceiving that a professor endorses more growth mindset beliefs increased how much

⁵ Analyses using the continuous manipulation check measure of perceived faculty mindset as the predictor demonstrated similar indirect effects of communal affordances, $b = 0.08$, $SE = 0.04$, 95% CI [0.02, 0.16], and agentic affordances, $b = 0.03$, $SE = 0.02$, 95% CI [0.002, 0.08]. Students exposed to a growth mindset STEM faculty member expected his class to offer more opportunities to fulfill communal goals, which in turn, predicted greater anticipated behavioral engagement in the class.

students anticipated they would engage in the course, and this effect occurred through beliefs that the course would afford more communal goals.

Studies 4a and 4b: Recalled Faculty Mindset

Studies 4a and 4b turned to examining real-life experiences in science or mathematics courses. We examined perceptions of a past course led by a faculty member perceived as endorsing either fixed or growth mindset beliefs among college students (Study 4a) and STEM majors (Study 4b). Study 4a employed text analysis methods (see Tausczik & Pennebaker, 2010) to explore whether participants describe contexts led by faculty members with growth or fixed mindsets differently; Study 4b examined reports of recalled behavioral engagement in past STEM courses taught by either growth or fixed mindset faculty.

Study 4a

Text analysis provides the opportunity to examine hypotheses in a manner that reduces potential demand; these methods can also provide rich understanding of participants' perceptions of various contexts (e.g., Mehl, 2006). Specifically, we examined whether participants spontaneously included other-oriented words and self-oriented words more frequently when writing about a course led by growth or fixed mindset faculty.

Method.

Participants. For Study 4a, we recruited 109 participants from the introductory psychology pool of a medium-sized Midwestern university. Sixteen respondents were excluded: Nine participants ($n_{\text{growth}} = 2$, $n_{\text{fixed}} = 7$) failed an attention check (adapted from Oppenheimer et al., 2009), and seven participants ($n_{\text{growth}} = 3$, $n_{\text{fixed}} = 4$) did not follow directions (i.e., discussing a social science class; describing an ambiguous discipline). Analyses including students who failed the attention check or did not follow directions show an identical pattern of results as the

reported analyses. The final Study 4a sample consisted of 93 participants (36 men, 57 women; $M_{\text{age}} = 19.26$), and 73 self-identified as White, 8 as Asian or Asian American, 6 as Black or African American, 3 as multiracial, 2 as Hispanic, and 1 indicated “other” but did not specify. Thirty-three percent of participants were STEM majors (e.g., computer science, zoology), and the remainder were from other majors (e.g., kinesiology, finance).

Sensitivity analyses showed ability to detect small to medium effects: Regression analyses with 3 predictors could detect a single regression coefficient with an effect size of $f^2 = .09$ or smaller, and mixed model ANOVAs with 2 groups and 2 dependent measures could detect within-between interactions with an effect size of $f^2 = .13$ or smaller.

Procedure. All procedures were approved by the institutional review board. All participants were asked to think about their math or science courses “from the past year or so,” and then participants were randomly assigned to consider a math or science course with a faculty member who endorsed either a growth or a fixed mindset.

Participants in the growth mindset condition read the following:

Which teacher or professor...**most strongly believed** that intelligence and talent in math or science can be grown and developed through hard work, effort, practice, and persistence? Today, we are interested in...a math or science course that was taught by a teacher or professor who **most strongly believed** that intelligence and talent in math or science can be grown and developed through hard work, effort, practice, and persistence.

Participants in the fixed mindset condition read the following:

Which teacher or professor...**most strongly believed** that intelligence and talent in math or science is just one of those things that is innate, in that some people

just have it and others don't, regardless of how hard they try? Today, we are interested in...a math or science course that was taught by a teacher or professor who **most strongly believed** that intelligence and talent in math or science is just one of those things that is innate, in that some people just have it and others don't, regardless of how hard they try.

Participants provided the course name and number, completed the manipulation check described below, and then responded in writing to the prompt, "Please tell us about your experience in this course for several minutes." Participants could not advance to the next screen until 2 minutes had elapsed.

Participants discussed courses in engineering ($n = 3$), math or statistics (e.g., calculus, statistics; $n = 36$), and natural sciences (e.g., chemistry, biology; $n = 57$). Following these instructions, participants responded to measures about their experiences in this course.

Measures. Unless otherwise noted, participants rated all items on scales from 1 (*not at all*) to 7 (*extremely*). We employed the measures of perceived faculty mindset (i.e., the manipulation check) from Studies 2a-b ($\alpha = .92$), helping behaviors from Study 2b ($\alpha = .95$), and goal affordances from Study 2a ($\alpha_{\text{communal}} = .81$; $\alpha_{\text{agentic}} = .76$).

Course experiences. Participants' course descriptions were analyzed with Linguistic Inquiry and Word Count (LIWC; Pennebaker, Booth, Boyd, & Francis, 2015), which contains a theory-driven dictionary of 248 other-oriented affiliation terms such as friend, social, and ally (generally aligning with communion). LIWC also contains a theory-driven dictionary of 213 self-oriented achievement terms such as win, success, and better (generally aligning with agency). LIWC searches for these terms in a given text sample and provides the percentage of

the text that consisted of the key dictionary terms (Pennebaker, Boyd, Jordan, & Blackburn, 2015).

Motivation to take future STEM courses. Two items assessed participants' motivation to persist with STEM coursework following the target course (i.e., "I wanted to take another course in this subject after completing this course; I wanted to take the next course in the class sequence after completing this course"). Items were averaged ($\alpha = .90$) and higher numbers indicate greater motivation to take more STEM courses.

Results.

Gender. Only one effect of participant gender emerged (all other $ps \geq .10$). Across conditions, women ($M = 4.44$, $SD = 1.14$) perceived more growth mindset among faculty than men ($M = 4.82$, $SD = 1.24$), $F(1, 89) = 4.99$, $p = .03$, $\eta_p^2 = .05$. Because gender did not interact with any variables other than those noted, we omitted gender from analyses.

Manipulation check. Participants asked to recall a growth mindset faculty member reported that the faculty member endorsed significantly stronger growth mindset beliefs than those asked to recall a fixed mindset faculty member, $t(91) = 8.47$, $p < .0001$, $d = 1.27$; $M_{\text{growth}} = 5.34$, $SD = 0.88$; $M_{\text{fixed}} = 3.78$, $SD = 0.90$.

Goal affordances. We investigated effects of faculty mindset by submitting communal and agentic goal affordances to a 2 (Faculty Mindset: growth, fixed) \times 2 (Goal Affordance Type: communal, agentic) mixed model ANOVA with goal affordance type as a within-subjects factor and faculty mindset as a between-subjects factor (see Figure 6).

Similar to previous studies, courses taught by growth mindset faculty were perceived to offer more goal affordances overall than courses taught by fixed mindset faculty, $F(1, 91) = 24.91$, $p < .0001$, $\eta_p^2 = .21$. In addition, courses were viewed as fulfilling more agentic goals (M

= 4.63, $SD = 1.38$) than communal goals ($M = 3.71$, $SD = 1.29$), $F(1, 91) = 55.81$, $p < .0001$, $\eta_p^2 = .38$.

The effect of faculty mindset was not moderated by type of affordance (Faculty Mindset \times Goal Affordance Type interaction, $p > .52$). Courses taught by growth (vs. fixed) mindset faculty were perceived as offering greater communal affordances, $F(1, 91) = 24.55$, $p < .0001$, $d = 1.03$, as well as greater agentic affordances, $F(1, 91) = 14.70$, $p = .0002$, $d = 0.80$.

Spontaneous discussion of affiliation and achievement. Across conditions, participants' descriptions included an average of 78 words ($SD = 25.17$). Of these, an average of 2.20% ($SD = 2.88$) of their descriptions included affiliation words (see Table 1 for examples); an average of 2.70% ($SD = 2.24$) of their descriptions included achievement words. As predicted, these tendencies differed by faculty mindset condition. Participants who recalled a course taught by a growth mindset faculty member ($M = 2.77\%$, $SD = 3.33$) spontaneously described the course with a larger proportion of affiliation terms than participants who recalled a course taught by a fixed mindset faculty member ($M = 1.59\%$, $SD = 2.18$), $t(81.63) = 2.04$, $p = .04$, $d = 0.42$. Moreover, participants who recalled a course taught by a growth (vs. fixed) mindset faculty member also spontaneously described the course with a larger proportion of achievement terms ($M = 3.40\%$, $SD = 2.22$ vs. $M = 1.96\%$, $SD = 2.03$), $t(91) = 3.26$, $p = .002$, $d = 0.68$. This finding is consistent with the idea that growth mindset contexts may be perceived to afford both agentic and communal goals.

Indirect effects on motivation to persist. We investigated whether faculty mindset indirectly predicted increased motivation to persist in STEM courses through communal and agentic goal affordances. We conducted parallel mediation analyses using Hayes' (2013) PROCESS macro model 4 in which faculty mindset (dummy coded: 0 = fixed mindset, 1 =

growth mindset) indirectly predicted STEM course motivation through the course's perceived communal and agentic goal affordances (see Figure 7).⁶ In this study, growth (vs. fixed) faculty mindset indirectly predicted interest through communal as well as agentic goal affordances.

Helping behavior. Similar to previous findings, growth mindset contexts were associated with more helping behavior. Participants who recalled courses taught by growth (vs. fixed) mindset faculty reported that they and their fellow classmates helped others more often, $t(91) = 2.19, p = .03, d = 0.45; M_{\text{growth}} = 4.32, SD = 1.55; M_{\text{fixed}} = 3.65, SD = 1.40$.

Study 4b

Method.

Participants. We aimed to recruit 260 STEM majors via MTurk based on a-priori power analyses to detect small to medium effects with independent-samples t-tests (i.e., $d = 0.35$) and ANOVA interactions (i.e., $\eta_p^2 = .175$; Faul et al., 2007, 2009). Our first data collection yielded only 152 STEM majors who followed instructions; we thus reopened data collection for a second wave. These two data collections yielded 327 U.S. college students majoring in STEM fields (e.g., biology, engineering). **Forty-seven respondents ($n_{\text{growth}} = 25; n_{\text{fixed}} = 22$) failed the instructional manipulation attention check adapted from Oppenheimer and colleagues (2009) and were excluded.** Results were similar when including participants who failed the attention check.

The final Study 4b sample consisted of 272 participants (143 men, 126 women, 3 other or not reporting; $M_{\text{age}} = 27.10$), and 157 self-identified as White, 40 as Black or African American, 31 as Asian or Asian American, 20 as Hispanic or Latinx, 12 as multiracial, and the remainder as other or preferred not to share. The majority (89%) attended colleges that awarded bachelor's

⁶ Analyses using the continuous measure of perceived faculty mindset as the predictor yielded significant indirect effects for communal affordances, $b = 0.28, SE = 0.12, 95\% \text{ CI } [0.08, 0.54]$, and agentic affordances, $b = 0.27, SE = 0.12, 95\% \text{ CI } [0.08, 0.55]$.

degrees or higher and the remainder (11%) attended 2-year colleges. Most (90%) carried a full load of classes during their normal semester. Participants included 11 first years, 36 sophomores, 66 juniors, 107 seniors, and 52 5th-year seniors.

Procedure. Participants considered a course in their major following the recalled faculty mindset manipulation instructions used in Study 4a. Participants provided the course title and number, and completed the manipulation check described below. They were asked to describe their experience, but descriptions were too brief to be analyzed with LIWC. Finally, participants completed the remaining measures described below. Participants named courses in computing or technology (e.g., computer science, computer programming; $n = 41$), engineering (e.g., intro to engineering; $n = 31$), math or statistics (e.g., calculus, statistics; $n = 73$), and natural sciences (e.g., chemistry, biology; $n = 127$).

Measures. Identical to Study 4a were measures of the manipulation check of perceived faculty mindset ($\alpha = .91$), goal affordances ($\alpha_{\text{communal}} = .86$; $\alpha_{\text{agentic}} = .83$), and helping behavior ($\alpha = .94$). Additionally, participants responded to items about *recalled behavioral engagement* (as assessed in Study 3 but measuring past behavioral engagement; $\alpha = .93$), and *course recommendations* (whether they would recommend *this course*, *this professor*, and *this subject* to a friend). Recommendation items were averaged into a measure of course recommendation ($\alpha = .85$).

Results.

Gender. The only effect of gender appeared in the Faculty Mindset \times Gender interaction on perceived faculty mindset, $F(1, 265) = 10.11, p = .002, \eta_p^2 = .04$. Both women and men reported that their instructors endorsed more growth mindset when asked to recall a growth vs. fixed mindset instructor, but women, $t(124) = 8.06, p < .0001, d = 1.45$, demonstrated a stronger

effect of the manipulation than men, $t(141) = 3.60, p = .0004, d = 0.60$. Gender did not qualify any other effects of condition, or moderate mediation models ($ps \geq .08$), so we omitted gender from analyses.

Manipulation check. Those who recalled growth mindset faculty reported that the faculty member endorsed significantly stronger growth mindset beliefs than those who recalled a fixed mindset faculty member, $t(270) = 8.12, p < .0001, d = 0.99$; $M_{\text{growth}} = 4.88, SD = 1.25$; $M_{\text{fixed}} = 3.63, SD = 1.28$.

Goal affordances. Courses overall were seen as offering similar fulfillment of communal goals ($M = 4.84, SD = 1.40$) and agentic goals ($M = 4.91, SD = 1.60$), $F(1, 270) = 0.86, p = .35, \eta_p^2 = .003$. Courses taught by growth mindset faculty were perceived to offer more goal affordances overall than courses taught by fixed mindset faculty, $F(1, 270) = 6.61, p = .01, \eta_p^2 = .02$. This effect was not moderated by affordance type, $p > .17$. Courses taught by growth (vs. fixed) mindset faculty were perceived as offering greater communal affordances, $F(1, 270) = 9.79, p = .002, d = 0.38$, but not greater agentic affordances, $F(1, 270) = 2.16, p = .14, d = 0.18$ (see Figure 6 panel B).

Indirect effects on recalled behavioral engagement and course recommendations. We conducted two parallel mediation analyses using Hayes' (2013) PROCESS macro model 4 in which faculty mindset (dummy coded: 0 = fixed mindset, 1 = growth mindset) indirectly predicted recalled behavioral engagement and course recommendations through the course's perceived communal and agentic goal affordances. As shown in Figure 8, faculty growth mindset predicted greater recalled behavioral engagement and greater course recommendations through elevated communal (but not agentic) goal affordances.⁷

⁷ We also conducted analyses using the continuous measure of perceived faculty mindset as the predictor. For recalled behavioral engagement, analyses yielded significant indirect effects of communal affordances, $b = 0.15$,

Helping behavior. The effect of faculty mindset on helping behavior did not reach significance. Participants who recalled courses taught by growth (vs. fixed) mindset faculty reported descriptively higher levels of helping, $t(270) = 1.12, p = .27, d = 0.14; M_{\text{growth}} = 4.39, SD = 1.24; M_{\text{fixed}} = 4.20, SD = 1.53$.

Discussion: Studies 4a & 4b

Studies 4a and 4b conceptually replicated previous experiments by drawing on students' past experiences in STEM education, rather than hypothetical scenarios. Past communal experiences in STEM were more strongly linked to memories of courses taught by professors perceived to endorse growth (vs. fixed) mindset beliefs. Replicating previous findings, recalled experiences with growth mindset faculty related to student motivation in STEM by increasing beliefs that STEM education provides more opportunities to pursue goals (communal goals in both studies; agentic goals in Study 4a). Moreover, participants who recalled a course taught by a growth (vs. fixed) mindset professor in Study 4a spontaneously described the course with more communion and agency terms.

Our final studies move beyond these effects to examine a new question: What are growth mindset practices that faculty can employ that might shape students' perceived goal affordances and interest? Drawing from teaching practice measures designed to assess growth mindset classroom behavior, we examine whether these practices signal more communal goal affordances not simply in the classroom context, but in the broader STEM career fields. If so, these practices suggest levers for intervention for faculty wishing to communicate goal affordances and stoke students' interest.

$SE = 0.03, 95\% \text{ CI } [0.10, 0.22]$, and agentic affordances, $b = 0.04, SE = 0.02, 95\% \text{ CI } [0.01, 0.08]$. For course recommendation, analyses yielded indirect effects of communal affordances, $b = 0.15, SE = 0.04, 95\% \text{ CI } [0.09, 0.23]$, and agentic affordances, $b = 0.06, SE = 0.02, 95\% \text{ CI } [0.02, 0.11]$.

Studies 5a-b: Specific Classroom Practices

Our core prediction was that growth-oriented teaching practices can foster increased helping behaviors within educational environments, and that experiencing such behaviors within an academic context can signal the affordances of a broader career field. In particular, we hypothesized that when students report more helping behavior in a STEM educational context, they will extrapolate from that experience to report greater beliefs that STEM careers afford communal goals, and that these STEM career communal affordances would predict enhanced interest in STEM careers. Thus, experiences with local growth-oriented teaching practices may indirectly predict enhanced STEM career interest through influencing beliefs about the broader values and opportunities of the field.

Method

Participants and procedure. All procedures were approved by the institutional review board. Study 5a participants ($n = 151$, 79 women) were recruited from MTurk. Their mean age was 35, and they ranged in age from 19 to 73. For Study 5b, we recruited 215 people from MTurk who had had recently taken a course in STEM (though they did not have to be currently enrolled in college). We excluded 42 respondents because they failed the attention check (adapted from Oppenheimer et al., 2009). The pattern of results was identical when including participants who failed the attention check. The final Study 5b sample consisted of 173 participants (84 men, 89 women; $M_{\text{age}} = 29.77$) who ranged in age from 18 to 61. Thirty-six percent of participants from each sample majored or currently worked in a STEM field. Racial/ethnic demographics were not collected in either sample. Sensitivity analyses indicated that in both studies, regression analyses with 4 predictors could detect a single regression coefficient with an effect size of $f^2 = .05$ (Faul et al., 2007, 2009).

To ensure a range of course experiences, participants were randomly assigned to consider a favorite or least favorite science or math class; we controlled for this factor in our analyses, but did not further examine it because it was not of theoretical interest.⁸ Study 5a participants could choose a course from any point in their education, and Study 5b participants discussed a course they had taken “within the past year or so.” They then responded to the following measures.

Measures. Participants rated all measures on scales from 1 (*not at all*) to 7 (*extremely*).

Growth mindset teaching practices. Study 5a participants reported the extent to which they were able to “develop and improve [their] understanding of the subject” during the class that they recalled. Study 5b participants responded to 5 items adapted from Midgley and colleagues’ survey (2000; i.e., “my teacher thought mistakes were okay as long as we were learning;” “my teacher wanted us to understand our work, not just memorize it;” “my teacher really wanted us to enjoy learning new things;” “my teacher recognized us for trying hard;” “my teacher gave us time to really explore and understand new ideas”). Items were averaged ($\alpha = .90$) and higher numbers indicated more growth mindset practices.

Class helping behavior. Study 5a participants rated agreement with one item investigating whether they “*helped others and/or gained knowledge about how STEM professionals help others*” during the class that they recalled. Study 5b participants responded to 4 items that assessed helping other students in the class (i.e., “In this class, I helped others;” “I helped my classmates understand class concepts or ideas;” “I helped my classmates with their

⁸ Analyses of effects of favorite versus least favorite class demonstrate that reported effects are not reducible to positivity bias. Independent groups t-tests showed that favorite classes were perceived as having higher growth mindset (Study 5a: $t(147) = 4.62, p < .0001, d = 0.76$; Study 5b: $t(171) = 6.16, p < .0001, d = 0.94$) and helping behaviors (Study 5a: $t(148) = 3.41, p = .0008, d = 0.54$; Study 5b: $t(171) = 5.11, p < .0001, d = 0.78$), but statistically equivalent degrees of STEM communal affordances and interest, $ps > .25$. The relationships between mindset and affordances are thus not accounted for by favorite versus least favorite class status.

homework or projects;” “I helped my classmates study for quizzes or exams”). These items were averaged into a measure of helping behavior ($\alpha = .95$), and higher numbers indicate greater recalled helping behavior.

STEM career affordances. Following Diekman and colleagues (2010, 2011), participants rated whether each of four STEM careers (i.e., aerospace engineer, computer scientist, mechanical engineering, and environmental scientist) fulfilled the goals of *intimacy*, *affiliation*, and *altruism*. We averaged items to form an index of STEM communal goal affordances ($\alpha_{\text{Study 5a}} = .84$; $\alpha_{\text{Study 5b}} = .81$). Similarly, participants rated whether the same four STEM careers afforded agentic goals of *power*, *achievement*, and *seeking new experiences or excitement* ($\alpha_{\text{Study 5a}} = .89$; $\alpha_{\text{Study 5b}} = .83$; Diekman et al., 2010, 2011).

STEM career interest. Participants rated their interest in pursuing careers as an aerospace engineer, computer scientist, mechanical engineer, or environmental scientist (Diekman et al., 2010, 2011). The four items were averaged into a STEM career interest measure ($\alpha_{\text{Study 5a}} = .80$; $\alpha_{\text{Study 5b}} = .81$).

Results

Gender. Across the two studies, participant gender moderated one effect (all other interaction $ps > .10$). In Study 5a, participant gender (effect coded male = -1, female = 1) moderated the relationship between STEM communal affordances and STEM career interest, $b = -0.24$, $p = .002$, $\beta = -.31$, $\Delta R^2 = .04$: STEM communal affordances predicted STEM career interest more strongly for men, $b = 0.73$, $p < .0001$, $\beta = .63$, than for women, $b = 0.24$, $p = .04$, $\beta = .21$. This effect did not replicate in Study 5b. Consistent with the other studies, gender is omitted from subsequent analyses.

Communal affordances predict interest. We regressed STEM career interest simultaneously onto STEM agentic affordances and STEM communal affordances. STEM communal affordances significantly predicted increased STEM career interest (Study 5a: $b = 0.58$, $SE = 0.10$, $p < .0001$, $\beta = .50$; Study 5b: $b = 0.53$, $SE = 0.09$, $p < .0001$, $\beta = .46$), but STEM agentic affordances did not (Study 5a: $b = -0.04$, $SE = 0.09$, $p = .68$, $\beta = -0.03$; Study 5b: $b = 0.15$, $SE = 0.09$, $p = .09$, $\beta = .13$). Given the goal to understand STEM career interest, subsequent analysis did not examine STEM agentic affordances.

Teaching practices and communal affordances. We examined whether growth mindset teaching practices related to helping behavior, and in turn, people's broader beliefs about and interest in STEM careers. In each study, we tested a serial mediation model using Hayes' (2013) PROCESS macro model 6 with 10,000 bootstrapped samples; we also controlled for favorite vs. least favorite class. Faculty growth mindset practices predicted increased helping behaviors, which predicted STEM communal affordances, which predicted STEM interest. As seen in Figure 9, recalling a STEM class that included growth mindset teaching practices predicted greater recalled helping behavior, which predicted greater perceived communal affordances offered by STEM professions, which, in turn, predicted interest in STEM careers. Significant indirect effects obtained in Study 5a, $b = 0.04$, $SE = 0.02$, 95% CI [0.01, 0.09], and Study 5b, $b = 0.03$, $SE = 0.02$, 95% CI [0.01, 0.07].

Discussion

Studies 5a and 5b identify specific growth mindset teaching practices associated with (a) class-based helping behaviors and (b) perceptions that STEM careers afford opportunities to pursue communal goals. Teachers who were perceived to focus on learning and understanding material set the stage for more helping behaviors in their classes, and these behaviors, in turn,

predict students' beliefs that science and engineering careers afford opportunities to work with and help others—which then relates to interest in those careers. For example, students whose teachers emphasized that mistakes were a normal part of the learning process also reported more helping behaviors in the course, which in turn affected broader beliefs about, and interest in, STEM careers. When faculty focus on student learning as opposed to student performance, they also set the stage for communicating STEM pathways afford opportunities to pursue communal goals.

Examining Effects Across Studies

As a final step, we considered whether evidence taken in sum across these studies supports our predictions – does faculty mindset cue goal affordances, and do these goal affordances in turn cue interest and engagement? Because Studies 2a, 2b, 3, 4a, and 4b all relied on similar experimental methodology, we tested effects across these studies. We meta-analyzed the effect sizes (i.e., Cohen's *ds*) of the experimental manipulation of faculty mindset on communal and agentic affordances using random effects models that weighted effects by sample size (Suurmond, van Rhee, & Hakof, 2017).

This analysis revealed a large effect of growth mindset on communal affordances, $d = 0.77$, $SE = 0.17$, 95% CI [0.30, 1.25], $Z = 4.52$, $p < .0001$, and a moderate effect of faculty mindset on agentic affordances, $d = 0.44$, $SE = 0.16$, 95% CI [-0.01, 0.90], $Z = 2.70$, $p = .01$. Although the Z test for agentic affordances was significant, the confidence intervals of the effect size crossed zero, suggesting that the effect of faculty mindset on agentic affordances is unreliable. Based on this analysis, we can conclude that faculty mindset had a large, significant effect on communal affordances across the experimental studies.

Next, we investigated whether communal affordances related to motivation and engagement across studies when controlling for agentic affordances, and vice-versa. Using data from all 8 studies, we meta-analyzed the semi-partial correlation between affordances and interest and engagement when controlling for the other type of affordance (Suurmond et al., 2017). Both models were random effects models that weighed effect size by sample size; for Study 4b, we used the recalled behavioral engagement measure as the dependent variable. Communal affordances demonstrated a moderate association with STEM interest and engagement when partialling out agentic affordances, $r = .37$, 95% CI [0.28, 0.45], $Z = 10.09$, $p < .0001$. Agentic affordances demonstrated a small association with STEM interest and engagement when partialling out communal affordances, $r = .15$, 95% CI [0.07, 0.23], $Z = 4.50$, $p < .0001$.

Finally, to understand whether the indirect effects of manipulated faculty mindset on interest and engagement emerged across studies, we combined data from Studies 2a – 4b ($N = 916$). Before combining data, we standardized the measures of interest and engagement; we used recalled behavioral engagement as the measure of interest and engagement from Study 4b. We then submitted data to Hayes' (2013) PROCESS macro model 4 with 10,000 bootstrapped samples to examine whether the effect of manipulated faculty mindset on interest and engagement was mediated in parallel by communal and agentic affordances. As seen in Figure 10, the indirect effect of manipulated faculty mindset through communal affordances accounted for most of the total indirect effect, but the indirect effect through agentic affordances was also significant. We thus conclude that faculty mindset confers benefits to interest and engagement through both communal and agentic affordances, but the pathway through communal affordances is considerably stronger.

Analyses that examine data across studies thus provide stronger evidence for our core claims. Across these studies, faculty mindset produces a large impact on communal affordances and a moderate impact on agentic affordances. Further, both communal and agentic affordances are associated with STEM interest and engagement, and both types of affordances mediate the relationship between faculty mindset and increased STEM interest and engagement. In each case, however, the findings for communal affordances are stronger than findings for agentic affordances.

General Discussion

Opting to engage in a particular educational or occupational pathway reflects the assumption that this pathway will lead to the fulfillment of valued goals. When the pathway leads away from those goals, students opt out. These studies provide a novel look at how faculty mindset can signal opportunities for goal pursuit in STEM fields. The STEM faculty mindset that is present in a specific context can shape student beliefs about the kinds of goals that will be fulfilled through STEM roles. These goal affordances, in turn, predict students' motivation to pursue STEM pathways. STEM faculty who endorse a growth mindset communicate to students that STEM fields afford opportunities to pursue both other-oriented, communal goals such as working with and helping others, as well as self-oriented, agentic goals such as achievement and success. In contrast, STEM faculty who endorse a fixed mindset communicate lower goal opportunities overall.

These findings suggest that faculty mindset beliefs have implications not only for adaptive student behaviors (e.g., seeking help and providing help to others), but also for beliefs that serve core motivational functions for students—helping them understand whether an academic path provides opportunities to fulfill their goals. Moreover, these studies suggest that

growth-mindset faculty were perceived as more likely to integrate helping behaviors in class. Taken together, these studies demonstrate a robust link between faculty mindset and students' beliefs about whether STEM allows them to pursue their goals.

These studies provide evidence for novel effects of fixed and growth mindset academic environments. Environments that are characterized by the growth mindset boost students' motivation by encouraging them to persist in the face of challenges (Blackwell, Trzesniewski, & Dweck, 2007), bolstering their sense of belonging (Good, Rattan, & Dweck, 2012), and alleviating identity threat (Emerson & Murphy, 2014, 2015). Here, institutional mindsets—as communicated by faculty beliefs—enhanced students' motivation by communicating that STEM classes and careers provide opportunities to pursue valued communal goals. Further, perceived opportunities to pursue communal goals do not come at the cost of agentic goals—growth mindset environments are perceived to foster both types of goals. This work joins a growing body of evidence suggesting that student perceptions of faculty mindsets may bring wide-ranging benefits to student belonging, identification, and interest in STEM.

Perceived goal affordances in STEM can motivate students to select into social roles. Beliefs that STEM provides opportunities to pursue agentic goals are important to STEM pursuits (Fuesting et al., 2017), but communal opportunities hold unique potential to cultivate interest in STEM (Brown et al., 2015; Diekman et al., 2011). Specifically, according to the combined analyses, faculty mindset predicted interest in STEM more strongly through beliefs that STEM afforded communal than agentic goals. The stronger relationships for communal affordances may emerge because they provide new information; given cultural stereotypes, students likely already perceive STEM contexts as providing opportunities to pursue agentic goals (Diekman et al., 2010, 2011). A key point for motivation research is that growth mindset

contexts were perceived as facilitating both agentic and communal goal pursuit; these ends are not seen as in opposition to each other.

Limitations and Future Directions

The current studies incorporate data from a racially diverse sample at an urban university (Study 1), predominantly White samples of college students (Studies 2a – 4b), and samples of adults who recently took a course in science or math (Studies 5a and 5b). Extant research suggests that communal affordance beliefs may be particularly powerful among underrepresented minority students in STEM (Smith, Cech, Metz, Huntoon, & Moyer, 2014; Thoman et al., 2015, 2017), and thus further research to document these processes among diverse samples is warranted. Further, investigations outside of a US context would offer a wealth of insight, particularly given cross-national variation in communal affordance stereotypes (e.g., Brown, Steinberg, Lu, & Diekmann, 2017).

Future research would do well to understand how these processes play out similarly and differently among students already in the STEM pathway and those in other majors. Although understanding these processes among students who are currently STEM majors is important, it is also essential to understand how faculty mindset influences beliefs about and attitudes toward STEM among students who are *not* STEM majors. Because virtually all students take entry-level science or math in high school or college, the messages that they perceive from faculty can influence whether they enter into the STEM pathway at all. In particular, student experiences in entry-level courses can set a cascade of positive effects in motion, similar to upward cycle effects from brief interventions (e.g., Yeager & Walton, 2011). For example, faculty growth mindset can set the stage for helping and being helped by peers or seeking out communal opportunities related to STEM: These activities in turn can produce benefits to belonging, motivation, and

interest. Longitudinal investigations of these relationships would be an important complement to the cross-sectional mediational analyses and the experimental methods used here. Inferences from cross-sectional mediation analyses have inherent limitations (e.g., Maxwell & Cole, 2007), although we attempted to mitigate concerns by also including experimental methodologies (e.g., Fiske, 2016).

Throughout this research, we investigated students' *perceptions* of their faculty members' mindsets but did not investigate faculty members' *actual* self-reported mindset beliefs. Previous research shows that faculty who personally endorse fixed mindset beliefs tend to engage in behaviors that communicate those beliefs (for example, by comforting students after failure or by stating that not everyone can be a "math person"; Rattan, Good, & Dweck, 2012). However, even if faculty members personally endorse growth mindset beliefs, the question remains as to whether their behavior and practices communicate communal affordances. Future research should examine whether interventions can effectively target faculty beliefs, behavior, or both to create a growth mindset culture in the classroom and stoke student interest. Understanding how assignments, lecture content, and class activities relate both to mindset and to goal affordances is an essential step.

Throughout this work, we found evidence that growth mindset contexts (compared to fixed contexts) signaled increased agentic goal affordances, suggesting that a focus on development also allows individuals to feel that they are able to achieve. Our measures of agentic goal affordances assessed whether individuals felt as though STEM could afford achievement and self-direction goals. Future work would do well to further explore this relationship, and to clarify whether individuals tend to perceive that they are able to pursue multiple aspects of agency (e.g., power, status, or achievement) within growth mindset contexts.

Another future direction of note is exploring the potential bidirectionality of the relationship between faculty mindset and affordances. The current studies clarified that faculty mindset signaled communal and agentic affordances, and it is also possible that increasing the communal affordances within a context can communicate a growth mindset. For instance, an increased focus on collaboration within an academic program may communicate that the environment prizes development rather than the display of ability.

Finally, the current work focused on STEM contexts, and as such does not provide insight into whether these processes operate similarly in other academic fields or other contexts. Communal opportunities have been demonstrated as influential in motivations to pursue politics (Schneider, Holman, Diekman, & McAndrew, 2016) and business (McCarty, Monteith, & Kaiser, 2014). In these fields as well, the mindset of leaders likely provide cues to the goal opportunities of a field or workplace.

Conclusion

Both growth mindset and communal affordances motivate interest in STEM. Understanding how these constructs fit together and their intertwined processes provides new levers for intervention to increase the motivation and interest for all students who wish to pursue communal and agentic goals. To return to the example that began this paper, the student who sees her chemistry professor as believing that her students can develop and grow makes inferences both about the immediate context and more generalized STEM roles. Faculty who cue growth mindsets can thus set into motion a beneficial sequence: Perceived faculty growth mindset fosters beliefs that students can pursue their valued goals, and these in turn foster interest and engagement in STEM.

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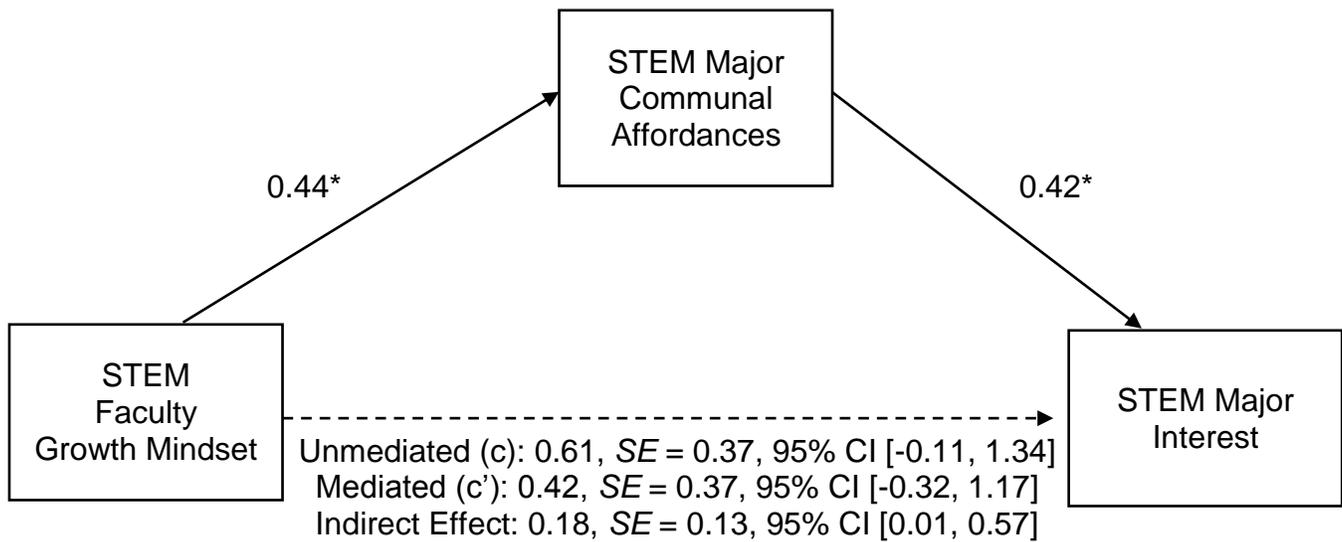
<https://doi.org/10.3102/0034654311405999>

Table 1

Examples of Free-Response Descriptions of STEM Courses (Study 4a)

Faculty Mindset	Example 1	Example 2
Growth	<p>My high school physics teacher absolutely adored physics and it really showed during class. He would group us into groups of four and have us work together to solve problems. He really emphasized persistence, teamwork, and critical thinking. He was a great role model and encouraged us all.</p>	<p>Dr. [faculty name] is a teacher who genuinely makes sure that, from the beginning, Chemistry 141 skills are revisited, mastered, and uses the 142 material to directly relate to what we have already learned. She also uses many different teaching techniques to cater to different students' learning styles. In class, we do lectures, [sic] group assignments, and group quizzes.</p>
Fixed	<p>My professor did not really care about us or how we were doing in the class, he just stood up at the front of the classroom and lectured at us for the entire class every Monday, Wednesday, and Friday. He didn't seem to show any genuine concern for our understanding of the material; it was either you can understand it or you don't and then you have to go home and teach yourself if you were struggling.</p>	<p>This course was a very difficult course for me since I am not good at chemistry. While this professor made himself available to students, he refused to answer questions regarding things that were written in our notes. He would repeatedly insult these students for asking for help and it wasn't right in my opinion. I went to this professor for help many times and for the most part he would try to help but made me feel dumb a lot of the time.</p>

A.



B.

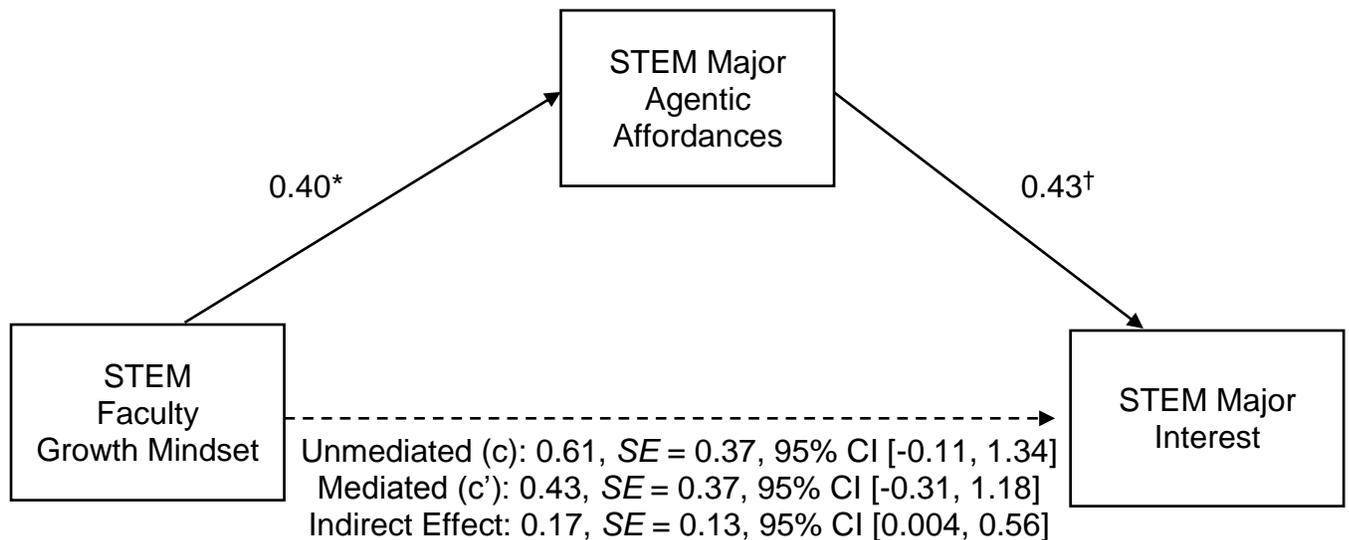


Figure 1. Perceived faculty mindset indirectly predicts increased interest in STEM

majors through increased STEM communal (Panel A) and agentic affordances (Panel B; Study 1).

Note: Figure reports unstandardized beta weights.

† $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .0001$

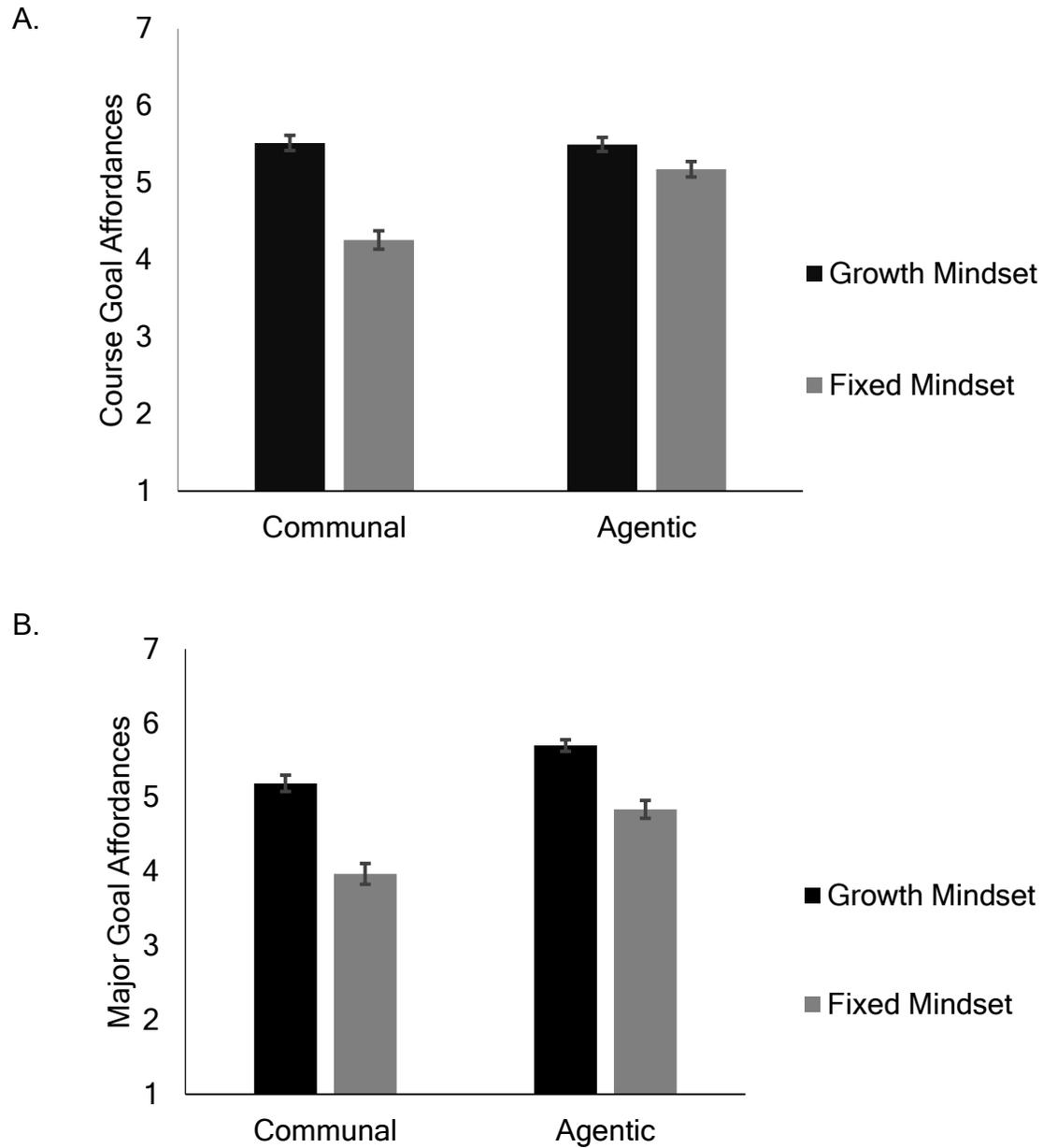
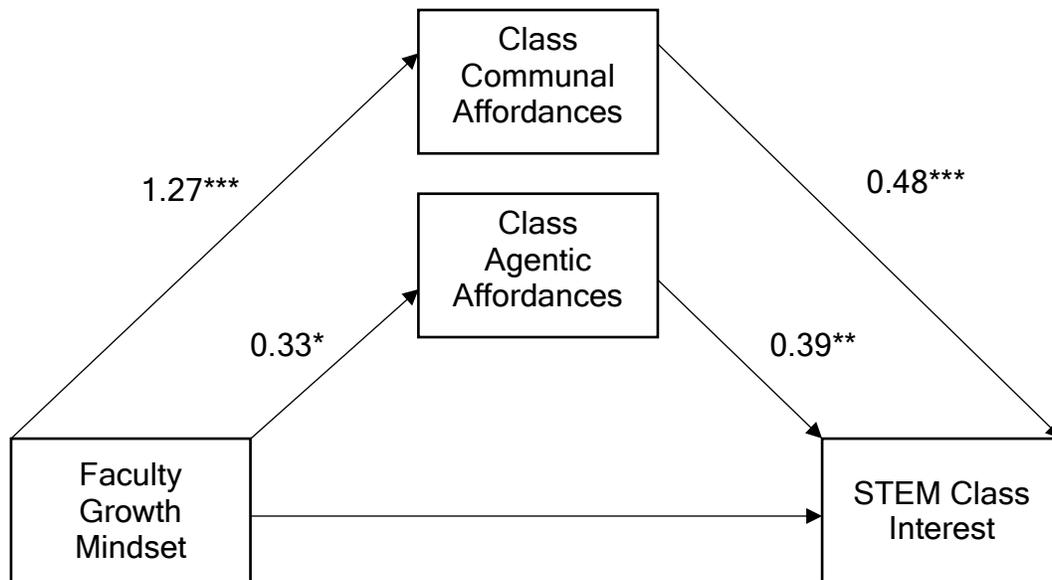


Figure 2. Experimental manipulation of faculty mindset influenced goal affordances of courses and majors (Studies 2a and 2b).

Note: Error bars represent ± 1 standard error.



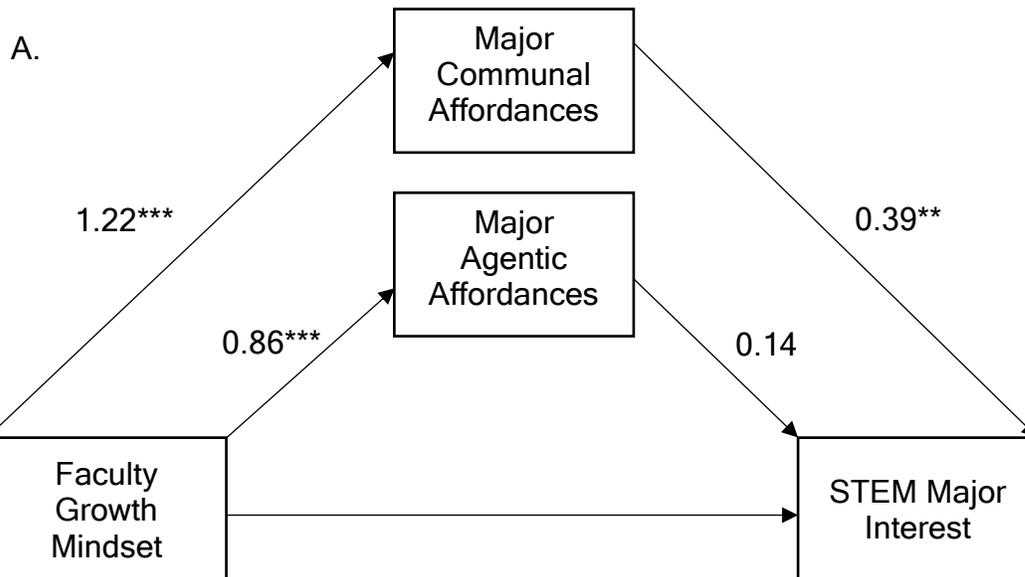
Unmediated: $b = 1.00$, $SE = 0.21$, 95% CI [0.59, 1.42]

Mediated: $b = 0.26$, $SE = 0.21$, 95% CI [-0.15, 0.67]

Total Indirect Effect: $b = 0.74$, $SE = 0.168$, 95% CI [0.46, 1.08]

Communal Indirect Effect: $b = 0.61$, $SE = 0.15$, 95% CI [0.36, 0.93]

Agentic Indirect Effect: $b = 0.13$, $SE = 0.07$, 95% CI [0.03, 0.30]



Unmediated: $b = 1.08$, $SE = 0.24$, 95% CI [0.61, 1.55]

Mediated: $b = 0.49$, $SE = 0.26$, 95% CI [-0.02, 1.00]

Total Indirect Effect: $b = 0.59$, $SE = 0.17$, 95% CI [0.30, 0.98]

Communal Indirect Effect: $b = 0.47$, $SE = 0.14$, 95% CI [0.23, 0.79]

Agentic Indirect Effect: $b = 0.12$, $SE = 0.11$, 95% CI [-0.08, 0.37]

Figure 3. Manipulated faculty mindset (dummy coded: fixed = 0, growth = 1) indirectly predicts increased STEM interest through beliefs that STEM education would afford communal and agentic goals (Panel A: Study 2a; Panel B: Study 2b).

Note: Figure reports unstandardized beta weights. * $p < .05$ ** $p < .01$ *** $p < .0001$

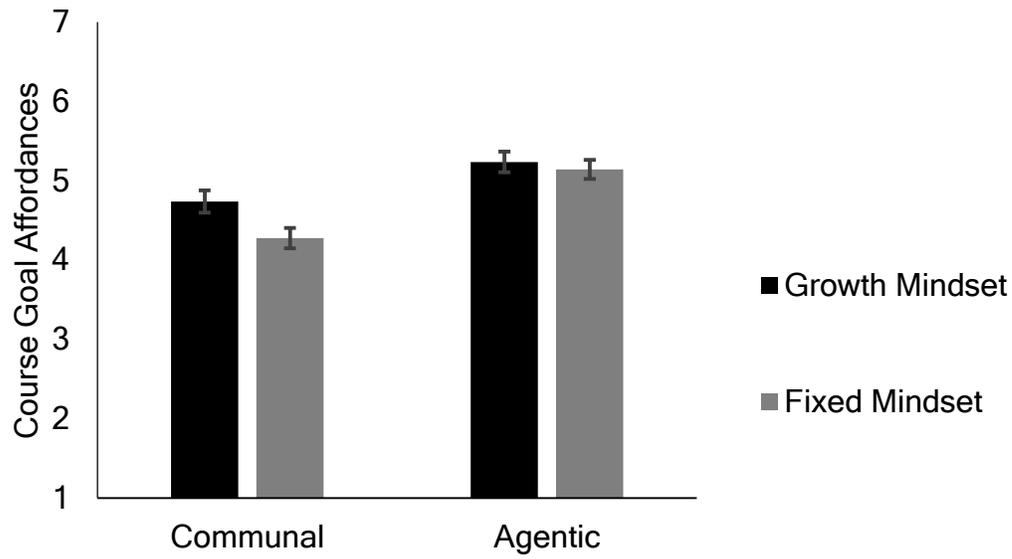


Figure 4. Experimental manipulation of faculty mindset influenced course communal affordances (Study 3).

Note: Error bars represent ± 1 standard error.

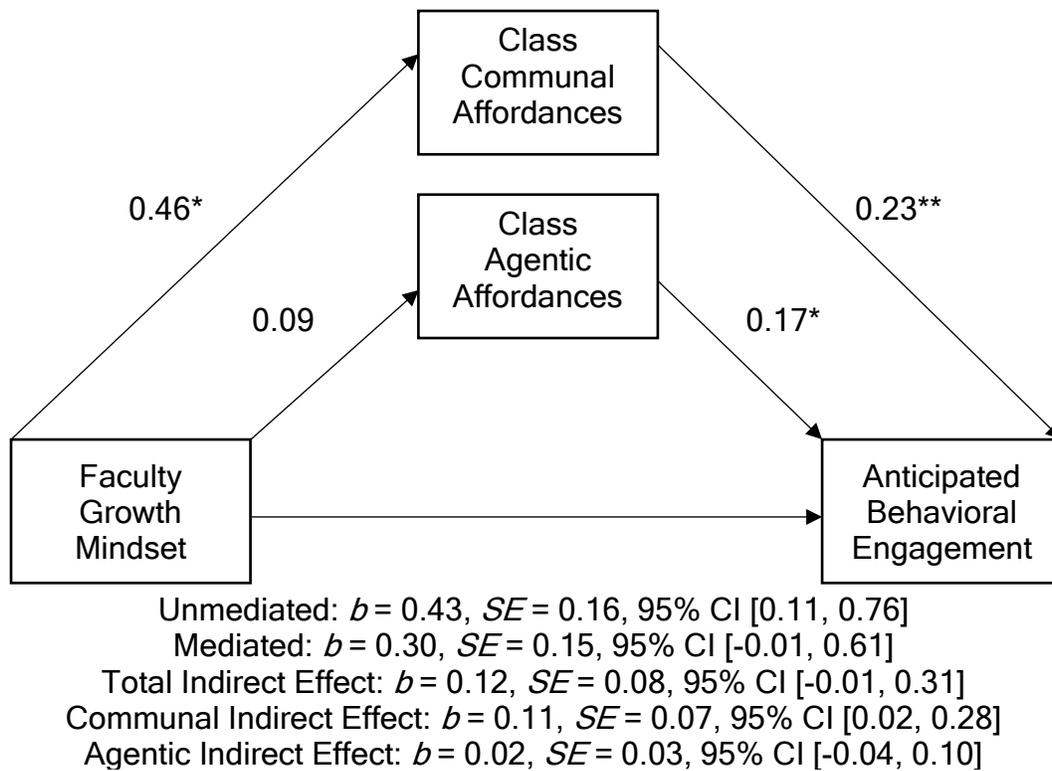


Figure 5. Manipulated faculty growth mindset (dummy coded: fixed = 0, growth = 1)

indirectly predicts increased anticipated STEM behavioral engagement through beliefs that STEM education affords communal goals (Study 3).

Note: Figure reports unstandardized beta weights.

* $p < .05$ ** $p < .01$ *** $p < .0001$

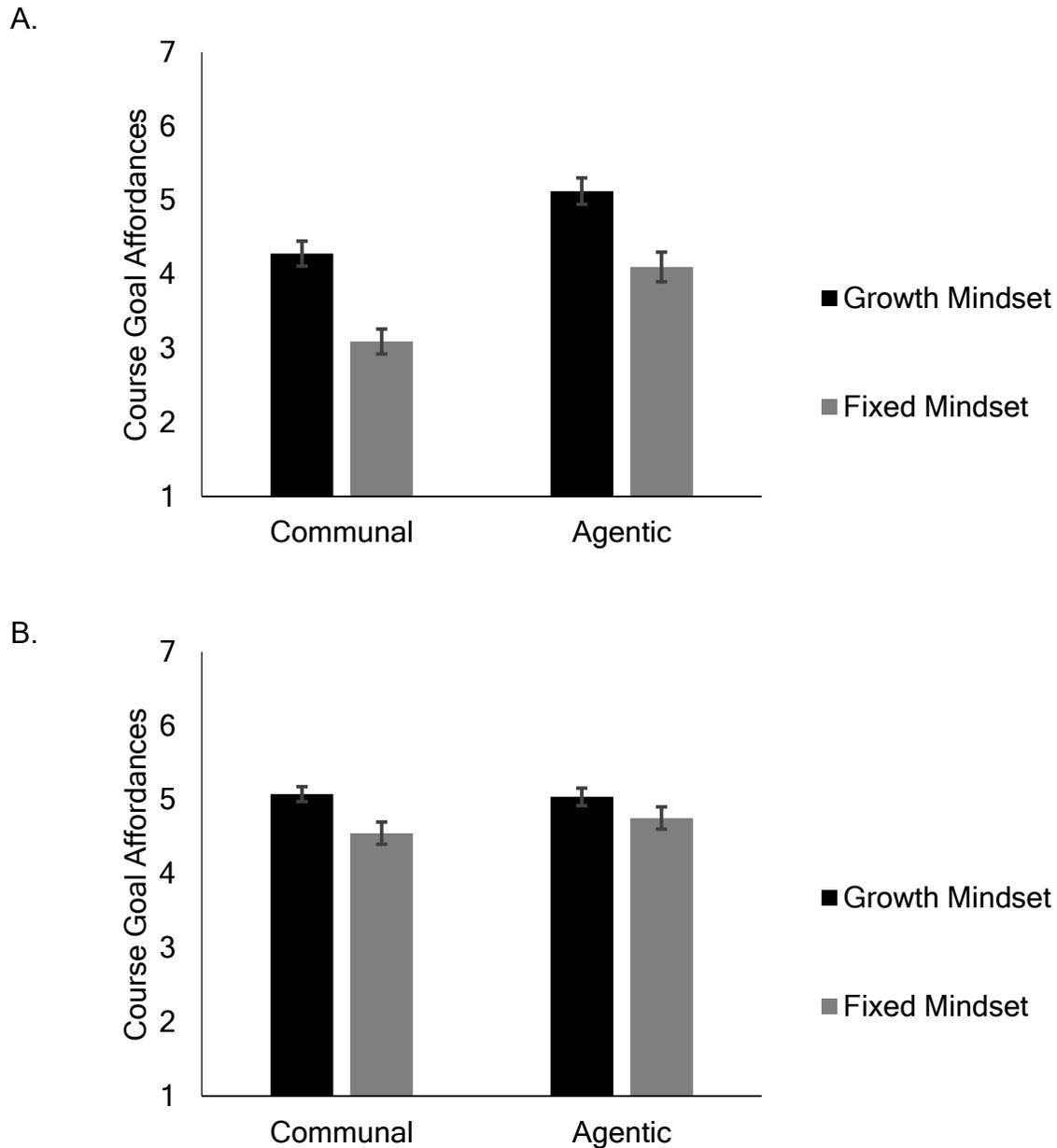


Figure 6. Participants describing a growth mindset versus fixed mindset faculty member's course reported that they believed that the course afforded more communal and agentic goals in Study 4a and more communal goals in Study 4b (Panel A: Study 4a; Panel B: Study 4b).

Note: Error bars represent ± 1 standard error.

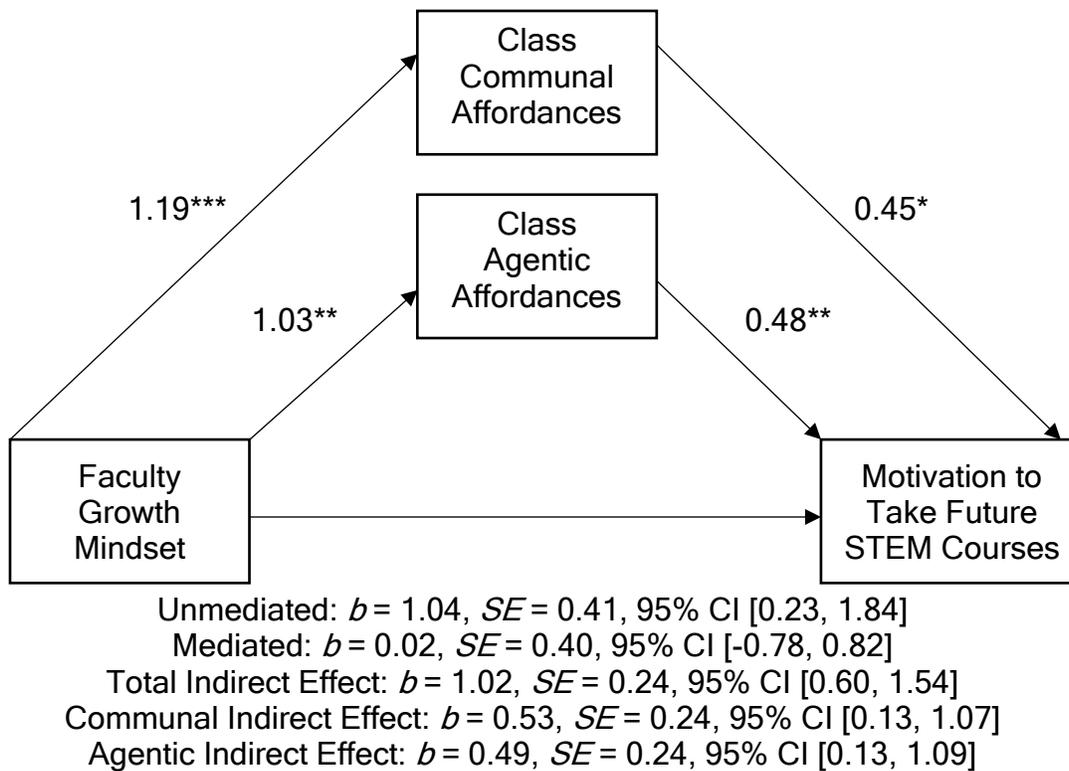
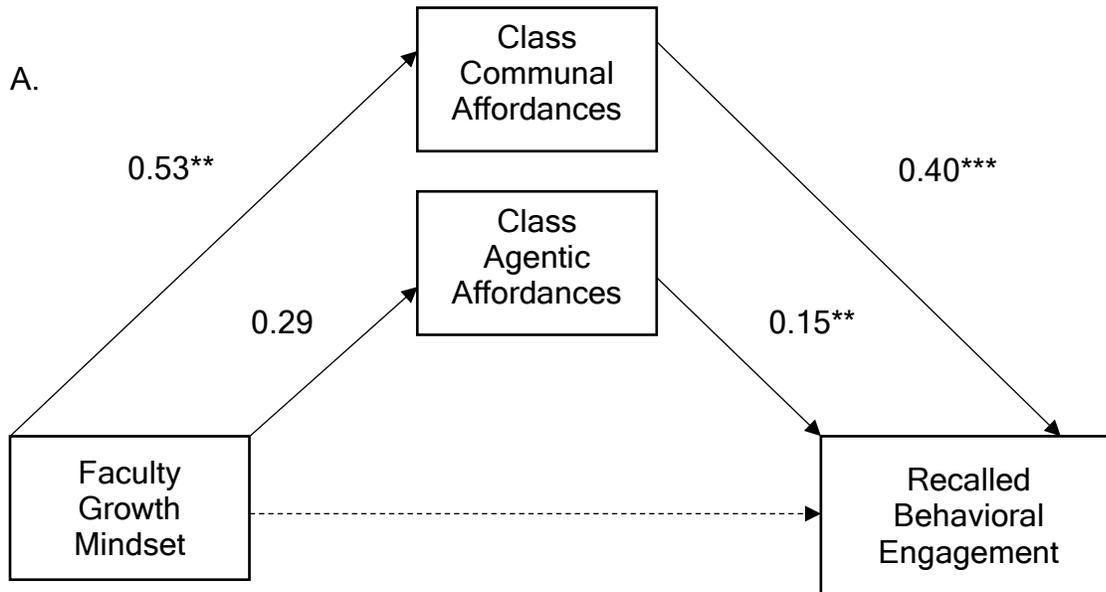


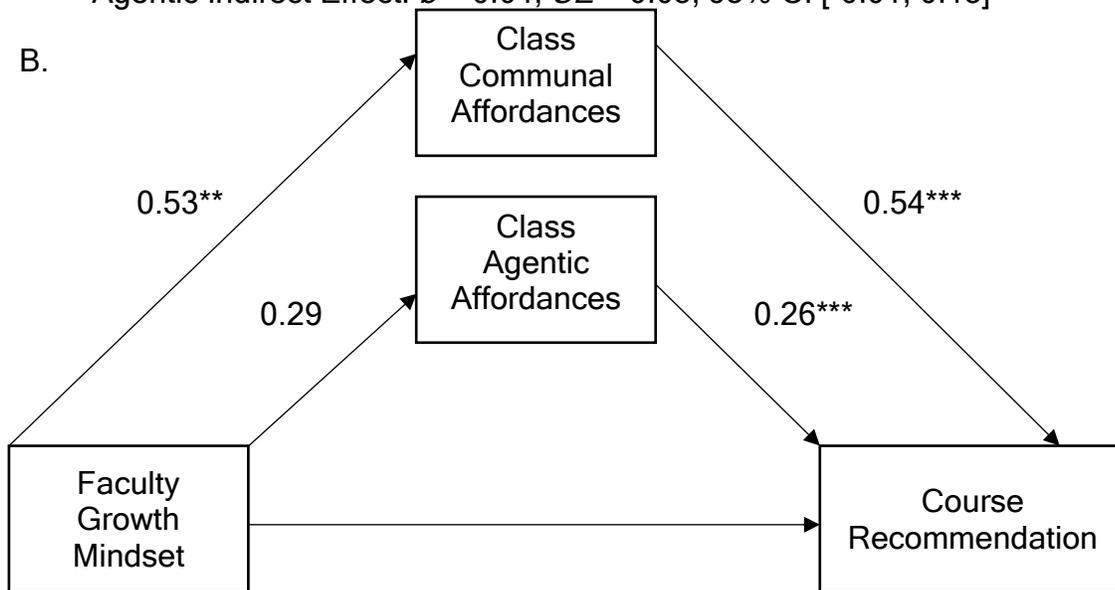
Figure 7. Manipulated faculty growth mindset (dummy coded: fixed = 0, growth = 1) indirectly predicts increased STEM motivation through beliefs that STEM education would afford communal and agentic goals (Study 4a).

Note: Figure reports unstandardized beta weights.

* $p < .05$ ** $p < .01$ *** $p < .0001$



Unmediated: $b = 0.17$, $SE = 0.15$, 95% CI [-0.13, 0.47]
 Mediated: $b = -0.08$, $SE = 0.13$, 95% CI [-0.33, 0.17]
 Total Indirect Effect: $b = 0.25$, $SE = 0.09$, 95% CI [0.08, 0.43]
 Communal Indirect Effect: $b = 0.21$, $SE = 0.07$, 95% CI [0.08, 0.36]
 Agentic Indirect Effect: $b = 0.04$, $SE = 0.03$, 95% CI [-0.01, 0.13]



Unmediated: $b = 0.91$, $SE = 0.18$, 95% CI [0.56, 1.26]
 Mediated: $b = 0.55$, $SE = 0.13$, 95% CI [0.29, 0.81]
 Total Indirect Effect: $b = 0.36$, $SE = 0.13$, 95% CI [0.11, 0.64]
 Communal Indirect Effect: $b = 0.28$, $SE = 0.10$, 95% CI [0.10, 0.51]
 Agentic Indirect Effect: $b = 0.08$, $SE = 0.06$, 95% CI [-0.02, 0.20]

Figure 8. Manipulated faculty growth mindset (dummy coded: fixed = 0, growth = 1) indirectly predicts increased recalled behavioral engagement and course recommendation through beliefs that STEM affords communal goals (Study 4b).

Note: Figure reports unstandardized beta weights.

* $p < .05$ ** $p < .01$ *** $p < .0001$

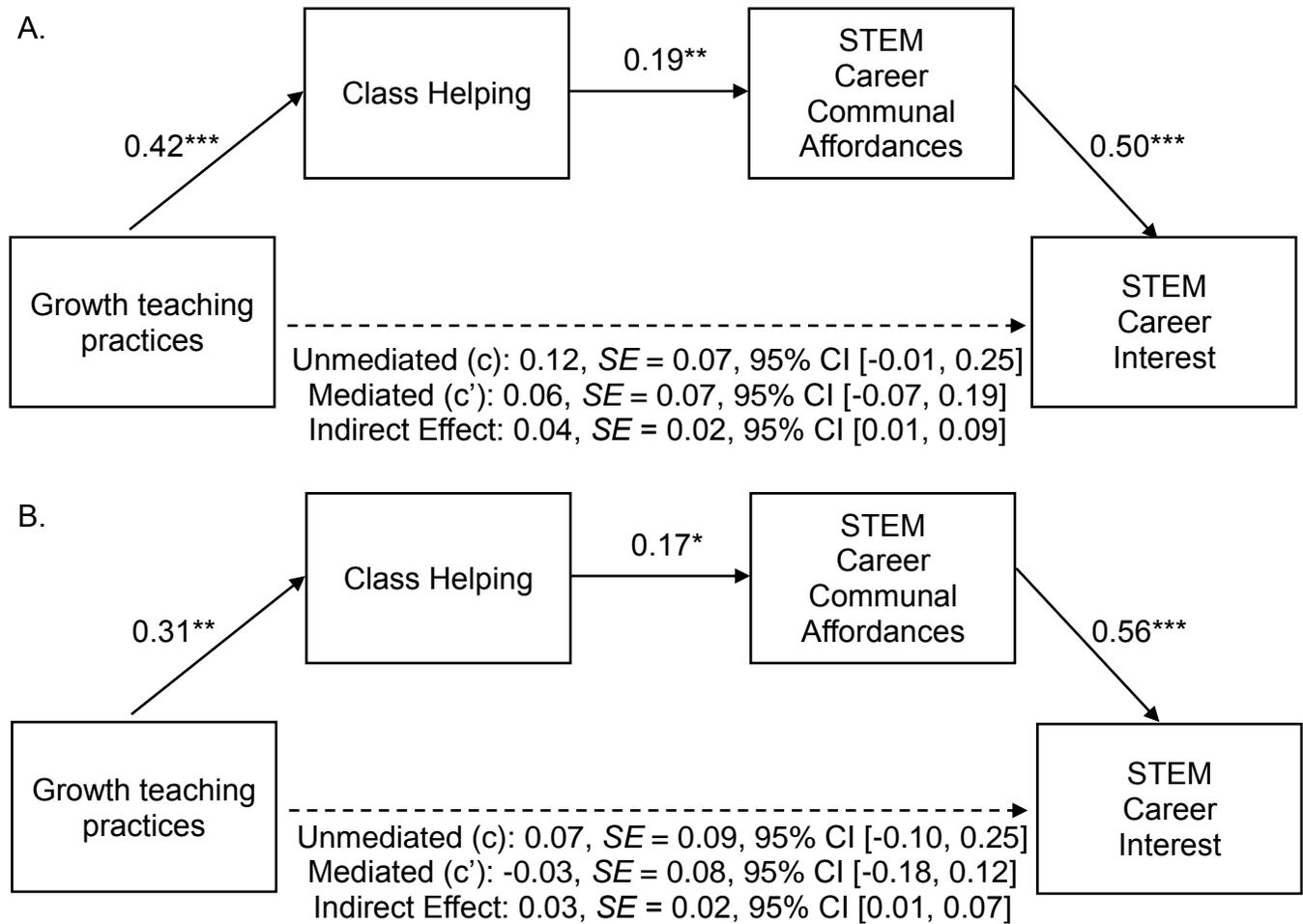


Figure 9. Growth-oriented teaching practices indirectly predict increased interest in STEM careers through class helping and STEM career communal affordances (Panel A: Study 5a; Panel B: Study 5b).

Note: Figure reports unstandardized beta weights.

* $p < .05$ ** $p < .01$ *** $p < .0001$

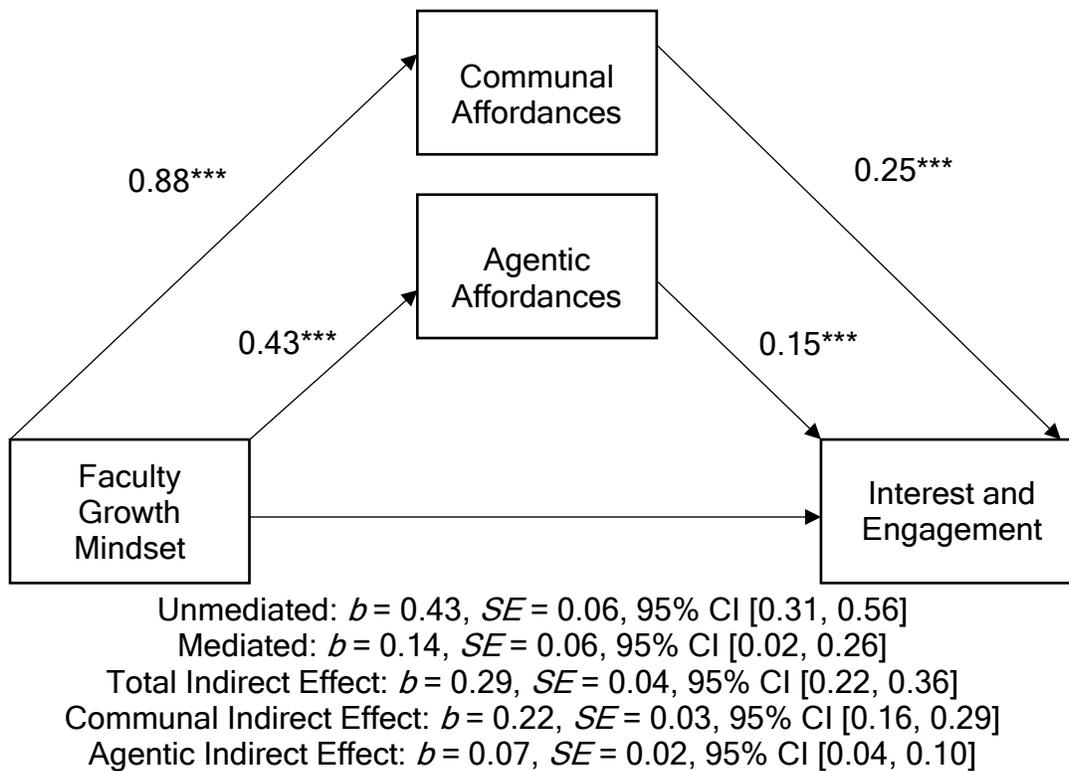


Figure 10. Combined data from Studies 2a - 4b (N = 916) show that manipulated faculty growth mindset (dummy coded: fixed = 0, growth = 1) indirectly predicts increased STEM interest and engagement through beliefs that STEM affords communal and agentic goals.

Note: Figure reports unstandardized beta weights.

* $p < .05$ ** $p < .01$ *** $p < .0001$