False growth mindsets in teachers negatively impact student beliefs and achievement

Abstract

Students' incremental beliefs about intelligence (commonly known as a "growth mindset") have become an increasingly popular topic among researchers, educators, and members of the general public concerned with promoting student success. However, there is evidence that people can reduce the concept of a growth mindset to the message that effort, by itself, can lead to success, without reference to the importance of help-seeking or choosing appropriate learning strategies. This "false growth mindset," particularly when adopted by teachers, may have unintended negative consequences, especially in situations when effort alone is not enough.This paper reports a series of analyses that examine how these teacher mindsets affect both beliefs about ability and subsequent academic achievement amongst their students. A non-parametric latent profile analysis of data from a nationally representative sample of over 3,800 9th-graders and more than 300 of their mathematics teachers in over 60 public schools indicated that 38% of teachers surveyed endorsed a false-growth mindset. Students in these classrooms were more likely than students in the classrooms of teachers with a true growth mindset (who made up just 39% of the sample) to view their teachers as having ‘fixed’ ability beliefs and were more likely to hold entity theories about their own intelligence. These student beliefs about ability themselves significantly mediated the relationship between teachers’ false growth mindsets and lower end-of-year student grades among students in those classrooms.

Keywords: growth mindset, incremental beliefs about intelligence, teacher practice, high-school, latent profile analysis, structural equation modeling

False growth mindsets in teachers negatively impact student beliefs and achievement

A 'growth mindset' is associated with a range of positive outcomes throughout people's lives, including improved academic success and more productive responses to setbacks and stressors (e.g. *1, 2*). Students who view intelligence as malleable believe that intellectual improvement is possible if they work for it (e.g. *3*). As a result, those who endorse a growth mindset are able to reframe potential setbacks, such as academic failure experiences or challenge, as opportunities for improvement (e.g. *4*; though see *5* for evidence that growth mindsets do not always correlate with theorized outcomes; and see *6, 7* for meta-analyses with competing findings about the efficacy of growth mindset interventions). Teachers who hold a growth mindset can both transmit these beliefs to their students and, in doing so, create supportive learning environments for all of their students (*8-11*).

Despite the recent popularity of the conceptualization (e.g. *12*), there is worry that, in the real world, the growth mindset is not interpreted, internalized, or enacted in its full proper scope (*13-15*). Instead of learning that effort, strategies, and help-seeking are all important tools for growing one's abilities, and that this change also requires support from broader sociopolitical systems (e.g. *16, 17*), growth mindsets appear to frequently be reduced to the simple maxim that anyone can improve themselves through simply trying hard (e.g. *18*). While this interpretation of a growth mindset may help students who are in supportive environments and whose struggles can be overcome through sheer individual persistence, it may be harmful when students need to try alternate strategies to overcome failure, or who need broader advice and mentorship in navigating roadblocks to success. Teachers who hold these *false growth mindsets* (i.e., those who believe that effort alone is the key to improving one's abilities) may be especially intolerant of

the failure of their students, as they may come to believe that since anyone can succeed by trying hard, students who are not succeeding simply are not trying hard enough. In elevating effort above the importance of strategy-use and help-seeking, a false growth mindset may even have the ironic effect of leading students to believe that they cannot improve on their abilities if, even when they try their hardest, they are unable to succeed. This belief may curdle into a student's sense that they aren't the sort of person who can do that sort of thing - the very hallmarks of an entity theory of ability.

Do False Growth Mindsets Matter?

Because educator's entity theorizing can affect the outcomes of a significant proportion of their classroom (*8, 19*), there are reasons to believe that a false growth mindset may be dangerous. Students whose teachers mainly praise their effort, without praising their strategies have been shown to interpret that praise as demeaning, indicating that their teacher does not believe that they have the ability to succeed in the class and that the teacher is just praising their effort as a sort of 'consolation prize.' Students who make this attribution are then more likely to question their abilities, ironically shading them towards an entity theory of their own intelligence (see *20* for a review).

Educators who truly believe that effort is the only thing that matters for one's outcomes may see the failures of others as an indication of their unwillingness to try hard enough to succeed, and a misunderstood growth mindset may lead people to blame others for their failures, i.e. victim-blaming (e.g. *21-23*). This line of thinking may be especially problematic in educational settings. If a teacher interprets a student's failure as coming from a lack of ability, they may be driven to pity, while if they interpret the failure as coming from a lack of effort, they may be driven to anger (*24, 25*). Teachers with a false growth mindset, therefore, may be less

likely to help struggling students, and may be communicating to students, either intentionally or unintentionally, that failure indicates that students are lacking innate ability and are unlikely to improve.

The Present Study

While the false growth mindset has been discussed among growth mindset educators (e.g. *26*), it is still unclear how prevalent such beliefs are among teachers, how students interpret these teacher beliefs, and how they relate to students' own beliefs and academic outcomes. In this paper, we use a large, nationally-representative sample of over 3,750 American 9th-grade public-school students nested within over 300 mathematics teachers across over 60 schools, collected as part of the National Study of Learning Mindsets (NSLM), to investigate the nature and consequences of teachers' false growth mindsets (see *27, 28* for methodological details). We use teachers' self-reported practices and beliefs to construct a set of mindset profiles that assess how teachers naturally understand various aspects of the growth mindset. We then look at their students, measuring student perceptions of their teacher's mindset as well as students' own mindsets, to understand how teacher mindsets get transmitted into student beliefs. Finally, we investigate how teacher mindset profiles influence student performance in the classroom, both directly and mediated through changes in the ways that students come to understand their teachers and themselves.

We predicted that teachers would endorse different beliefs related to growth mindset, including a false growth mindset. Specifically, we predicted that there would be a set of teachers who believed that students could become smarter and better at math, but would emphasize the importance of effort and downplay the importance of strategy use and help-seeking. These beliefs would also be reflected in teachers' classroom structures. We predicted that having a

teacher with a false growth mindset profile (compared to a more comprehensive 'true' growth mindset profile) would lead students to be more likely to 1) perceive that their teacher held fixed beliefs about intelligence, and 2) adopt fixed beliefs themselves. These increases, we predicted, would partially mediate the relation between teacher mindset profiles and students' end-of-year grades. Finally, we predicted that these relations would be stronger for students with lower prior academic performance, as they would be the most likely to struggle, and therefore the most likely to face negative consequences from teachers with a false growth mindset profile.

Results

Confirmatory Analyses

Do Teachers Endorse a False Growth Mindset? Profiles of Teacher Beliefs

We initially sought to identify which, if any, teachers possessed patterns of belief that matched our conceptualization of the false growth mindset. To categorize teachers' beliefs, we used a multi-level non-parametric latent profile analysis (LPA), with teachers nested within schools (*29, 30*). Latent profile analysis is a person-centered analytic approach which looks at the way that participants respond to a set of items, modelling the natural variation in patterns of responding as the function of a set of distinct underlying latent variables. Latent profiles allow researchers to capture entire complex worldviews without resorting to 4- and 5-level interaction terms (e.g. *31*). Thus, this analysis is a good match for identifying a construct such as the false growth mindset which is defined in terms of the relative relationships of its constituent parts. By adding a multilevel aspect to these analyses, we can model how profiles that are expressed across teachers differ based on the schools in which they teach.

Using both multiple- and free-response data from teachers asked about their beliefs about mindsets, ability, their teaching practices, and the reactions that they would have to hypothetical students who were either struggling or succeeding in their class, we initially fit flat (un-nested) models and compared model fit for solutions that modeled between 2 and 8 profiles. Based on the fit statistics of the flat models, we then fit a set of multilevel nonparametric models with 2 to 5 Level-1 (teacher) profiles and 1 to 5 Level-2 (school) profiles. A solution with three Level-1 profiles and one Level-2 profile best fit the data (aBIC = 19,666.39, AIC = 19,608.21, Entropy = .89). The existence of only one Level-2 (school-level) profile indicated that the three lower-level profiles did not differ based on the school that the teacher taught in, and that latent profiles were expressed similarly regardless of school context. See Table 1 for point estimates for all items used in the final profile solution. Profile fit statistics for all profiles can be found in the Online Supplement.

Teachers belonging to the first profile, which we characterized as exhibiting a *False Growth Mindset* (*n* = 117; 38% of the sample) *strongly* agreed with the statement that people could grow their ability, and that any student had the intellectual potential to do well at the highest level of college mathematics. This group tended to praise the efforts of successful students while, at the same time, not pushing them to try harder challenges. Coding of the teachers' free responses about what they would say to the struggling and successful students suggested that these teachers were also likely to respond in more authoritarian fashion to struggling students: demanding that they do things the way that the teacher wanted and being less likely to acknowledge the student's way of seeing the world or approaching the class problems; while tending towards strong positivity in their messages to the succeeding students. In other words, these teachers showed some variant of a false growth mindset: believing that

students can grow their ability and that everyone has the potential to succeed, while emphasizing the value of effort and having fewer intentions to help students find their own ways of succeeding in school.

Teachers belonging to the second profile, which we characterized as exhibiting a *True Growth Mindset* (n = 120; 39% of the sample) rated growth mindset-related items positively but less highly than teachers in the *False Growth Mindset* profile. These teachers were moderately likely to praise the effort of succeeding students, and provided feedback that was more empathetic and supportive of each student's individual needs and worldviews. These teachers, in other words, planned on providing behavioral support for success, with an eye towards being mindful of the different problems that different students may be having.

Teachers belonging to the third profile, which we characterized as exhibiting an *Entity Theory* (n = 68; 22% of the sample) tended to believe that one's intelligence is immutable, that being a top math student is the sort of thing that cannot be taught, and that success in math requires talent, not just hard work. These teachers were also likely to believe that teaching itself is something that requires talent, and that really great teachers are born, not made. In short, these teachers reported beliefs that ability is a fixed quantity both for students and for themselves and their fellow teachers. These teachers also provided a wide range of free responses to both the struggling and succeeding students, underlining the heterogeneity contained within an entity theory.

Are Teacher Beliefs Associated with Student Outcomes? Assessing the Direct Relation Between Teacher Growth Mindset Profile and Student Grades

After identifying a profile solution, we used profile membership to predict the grades of students in teachers' classrooms. Using data from 5453 students nested within 139 teachers

(those student and teacher pairs for which we were able to uniquely match classrooms, and for whom we had student grade data available), we, unexpectedly, did not find evidence that students with teachers profiled as holding false growth mindsets had lower end-of-year grades than those students with teachers profiled as holding true growth mindsets, False $M = 2.46$ [2.31, 2.62]; True $M = 2.56$ [2.41, 2.72], $b = -.10$ [-.31, .12], $t(128.55) = -0.91$, $p = .37$, $d = -0.079$ [-0.13, 0.24]. We additionally did not find evidence that the effect of teacher mindset on student grades was different based on students' prior-semester grades, interaction $b = 0.0002$ [-0.06, .06], $t(1399) = 0.009$, $p = .99$. This null effect is difficult to interpret however, given that unexpected issues with the available data limited this analysis to just 1403 students nested within 30 teachers, only 10 of whom were categorized as believing in a false growth mindset. Moreover, students enrolled in schools that reported their prior-semester grades had significantly higher grades during the semester in which the data were collected than students whose schools did not report prior-semester grades: $t(3249.1) = 5.45$, $p < .001$, $d = 0.15$ [0.09, 0.20]. As such, the sample included in our interaction models may not be representative of our broader set of students and teachers.

Do Student Beliefs Mediate the Relation Between Teacher Mindsets and Student Grades?

Next, we considered whether or not educators' beliefs were indirectly related to their students' end-of-term grades through their students' own beliefs about ability or perceptions of their teachers' beliefs. We had predicted that student beliefs and perceptions would mediate the link between teacher mindset and student outcomes, with students whose teacher held a false growth mindset being more likely than students whose teacher held a true growth mindset to think that their teacher had a fixed mindset about ability, that their teacher cared especially strongly about students' efforts, and that students themselves would come to believe that they

had a fixed ability to do well in the class, all of which would lead to lower student grades. Using data from 4905 students nested within 138 teachers (additionally restricting the data in the direct tests to those students for whom we could calculate self-report beliefs), we found that a teacher profiled as holding a false growth mindset, compared to one profiled as holding a true growth mindset, predicted an increase in time-2 student entity-theory beliefs (*a* path), $b = 0.21$ [0.056, 0.36], $p = .007$; and an increase in student entity-theory beliefs predicted a decrease in end-of-year grades (*b* path), combined Level-1 & mean Level-2 $b = -1.73$ [-2.94, -0.52], $p = .005$; overall indirect effect = -0.36 [-0.70, -0.014], $p = .041$. While we did find that students whose teachers were profiled as holding a false growth mindset were less likely to think that their teacher had a growth mindset about ability than those students whose teachers profiled as holding a true growth mindset, $b = -0.12$ [-0.24, -.002], $p = .046$, we did not find evidence for mediation of teacher false growth mindset to end-of-year student grades through student perceptions of their teacher's theories of ability, indirect effect = 0.18 [-0.14, 0.51], $p = .27$; nor through student perceptions of their teacher's theories of effort, indirect effect = 0.70 [-0.24, 0.10], $p = .41$. See Figure 1 for a simplified path diagram.

In a set of exploratory mediation models outside of an SEM framework (i.e. without simultaneously controlling for the effects of all three mediators), we find that both student entity beliefs and perceptions of teacher ability beliefs separately mediate the relationship between teacher mindset and end of year student grades: average causal mediation effect through student entity theorizing = -0.026 [-0.050, -0.0042], p = .024; average causal mediation effect through perceptions of teacher beliefs about ability, -0.013 [-0.027, -0.0019], p = .026. See Online Supplement for details.

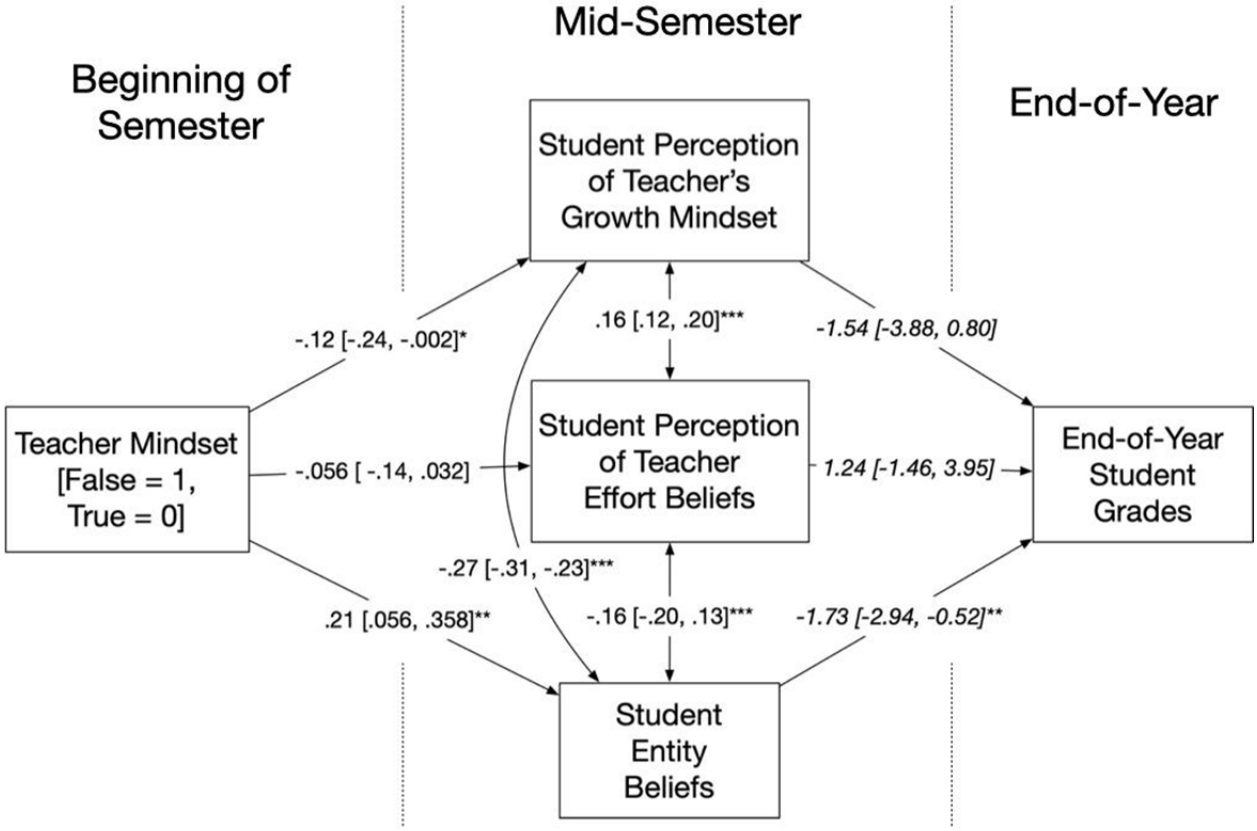

Figure 1. Simplified output for multilevel structural equation model.

Italics indicate combined Level-1 and Level-2 effects. Brackets contain 95% confidence intervals; *p <. 05, **p < .01, ***p< .001.

Exploratory Analyses

Comparing Student Growth Mindsets Across Teacher Profiles

We compared student entity theories at time-2 across the three profiles (false growth mindset, true growth mindset, and entity theory). Using 6,133 students nested within 170

teachers, we conducted a one-way ANOVA, with a random intercept for teachers' classroom. Results indicated that students nested within the three teacher mindset profiles differed significantly: $F(2, 141.79) = 3.48$, $p = .034$. Follow-up uncorrected pairwise tests (Maxwell & Delaney, 2004) suggested that students in classrooms where their teacher was profiled as having a true growth mindset (M = 2.58, SD = 1.18) endorsed entity beliefs significantly less than students whose teacher was profiled as having a false growth mindset (M = 2.78, SD = 1.22): b = -0.19 [-0.38, -0.0081], $z = -2.44$, $p = .015$; and students whose teachers were profiled as having a true growth mindset endorsed entity beliefs marginally less than students in classrooms where their teacher was profiled as having an entity theory (M = 2.73, SD = 1.16): b = -0.19 [-0.42, 0.046], $z = -1.88$, $p = .060$. There was no difference between students in classrooms where their teachers were profiled as having a false growth mindset versus those where their teachers were profiled as having an entity theory: $b = 0.0046$ [-0.23, 0.24], $z = 0.046$, $p = .96$. See Figure 2.

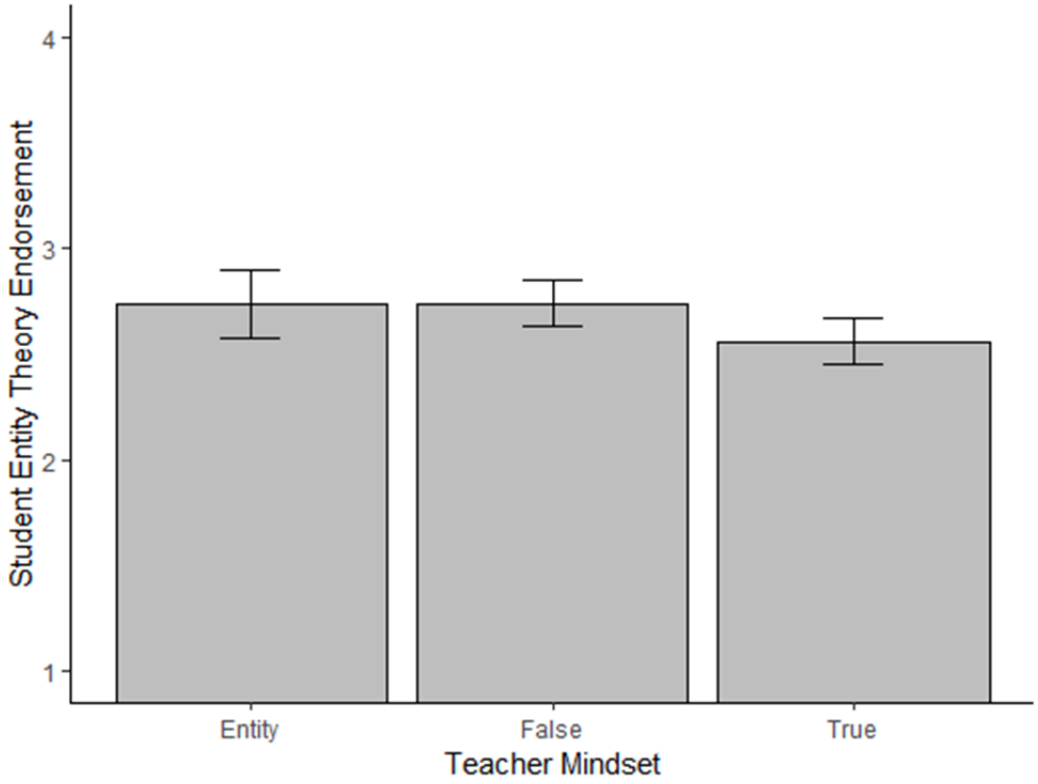

Figure 2. Student endorsement of entity theories of intelligence by the mindset profile of their teacher. Error bars indicate 95% confidence intervals.

Additional Exploratory Analyses

For models that use alternate GPA measures, including math GPA specifically, as the primary dependent variable; models that compare the effect of teachers profiled as having true growth mindset to those profiled as having an entity theory; models that compare the effect of teachers profiled as having an entity theory to those profiled as having false growth mindset; models that investigate moderation of effects by student demographics or mindset-intervention condition; models that investigate differences in student perceptions of teacher mindset across profiles; and models that investigate whether it is more likely that teachers influence student mindsets or that students influence teacher mindsets, see the Online Supplement.

Discussion

Recent work on the positive effects of educators holding growth mindsets on their students' academic performance and motivation (e.g., *8*) has drawn increased attention to interventions and programs designed to promote educators' growth mindsets. While growth mindset interventions teach that people can improve their abilities through hard work, the use of good strategies, and a willingness to ask for help, educators and students may misunderstand this message, omitting the last two elements and leaving them with a "false growth mindset." Such belief acts as a sort of bumper-sticker version - that anyone can improve their ability or intelligence, as long as they simply try (and that, therefore, if someone isn't getting better, they're simply not trying hard enough). We found that this misconception is widespread: among teachers who expressed growth mindset beliefs of any sort, we found that teachers were just as likely to be profiled as holding a false growth mindset (38% of the surveyed) as to be profiled as holding a true growth mindset (39% of the surveyed); and that this belief had meaningful implications for student outcomes.

Students in classrooms with teachers who adopted a false growth mindset were more likely to have fixed mindsets and subsequently had lower academic performance than students whose teachers adopted true growth mindsets. We did not find a direct effect of teacher growth mindset on grades, perhaps due to relatively limited statistical power to detect a small effect (while the point estimate for our identified effect size, $d = .079$, does not differ substantially from the effect of the growth mindset intervention identified across all students in the NSLM, $d \sim 0.05$; *27*, due to our sample restrictions [~5,500 students, as compared to the ~12,500 in the full study], we may have simply been underpowered to detect an effect of this size, as one would

need a sample of 12,562 for 80% power to detect d = .05). We did, however, find the hypothesized mediated relationships. Compared to students whose teachers held true growth mindsets, students whose teachers adopted false growth mindsets tended to be more likely to perceive this teacher as holding a fixed mindset and to view their own ability as fixed. These beliefs about their own abilities predicted lower end-of-year grades for students, mediating the link between teacher beliefs and student outcomes. In exploratory follow-up analyses, we found that the endorsement of entity theories among students with teachers holding false growth mindsets was essentially equivalent to those among students with teachers holding entity theories. Due to the underlying sampling strategy, these analyses allow us to suggest that these patterns of belief and their consequences may be widely shared across American teachers and schools.

Contrary to our expectations, teachers in all three profiles appeared to endorse similar approaches in their teaching, with relatively little difference across profiles in how teachers reported that they would address a student struggling in their classroom. In both cases, we may be dealing with an issue of "cheap talk," where teachers find it easier to think about their teaching-self in the abstract, without having to deal with the concrete everyday, where they may not be able to live up to their ideals (e.g. *32*). It may be instructive, then, that we appeared to see greater differentiation in the coding of the free-responses to the students, where the teacher had to generate responses themselves, without experimenter-cued answers to fall back upon. An intensive observational approach, which directly documents what teachers *do* in their classroom, rather than what they *say*, may prove useful for validation purposes.

We expect that the vast majority of the teachers surveyed in this study self-identify as having a growth mindset, but as the analyses show, precisely how that mindset is comprised and

instantiated has very different repercussions for students. This issue marks the importance for mindset researchers to focus on intervention fidelity (e.g. *33-35*). Mis-specified interventions may bias people towards a misunderstanding of the meaning of the growth mindset, and researchers have shown that what one takes away from a growth mindset intervention alters its effects: in one study, students who interpreted a growth mindset as involving effort alone showed no improvement in end-of-year grades relative to a control, while those who interpreted a growth mindset as involving flexible strategy use and a willingness to ask for help do show improvement (*36*). Future work investigating how different student- and educator-focused growth mindset interventions lead to differing levels of both true and false growth mindsets is a vital step in ensuring that the benefits of the true growth mindset are properly unlocked. After all, those teachers classified as holding a false growth mindset have students who look very similar to those teachers endorsing a fixed mindset, and look very different from those holding a true growth mindset.

In closing, we note one primary, unavoidable issue with these analyses: we were unable to directly measure teachers' false growth mindset, relying instead on a proxy measure. The profiles that we identified do differ from each other in meaningful ways, but as with factor analysis, for example, researchers are interpreting the psychological roots of these differences. While we identified and labeled the profiles prior to the regression and SEM phase of our analyses, and while the profiles do largely act in a predictable way (with teachers classified as possessing a true growth mindset inculcating a stronger growth mindset in their students than those teachers classified as entity theorists, for example), they are nevertheless dependent on the set of questions selected for analysis and may not represent true sets of beliefs in the broader

population. Looking more deeply at false growth mindset beliefs, with a psychometrically-validated tool designed for the purpose, therefore, is a clear need.

The purpose of the current work is not to blame educators or students for incomplete understandings of mindset theory, but to instead put the onus on growth mindset researchers to more effectively communicate the importance of help-seeking and other learning strategies to a true growth mindset. A failure to do so, as demonstrated in the current research, may prevent researchers and educators from capitalizing on the well-evidenced promise of growth mindset work. Given the increasing popularity of growth mindset interventions for both students and educators, there is a clear need to understand not only the elements necessary for a growth mindset belief that meaningfully impacts student motivation and achievement, but also how to communicate these elements effectively. This paper outlines an important opportunity to improve how mindset researchers communicate their work and thus have a greater impact on teaching and learning across educational contexts.

Materials and Methods

Disclosures

Preregistration

All models were refined on an initial 10% of the data, randomly selected, that was made available as an exploratory set for this purpose. After models were finalized, the remaining 90% of the data were made available for the confirmatory tests reported below. The preregistration for this project can be found at https://osf.io/vfxds?view_only=87d1b260a5994cd4bc863b2ef2680d36

Data & Materials

All data and codebooks for the National Study of Learning Mindsets are available at https://doi.org/10.3886/ICPSR37353.v1. Analysis scripts for this project can be found at https://osf.io/qz4g9/?view_only=87d1b260a5994cd4bc863b2ef2680d36. The Online Supplement can be found at https://osf.io/h7s6v/?view_only=87d1b260a5994cd4bc863b2ef2680d36.

Reporting

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

Ethical Approval

The underlying data analyzed in this paper were collected under approval from the Institutional Review Board at Stanford University (30387), ICF (FWA00000845), and the University of Texas at Austin (#2016-03-0042).

Participants

Data come from the National Study of Learning Mindsets (NSLM). The NSLM is a large nationally-representative study of a growth-mindset intervention conducted with over 12,000 9th graders from 65 public schools across the United States along with over 350 of their mathematics teachers. The NSLM is the largest randomized-controlled-trial of growth-mindset interventions to date in a US K-12 setting, and its careful sampling provides an unmatched window into processes surrounding growth mindsets (*27*, see *28* for more about the stratified random sampling and national representation). At the beginning of the semester, students completed a short online session, in which they either learned about a growth mindset, or received a control intervention. 1-4 weeks later, all students completed a set of follow-up measures. Teachers, blind to the condition that their students were randomized into, were simply surveyed at the beginning of the semester.

The subsample of data analyzed here come from the pairing of students and teachers where the student filled out the full complement of measures above, where the student and teacher could be uniquely matched (i.e. the student only had one teacher who filled out survey measures in the dataset), and where end-of-year grades for the student were provided by the school. Depending on the precise specification, the data comprise between 3,835-5,453 students nested within 305 teachers in 61 schools.

Materials

Our primary dependent variable was end of year student grade point average (standardized to a 0-4.3 scale). For those students who took the intervention in the fall semester, we used an average of their fall and spring semester GPAs, while for those students who took the intervention in the spring semester, we just used their spring-semester GPA. $M = 2.45$, $SD = 1.24$.

Student entity theorizing was measured by three items, scale alpha = .80 [.79, .80], $M = 2.70$, $SD = 1.20$; student perceptions of teacher beliefs about ability were measured by five items, scale alpha = .74 [.73, .75], $M = 3.91$, $SD = 1.01$; student perceptions of teacher beliefs about effort were measured by four items, scale alpha = .69 [.68, .70], $M = 3.69$, $SD = 0.84$. Teacher beliefs were assessed with 20 multiple-choice questions, plus coding of two free-response items (see Table 1 for all items).

Analytic Strategy

Analyses were conducted in two phases. In phase one, we identified patterns of response across teachers, using multilevel nonparametric latent profile analysis (LPA) to identify teachers as having a true growth mindset, a false growth mindset, or an entity theory of intelligence. Once

teachers had been classified to a profile, we then looked at the outcomes of students in their classrooms, analyzing whether teacher mindset affected student grades and student beliefs.

As LPA is an inherently exploratory framework, we fit multiple potential models and registered a decision rule about which model to interpret in further analyses. To select the number of profiles to model, we first fit a series of flat LPAs (models with no nesting) that varied in their number of profiles. Based on the fit of the flat models, we then fit multilevel non-parametric LPAs that varied in their number of profiles both at Level 1 (the teacher level) and at Level 2 (the school level). To identify the best-fitting model, we selected the model with the lowest sample-adjusted Bayesian Information Criterion (aBIC), as long as each profile contained at least 10% of the sample, so as to make sure that each profile was capturing a meaningful proportion of the overall data (see Gaspard et al., 2019 for a broadly similar decision rule). If the model with the lowest aBIC did not generate profiles that each contained at least 10% of the sample, we selected the model with the next highest aBIC, until we found a solution that fit both our decision rules. All models used sampling weights in order to maximize the generalizability of the profile results.

After identifying the best-fitting model, we then interpreted the profiles, classifying them as true growth mindset theorists, false growth mindset theorists, or entity theorists, based on their patterns of results and how they related to our theoretical framework.

Once teachers had been categorized into profiles of responding, we collapsed students across their intervention condition, first determining whether students in classes where their teacher had a false growth mindset ended up with worse end-of-semester grades than those students in classes where their teachers had a true growth mindset, by fitting a multilevel regression predicting students' final grades from the teacher mindset dummy described above,

with a random intercept for the teachers' classroom. In this, as in the other models presented here, there are no additional covariates above what is described in the text.

We then followed-up by testing whether the impact of teacher false growth mindset was stronger for students with lower grades in the previous semester, by fitting a multilevel regression predicting students' final grades from the teacher mindset dummy interacted with students' prior-semester grades, with a random intercept for the teachers' classroom.

Finally, to look at whether student beliefs mediated the link between teacher mindset and student grades, we fit a 2-(1, 1, 1)-1 multilevel structural equation model with random slopes (*37-39*): we modeled a level-2 (teacher-level) manifest independent variable (the teacher mindset dummy) predicting three level-1 (student-level) mediating manifest variables: students' time-2 beliefs about their teacher's growth mindset; students' time-2 beliefs about their teacher's theory of effort; and student's own time-2 mindset. Both the IV and the mediators then predicted a manifest level-1 DV: students' end of semester grades. For all the paths from the level-1 mediators, we fit both random slopes and random intercepts. Code for the model can be found at https://osf.io/8tvc5/?view_only=87d1b260a5994cd4bc863b2ef2680d36. We additionally tried to fit a matching 2-(1, 1, 1)-1 model with moderation by prior-semester grades, but the model would not converge. All LPA and SEM models were run in MPlus 8, while all data cleaning and regression models were run using R 3.6.0. All multilevel models were conducted using the *lme4* and *lmerTest* packages, with *p*-values calculated using Satterthwaite-approximated degrees of freedom (*40*).

References

1. Dweck, C. S. (1999). *Self-Theories: Their role in motivation, personality and development.* Philadelphia: Taylor and Francis/Psychology Press.
2. Dweck, C. S. (2006). *Mindset*. New York: Random House
3. Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*(2), 256–273.
4. Mueller, C. M., & Dweck, C. S. (1998). Praise for intelligence can undermine children's motivation and performance. *Journal of Personality and Social Psychology, 75*(1), 33–52.
5. Burgoyne, A. P., Hambrick, D. Z., & Macnamara, B. N. (2020). How firm are the foundations of mind-set theory? The claims appear stronger than the evidence. *Psychological Science, 31*(3), 258-267.
6. Burnette, J. L., O'Boyle, E. H., VanEpps, E. M., Pollack, J. M., & Finkel, E. J. (2013). Mind-sets matter: A meta-analytic review of implicit theories and self-regulation. *Psychological Bulletin, 139*(3), 655.
7. Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological Science, 29*, 549-571
8. Canning, E. A., Muenks, K., Green, D. J., & Murphy, M. C. (2019). STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes. *Science Advances, 5*(2), eaau4734.
9. Park, D., Gunderson, E. A., Tsukayama, E., Levine, S. C., & Beilock, S. L. (2016). Young children's motivational frameworks and math achievement: Relation to teacher-reported instructional practices, but not teacher theory of intelligence. *Journal of Educational Psychology, 108*(3), 300-313.
10. Leroy, N., Bressoux, P., Sarrazin, P., & Trouilloud, D. (2007). Impact of teachers' implicit theories and perceived pressures on the establishment of an autonomy supportive climate. *European Journal of Psychology of Education, 22*(4), 529-545.
11. Rattan, A., Savani, K., Komarraju, M., Morrison, M. M., Boggs, C., & Ambady, N. (2018). Meta-lay theories of scientific potential drive underrepresented students' sense of belonging to science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology, 115*(1), 54-75
12. Mindset Scholars Network (2020). *Compendium of studies that measure learning mindsets: Section 1: Growth mindset*. https://mindsetscholarsnetwork.org/csmlm/section-1/
13. Dweck, C. (2015). Carol Dweck revisits the growth mindset. *Education Week, 35*(5), 20-24
14. Dweck, C. (2016, January 11). Recognizing and overcoming false growth mindset. *Edutopia*. Retrieved from https://www.edutopia.org/blog/recognizing-overcoming-false-growth-mindset-carol-dweck
15. Dweck, C. (2017, January 18). Growth mindset is on a firm foundation but we're still building the house. *Mindset Scholars Network*. Retrieved from https://mindsetscholarsnetwork.org/growth-mindset-firm-foundation-still-building-house/

16. Walton, G. M. & Yeager, D. S. (2020). Seed and soil: Psychological affordances in contexts to explain where wise interventions succeed or fail. *Current Directions in Psychological Science*
17. Yeager, D. S., Romero, C., Paunesku, D., Hulleman, C. S., Schneider, B., Hinojosa, C., ... & Trott, J. (2016). Using design thinking to improve psychological interventions: The case of the growth mindset during the transition to high school. *Journal of Educational Psychology, 108*(3), 374-391.
18. Yettick, H., Lloyd, S., Harwin, A., Riemer, A., & Swanson, C. B. (2016). *Mindset in the classroom: A national study of K-12 teachers*. Bethesda, MD: Education Week Research Center.
19. Haimovitz, K., & Dweck, C. S. (2017). The origins of children's growth and fixed mindsets: New research and a new proposal. *Child Development, 88*(6), 1849-1859.
20. Amemiya, J., & Wang, M. T. (2018). Why effort praise can backfire in adolescence. *Child Development Perspectives, 12(*3), 199-203.
21. Burnette, J. L., Hoyt, C. L., Dweck, C. S., & Auster□Gussman, L. (2017). Weight beliefs and messages: Mindsets predict body□shame and anti□fat attitudes via attributions. *Journal of Applied Social Psychology, 47*(11), 616-624.
22. Hoyt, C. L., Burnette, J. L., Auster-Gussman, L., Blodorn, A., & Major, B. (2017). The obesity stigma asymmetry model: The indirect and divergent effects of blame and changeability beliefs on antifat prejudice. *Stigma and Health, 2*(1), 53-65.
23. Ryazanov, A. A., & Christenfeld, N. J. S. (2018). Incremental mindsets and the reduced forgiveness of chronic failures. *Journal of Experimental Social Psychology, 76*, 33–41.
24. Butler, R. (1994). Teacher communications and student interpretations: Effects of teacher responses to failing students on attributional inferences in two age groups. *British Journal of Educational Psychology, 64*(2), 277-294
25. Georgiou, S. N., Christou, C., Stavrinides, P., & Panaoura, G. (2002). Teacher attributions of student failure and teacher behavior toward the failing student. *Psychology in the Schools, 39*(5), 583–595
26. Dweck, C. (2016, January 13). What having a growth mindset actually means. *Harvard Business Review*. Retrieved from https://hbr.org/2016/01/what-having-a-growth-mindset-actually-means
27. Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., ... & Paunesku, D. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature, 573*(7774), 364-369.
28. Gopalan, M., & Tipton, E. (2018, November 3). Is the National Study of Learning Mindsets Nationally-Representative? https://doi.org/10.31234/osf.io/dvmr7
29. Finch, W. H. & French, B. F. (2014) Multilevel Latent Class Analysis: Parametric and nonparametric models. *The Journal of Experimental Education, 82*(3), 307-333.
30. Henry, K. L. & Muthén, B. (2010). Multilevel Latent Class Analysis: An application of adolescent smoking typologies with individual and contextual predictors. *Structural Equation Modeling, 17*(2), 193-215.
31. Bergman, L. R., & Trost, K. (2006). The person-oriented versus the variable-oriented approach: Are they complementary, opposites, or exploring different worlds?. *Merrill-Palmer Quarterly, 52*(3), 601-632.

32. Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics, 15*(2), 105-127.
33. Hulleman, C. S., & Cordray, D. S. (2009). Moving from the lab to the field: The role of fidelity and achieved relative intervention strength. *Journal of Research on Educational Effectiveness, 2*(1), 88-110
34. Murrah, W. M., Kosovich, J., & Hulleman, C. (2017). A framework for incorporating intervention fidelity in educational evaluation studies. In G. Roberts, S. Vaughn, S. N. Beretvas, & V. Wong (Eds.), *Treatment fidelity in studies of educational intervention* (pp. 39–60). New York: Routledge.
35. O'Donnell, C. L. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K–12 curriculum intervention research. *Review of Educational Research, 78*, 33-84.
36. Wormington, S. (under review). Is effort enough or do I need strategies, too? Assessing the fidelity and efficacy of a growth mindset intervention in developmental mathematics.
37. Stride C. B., Gardner S., Catley. N. & Thomas, F. (2015). *Mplus code for mediation, moderation, and moderated mediation models.* Retrieved from. http://www.offbeat.group.shef.ac.uk/FIO/mplusmedmod.htm
38. Preacher, K. J., Zhang, Z., & Zyphur, M. J. (2011). Alternative methods for assessing mediation in multilevel data: The advantages of multilevel SEM. *Structural Equation Modeling, 18*, 161- 182.
39. Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. Psychological Methods, 15, 209-233.
40. Kuznetsova A., Brockhoff P. B., & Christensen R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software, 82*(13), 1–26.
41. Browman, A. S., Miele, D. B., O'Dwyer, L. M., & May, S. C. (2020) Teachers' growth mindsets and the differential treatment of high- and low-ability students. https://doi.org/10.31219/osf.io/mkh4s.
42. Tingley, D, Yamamoto, T, Hirose, K, Keele, L, Imai, K. (2014). Mediation: R package for causal mediation analysis. Journal of Statistical Software, 59(5), 1-38.

Acknowledgments

The authors would like to thank Jamie DeCoster for help with the structural equation models and Jenny Buontempo for guidance through the underlying data.

Funding

Research reported in this manuscript was supported by a National Study of Learning Mindsets Early Career Fellowship, with funding provided by the Bezos Family Foundation to the Mindset Scholars Network and the University of Texas at Austin Population Research Center. The University of Texas at Austin receives core support from the National Institute of Child Health and Human Development under the award number 5R24 HD042849.

This manuscript uses data from the National Study of Learning Mindsets (doi:10.3886/ICPSR37353.v1) (PI: D. Yeager; Co-PIs: R. Crosnoe, C. Dweck, C. Muller, B. Schneider, & G. Walton), which was made possible through methods and data systems created by the Project for Education Research That Scales (PERTS), data collection carried out by ICF International, meetings hosted by the Mindset Scholars Network at the Center for Advanced Study in the Behavioral Sciences at Stanford University, assistance from C. Hulleman, R. Ferguson, M. Shankar, T. Brock, C. Romero, D. Paunesku, C. Macrander, T. Wilson, E. Konar, M. Weiss, E. Tipton, and A. Duckworth, and funding from the Raikes Foundation, the William T. Grant Foundation, the Spencer Foundation, the Bezos Family Foundation, the Character Lab, the Houston Endowment, the National Institutes of Health under award number R01HD084772-01, the National Science Foundation under grant number 1761179, Angela Duckworth (personal gift), and the President and Dean of Humanities and Social Sciences at Stanford University. These data were made available to the researchers through the Population Research Center at The University of Texas at Austin which is supported by grant P2CHD042849, awarded by the Eunice Kennedy Shriver National Institute of Health and Child Development. Opinions reflect those of the authors and do not necessarily reflect those of the granting agencies.

Author Contributions

N.B. designed the study; N. B., S. V. W., and D. M. S. refined the methods and data analysis; N. B. drafted the initial manuscript, which was then heavily revised by S. V. W. and D. M. S.

Competing Interests

The authors declare that they have no competing interests.

Data and Materials Availability

All data and codebooks for the National Study of Learning Mindsets are available at https://doi.org/10.3886/ICPSR37353.v1. Analysis scripts for this project can be found at https://osf.io/qz4g9/?view_only=87d1b260a5994cd4bc863b2ef2680d36.

Table 1.

Parameter estimates for latent profile solution

Item	Profile 1 - False	Profile 2 -True	Profile 3 - Entity
	M (SE)	*M (SE)*	*M (SE)*
What percent of the [hypothetical students] had the intellectual potential to excel at the highest levels of high school math?	69.028 (3.730)	54.958 (3.350)	53.887 (3.126)
Mindset Beliefs [1 = Strongly Disagree - 6 = Strongly Agree]			
People have a certain amount of intelligence, and they really can't do much to change it.	1.878 (0.142)	2.249 (0.083)	3.104 (0.286)
Being a top math student requires a special talent that just can't be taught.	1.882 (0.193)	2.267 (0.072)	3.449 (0.244)
If you want to succeed in math, hard work alone just won't cut it; you need to have a natural gift or talent.	1.61 (0.089)	2.039 (0.075)	2.947 (0.365)
Some people are just born great teachers; if you're not, there's not much you can do to become a really great teacher.	1.646 (0.112)	1.976 (0.085)	2.79 (0.309)
If I really try hard, I can get even the most difficult or unmotivated student to learn.	4.369 (0.127)	4.19 (0.117)	4.063 (0.223)
Advice to a Struggling Student [1 = Extremely Likely - 5 = Extremely Unlikely]			
Don't worry - it's ok not to be a math person.	4.785 (0.096)	4.699 (0.076)	4.563 (0.148)
Please come get tutoring after class/school.	2.535 (0.172)	2.507 (0.117)	2.72 (0.216)
Keep working hard and you'll get it.	1.912 (0.12)	1.703 (0.088)	2.132 (0.186)
Let's look at what went wrong in your process and see what happens when we fix it.	1.7 (0.097)	1.666 (0.073)	1.77 (0.118)
Let's see what you don't understand and I'll explain it differently.	1.646 (0.094)	1.697 (0.087)	1.822 (0.126)
Advice to a Succeeding Student [1 = Extremely Likely - 5 = Extremely Unlikely]			
Let's find something to challenge and	3.777 (0.124)	3.741 (0.099)	3.544 (0.304)

confuse you, so you can learn more.			
When it's easy, that's when it's time to try something harder.	4.786 (0.112)	4.624 (0.067)	4.282 (0.234)
Great job, you must be working hard.	2.676 (0.184)	3.072 (0.118)	2.531 (0.199)
It's great that it's so easy for you.	2.507 (0.226)	2.222 (0.1)	2.716 (0.376)
You're lucky that you're a math person.	3.197 (0.211)	2.718 (0.131)	3.162 (0.322)
Practices [1 = Extremely True - 5 = Not at all True]			
I tell my 9th grade students it is important to work hard in math class.	1.532 (0.085)	1.503 (0.079)	1.571 (0.131)
I try to put my slower/remedial 9th grade students together for group work.	4.02 (0.125)	4.135 (0.078)	3.954 (0.173)
I allow my 9th grade students to revise and resubmit work when they did not get a good enough score initially.	2.269 (0.228)	2.695 (0.135)	2.863 (0.18)
It slows my class down to encourage lower achievers to ask questions.	4.607 (0.077)	4.411 (0.072)	4.249 (0.151)
Free-Response Coding			
Succeeding Student: Autonomy-Supportive [1] to Controlling [3]	2.65 (0.076)	2.219 (0.084)	2.547 (0.09)
Succeeding Student: Mastery-Oriented [1] to Performance-Oriented [3]	2.55 (0.17)	2.763 (0.042)	2.21 (0.192)
Succeeding Student: Negativity [1] to Positivity [3]	3 (0.00)	1.991 (0.009)	3 (0.00)
Struggling Student: Autonomy-Supportive [1] to Controlling [3]	2.64 (0.09)	2.524 (0.06)	2.433 (0.124)
Struggling Student: Mastery-Oriented [1] to Performance-Oriented [3]	2.519 (0.114)	2.498 (0.058)	2.427 (0.151)
Struggling Student: Negativity [1] to Positivity [3]	2.624 (0.111)	2.458 (0.055)	2.426 (0.148)

Online Supplementary Material for
"False growth mindsets in teachers negatively impact student beliefs and achievement"

Materials

Teacher Survey

To assess teachers' beliefs about the importance of effort, ability, strategies, and their attitude towards more and less successful students, we selected the following questions from the beginning-of-the-semester Teacher Survey:

Teachers were given a set of videos of classrooms, and were asked "Based on your professional judgment, what percent of the math students in the last three videos probably had the intellectual potential to excel at the highest levels of high school math, like Calculus?"

They were then told to "Imagine that one of your 9th grade math students was very discouraged in math class. The student kept getting low grades on assignments. The student didn't always try, but when he or she did try hard, the student would still get things wrong, even after practicing." They were were asked (on a scale from 1 = extremely likely to 5 = not at all likely) how likely they would be to say the following statements: "Don't worry—it's okay to not be a math person;" "Please come get tutoring after class/school;" "Keep working hard and you'll get it;" "Let's look at what went wrong in your process and see what happens when we fix it;" and "Let's see what you don't understand and I'll explain it differently."

Next, teachers were told to "Imagine one of your math students was doing very well in math class. The student is getting really high grades on assignments, often without trying or putting in much time. The student doesn't ask questions because he or she isn't confused by very much." They were asked (on a scale from 1 = extremely likely to 5 = not at all likely) how likely they would be to say the following statements: "Let's find something to challenge and confuse you, so you can learn more;" "When it's easy, that's when it's time to try something harder;"

"Great job, you must be working hard;" "It's great that it's so easy for you;" and "You're lucky that you're a math person."

Teachers were then asked about their general practices in 9th grade math (on a scale from 1 = extremely true to 5 = not at all true): "I tell my 9th grade students it is important to work hard in math class;" "I try to put my slower/remedial 9th grade students together for group work;" "I allow my 9th grade students to revise and resubmit work when they did not get a good enough score initially;" and "It slows my class down to encourage lower achievers to ask questions."

Finally, teachers were asked about their beliefs about ability more generally and their attitudes about teaching more specifically (on a scale from 1 = strongly disagree to 6 = strongly agree, with no neutral midpoint): "People have a certain amount of intelligence, and they really can't do much to change it;" "Being a top math student requires a special talent that just can't be taught;" "If you want to succeed in math, hard work alone just won't cut it; you need to have a natural gift or talent;" "Some people are just born great teachers; if you're not, there's not much you can do to become a really great teacher;" and "If I really try hard, I can get even the most difficult or unmotivated student to learn."

Additionally, teachers were able to write about what feedback they would give to the student who was struggling and the student who was doing well. We made use of these data, using coding generated by Browman and colleagues (*41*). The authors had two independent coders rate the teachers across three dimensions (on a three point bipolar scale with a midpoint indicating neither of the two options): the degree to which the teacher was autonomy-supportive versus controlling (e.g. "Acknowledges or prompts a dialogue/discussion about their rationale or the unique way in which they have chosen to think about or approach their work" versus "Proposes to make the student do the work in the teacher's own/preferred way"; ICC for

struggling student response = .78; ICC for excelling student response = .72); the degree to which the teacher was mastery-oriented versus performance-oriented (e.g., "Emphasizes the importance of understanding course material" versus "Emphasizes the importance of getting the right answer or of not making mistakes on course work"; ICC for struggling student response = .77; ICC for excelling student response = .83); and the degree to which the teacher expressed positivity versus negativity (e.g., "Expresses warmth, approval, encouragement, or gave positive feedback to the student" versus "Expresses frustration, annoyance, or hostility or gave negative feedback to the student"; ICC for struggling student response = .80; ICC for excelling student response = .86). See Browman et al. (under review) for more details.

Student Survey

We used three sets of variables from the student surveys, which we collapsed into composite variables when used in analyses. Composite variables were based on the average of non-missing data for the scale in question. All values, unless otherwise noted, come from surveys taken roughly 1-4 weeks after the teacher surveys. In the pre-pregistration exploratory dataset, we conducted an exploratory factor analysis, using parallel analysis to determine the number of factors to extract, and found that our items measuring student perceptions about their teacher's beliefs formed two factors.[1] In the confirmatory dataset, we found the same pattern of results (TLI = .964, RMSEA = .044, 43% of variance explained). See Table S1 for factor loadings and see the Figure S1 for the correlation matrix between the student-level variables.

Student Growth Mindset

This construct was generated from three questions (all on a scale from 1 = strongly disagree to 6 = strongly agree with no neutral midpoint): "You have a certain amount of

[1] In both the exploratory dataset and the confirmatory dataset, an additional item, "My math teacher thinks failure is bad and should be avoided." did not load onto either factor, and was therefore dropped

intelligence, and you really can't do much to change it;" "Your intelligence is something about you that you can't change very much;" and "Being a 'math person' or not is something that you really can't change. Some people are good at math and other people aren't." Scale alpha = .80 [.79, .80], *M* = 2.70, *SD* = 1.20 (*1*).

Student Perceptions of Teacher Beliefs About Ability

This construct was generated from five questions (all on a scale from 1= extremely true to 5 = not at all true): "My math teacher seems to believe that only a few students will understand the hardest problems;" "My math teacher seems to like you better if you are good at math;" "My math teacher calls you "smart" if you are good at math;" "My math teacher seems to believe that students can't really change how smart they are;" and "My math teacher thinks that some kids are smart and others are not." Scale alpha = .74 [.73, .75], *M* = 3.91, *SD* = 1.01.

Student Perceptions of Teacher Beliefs About Effort

This construct was generated from four questions (all on a scale from 1 = not at all true to 5 = extremely true): "My math teacher believes that everybody in my class can be very good at math;" "My math teacher thinks failure helps us learn and grow;" "My math teacher accepts nothing less than our full effort;" and "My math teacher asks questions to be sure we are following along when s/he is teaching." Scale alpha = .69 [.68, .70], *M* = 3.69, *SD* = 0.84.

Correlations between student-level variables

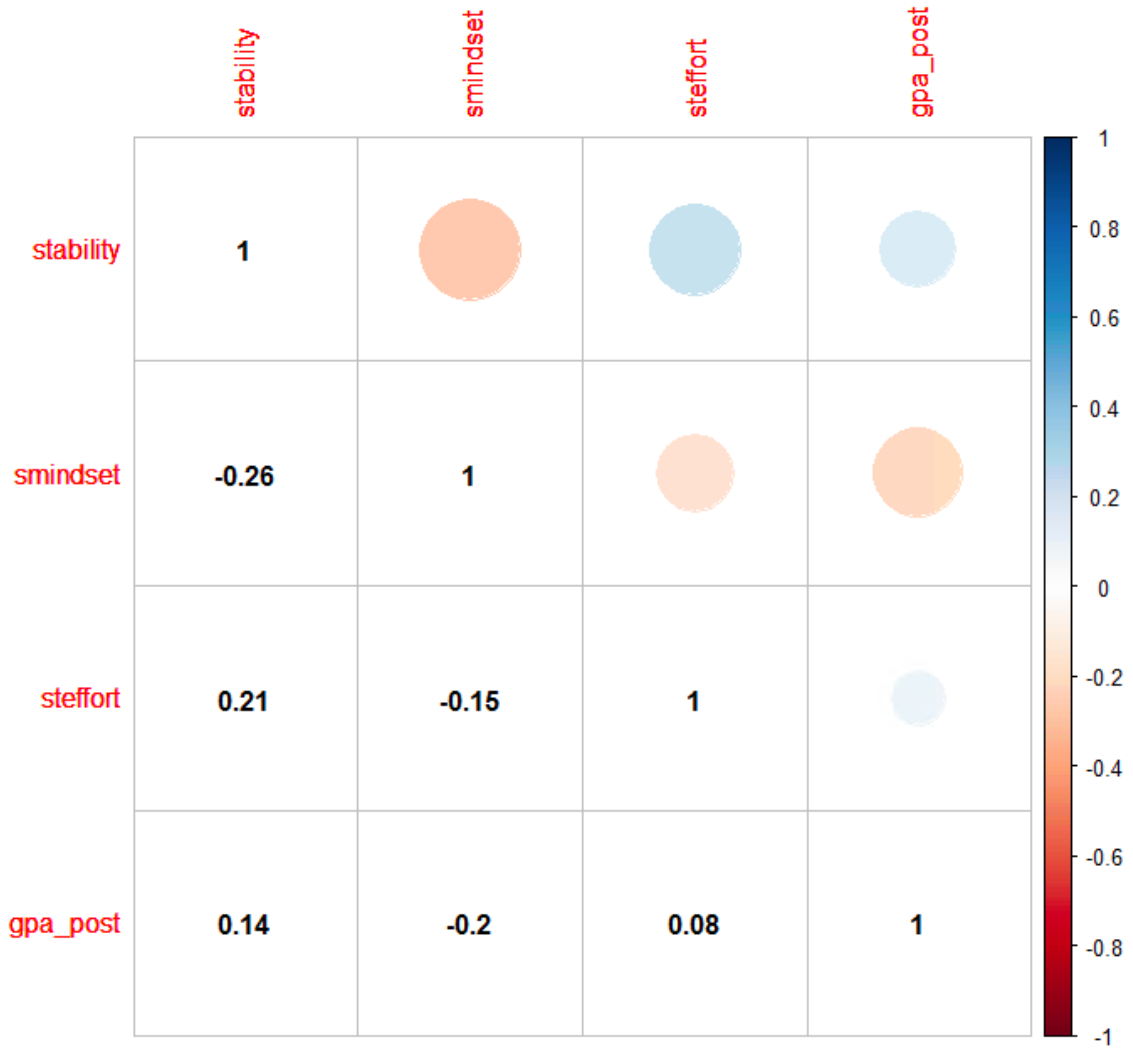

Figure S1. Correlations between student-level variables. "stability" = student perception of teacher beliefs about ability; "smindset" = students' entity theory about intelligence; "steffort" = student perception of teacher beliefs about effort; "gpa_post" = end of year grade-point-average

Alternate Tests of Mediation

To further examine results of the multilevel SEM, we conducted an additional set of mediational models outside of an SEM framework, testing whether changes in student entity theories mediated the effect of teacher false growth mindset on end-of-year student grades without taking student beliefs about their teacher's theories of effort and intelligence into

account. Using the *mediation* package in R (*42*), we fit a mediational model with random intercepts for classroom and random slopes on the *b*-path, on data from 4,914 students nested within 138 teachers (the sample differs from the SEM models due to missingness in the beliefs about teacher effort and ability theories). Results suggested that student entity theories did still mediate the relationship: compared to teachers profiled as having a true growth mindset, teacher false growth mindset predicted student entity theory (*a* path): $b = 0.19$ [0.043, .34], $t(123.48) = 2.53$, $p = .013$; and, controlling for teacher mindset, student entity theory predicted end-of-year grades (*b* path): $b = -0.13$ [-0.16, -0.10], $t(96.31) = -7.77$, $p < .001$; average causal mediation effect = -0.026 [-0.050, -0.0042], $p = .024$.

We additionally tested whether student perceptions of teacher growth mindset mediated the relationship between teacher mindset and student grades, without controlling for students' own mindset beliefs. As this model did not converge with a random slope, we used just random intercepts for teachers' classroom. Using data from 4,620 students nested within 138 teachers, we found that teachers profiled as having a false growth mindset, compared to teachers profiled as having a true growth mindset predicted lowered student perception of teacher growth mindset beliefs (*a* path): $b = -0.13$ [-0.24, -0.013], $t(126.29) = -2.18$, $p = .031$; and, controlling for teacher mindset, student perceptions of teacher growth mindset predicted end-of-year grades (*b* path): $b = 0.11$ [0.076, 0.14], $t(4561.49) = 6.70$, $p < .001$; average causal mediation effect = -0.013 [-0.027, -0.0019], $p = .026$.

Testing the causal direction of the teacher - student relationship

In an additional set of analyses, we attempted to identify the causal direction of the effect of student mindsets - whether teachers with a false growth mindset changed the mindsets of their students, or whether classrooms full of students with entity theories led to teachers adopting false

growth mindsets of their own. We fit a model predicting student's time-2 entity theories from their time-1 entity theories (measured at the beginning of the semester, 1-4 weeks before the time-2 survey) and the teacher mindset dummy. This model also did not converge with random slopes, so we also simplified it to just estimate random intercepts. Using data from 4,880 students nested within 138 classrooms, controlling for students' time-1 mindsets and with a random intercept for classroom, teacher false growth mindset marginally predicted students' time-2 mindsets (*a* path): $b = 0.075$ [-0.010, .16], $t(117.70) = 1.73$, $p = .087$. Controlling for time-1 student and teacher mindsets, however, time-2 student mindsets still predicted end-of-year grades (*b* path): $b = -0.13$ [-0.16, -0.093], $t(4795.85) = -7.71$, $p < .001$; average causal mediation effect = -0.0094 [-0.021, 0.00036], $p = .062$.

In contrast to the *b* path above, the effect of time-1 student mindsets on end-of-year grades, controlling for teacher mindset and time-2 student mindsets was far weaker: $b = -0.035$ [-0.069, -0.0011], $t(4798.46) = -2.02$, $p = .044$. In other words, it appears that students' mid-semester mindsets are the most predictive of end-of-year grades, and that those mindsets changed marginally more with teachers who held a false growth mindset, suggesting that it is more likely that teachers are affecting student mindset beliefs than the reverse.

Alternate Grade Specifications

End-of-Year Math GPA

We then re-ran these models looking just at students' end-of-year math GPA (calculated in the same way as our end-of-year measure in the main text. Our results were largely consistent. As with total end-of-year GPA, we found no direct effect of teacher mindset on student grades

(5542 students nested within 140 teachers): b = -0.091 [-.31, .13], t(128.02) = -0.82, p = .41; and no moderation by prior GPA (1423 students nested within 32 teachers): b = -0.0024 [-0.059, 0.063], t(1418.08) = 0.077, p = .94. In our SEM models (4592 students nested within 139 teachers), we again found evidence for a significant indirect effect for teacher mindset predicting student grades through student entity theorizing: -0.32 [-0.64, -0.054], p = .048, while finding no significant evidence for an indirect effect through either measure of student perceptions of their teachers. Finally, in a causal mediation framework, we again found evidence for the mediating effects of student entity theorizing on the relationship between teacher mindset and end-of-year math grades (5002 students nested within 139 teachers): average causal mediation effect = -0.024 [-0.046, -0.0029], p = .022; and again found evidence for mediation through student perception of teacher mindset beliefs (4703 students nested within 139 teachers): average causal mediation effect = -0.014 [-0.027, -0.0022], p = .012. See Figure S2.

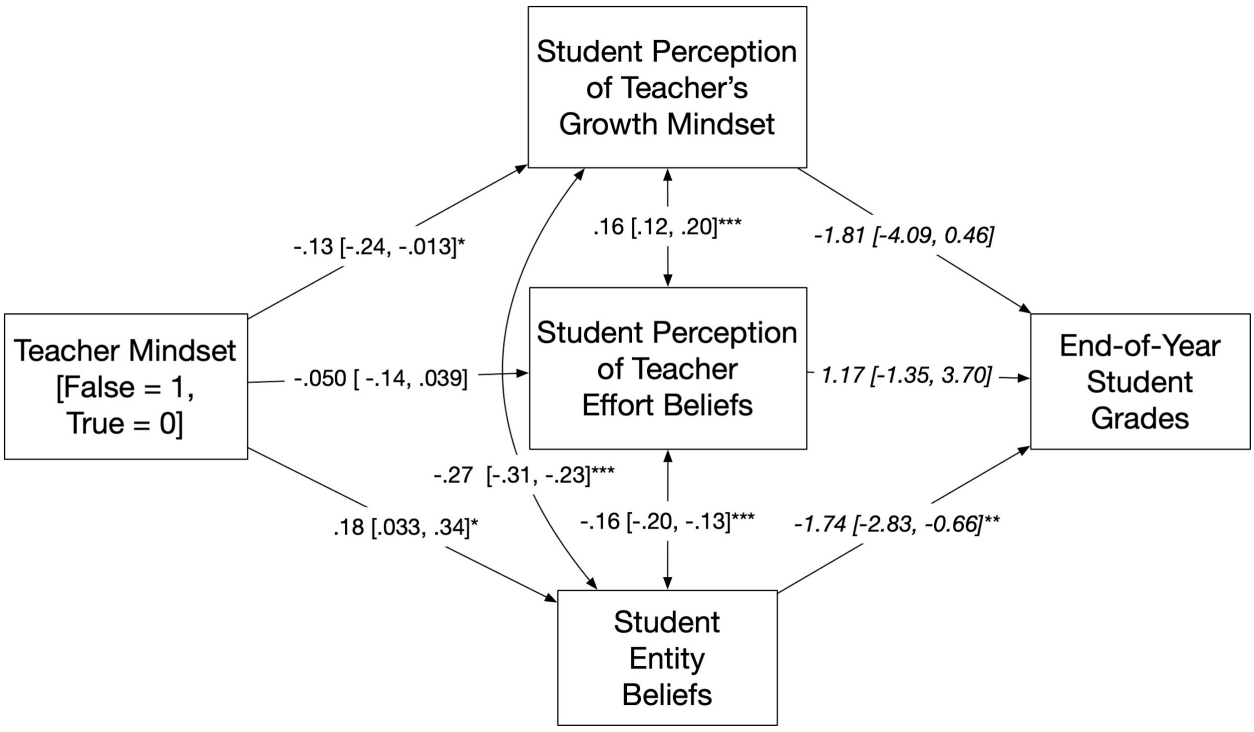

Figure S2. Path diagram for SEM analyses using end-of-year math grades.

End of Spring Semester Grades

We reran all models in the main text using students' grades at the end of Spring semester as the DV of choice. Our results were largely consistent, though they were impacted some by reduced power relative to the main-text analyses. Our in-text measure correlated with end-of-spring-semester grades $r(5,689) = .968$ [.965, .969], $p < .001$. As with total end-of-year GPA, we found no direct effect of teacher mindset on student grades (4608 students nested within 122 teachers): $b = -0.12$ [-.34, .094], $t(109.81) = -1.11$, $p = .27$; and no moderation by prior GPA (1401 students nested within 30 teachers): $b = -0.0069$ [-0.074, 0.060], $t(1394.76) = -0.20$, $p = .84$. In our SEM models (3835 students nested within 122 teachers), we found only marginal evidence for an indirect effect for teacher mindset predicting student grades through student entity theorizing: -0.40 [-0.90, 0.093], $p = .11$, while finding no significant evidence for an indirect effect through either measure of student perceptions of their teachers. See Figure S3 for path-coefficients. Finally, in a causal mediation framework, we again found evidence for the mediating effects of student entity theorizing on the relationship between teacher mindset and grades (4188 students nested within 122 teachers): average causal mediation effect = -0.037 [-0.063, -0.016], $p < .001$; and again found evidence for mediation through student perception of teacher mindset beliefs (3932 students nested within 122 teachers): average causal mediation effect = -0.015 [-0.029, -0.0029], $p = .004$.

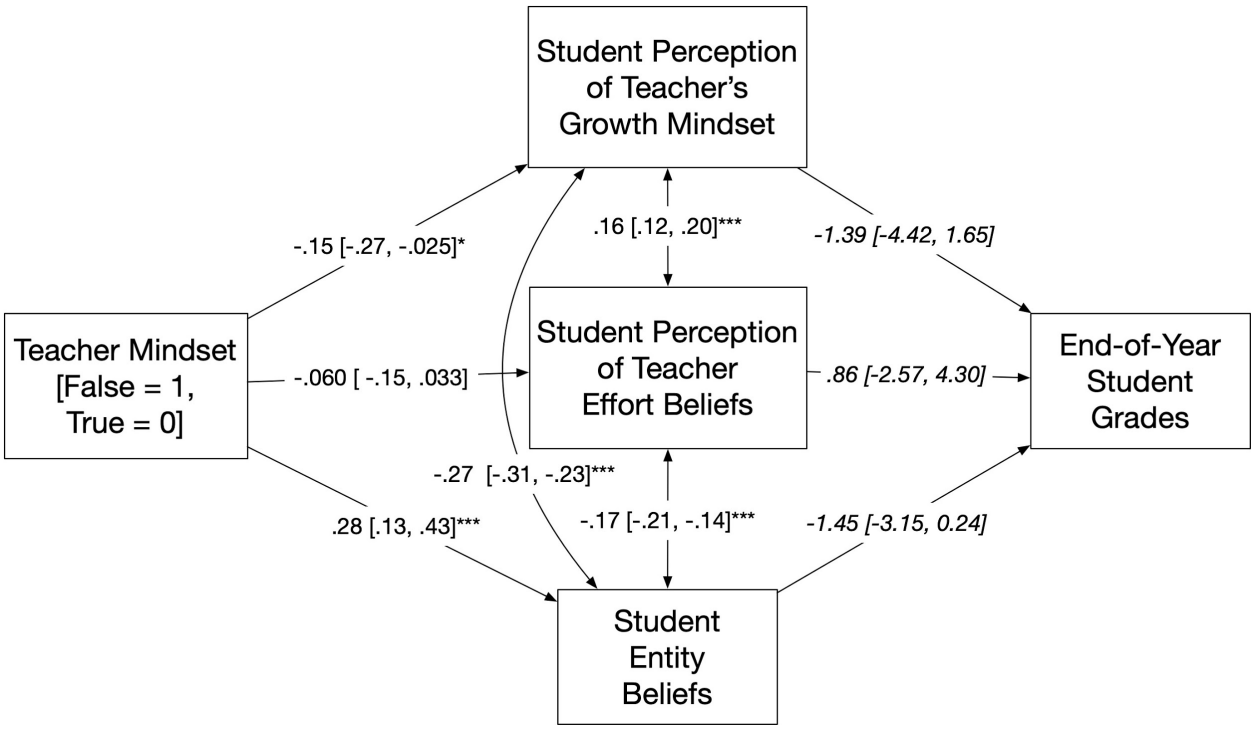

Figure S3. Path diagram for SEM analyses using Spring-semester grades.

Imputed Grades

To address the decrease in sample-size from using just end of Spring semester grades, we reran all models again using Spring semester grades when available, and otherwise using the post-intervention grades used in the main text. Our in-text measure of GPA correlated with this imputed measure $r(6781) = .973$ [.972, .975], $p < .001$. Our results were largely consistent. As with total end-of-year GPA, we found no direct effect of teacher mindset on student grades (5457 students nested within 139 teachers): $b = -0.10$ [-.32, .11], $t(128.47) = -0.94$, $p = .35$; and no moderation by prior GPA (1403 students nested within 30 teachers): $b = -0.0075$ [-0.075, 0.060], $t(1396.77) = -0.22$, $p = .83$. In our SEM models (4511 students nested within 138 teachers), we again found marginal evidence for an indirect effect for teacher mindset predicting student grades through student entity theorizing: -0.35 [-0.72, 0.023], $p = .066$, while finding no

significant evidence for an indirect effect through either measure of student perceptions of their teachers. See Figure S4 for path-coefficients. Finally, in a causal mediation framework, we again found evidence for the mediating effects of student entity theorizing on the relationship between teacher mindset and grades (4917 students nested within 138 teachers): average causal mediation effect = -0.027 [-0.049, -0.0054], p = .014; and again found evidence for mediation through student perception of teacher mindset beliefs (4622 students nested within 138 teachers): average causal mediation effect = -0.014 [-0.026, -0.0014], p = .038.

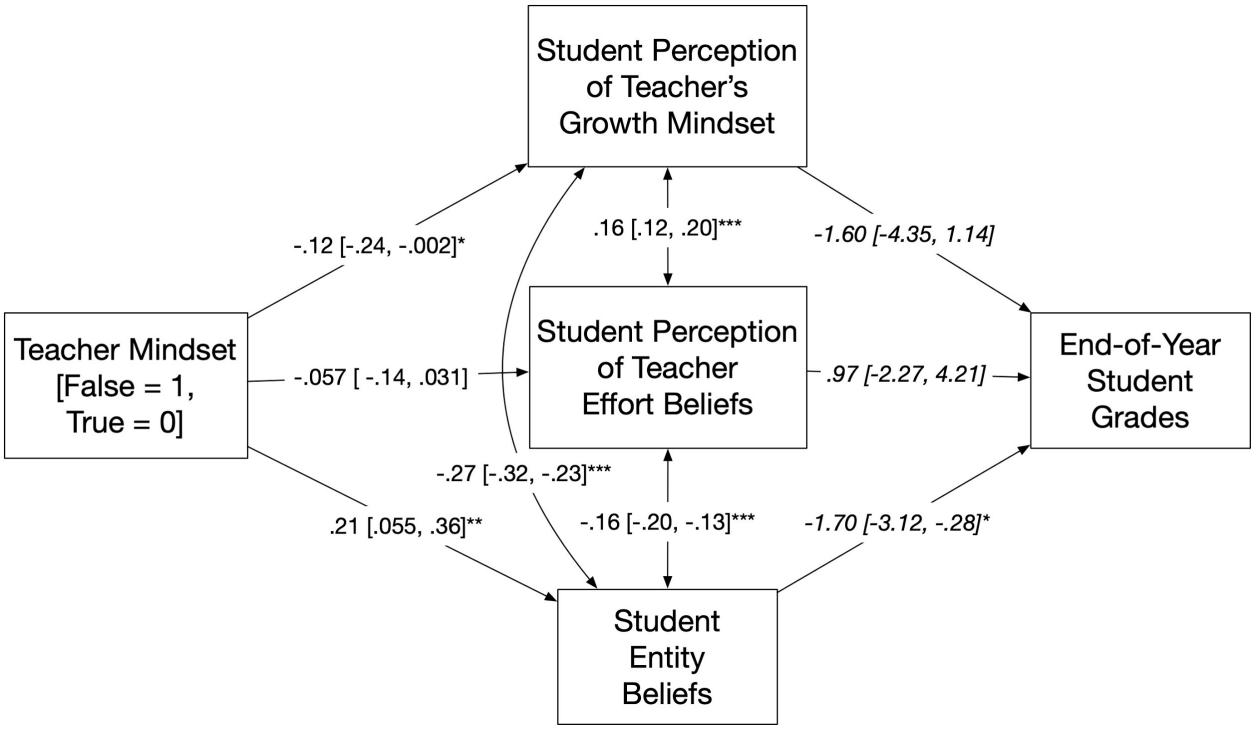

Figure S4. Path diagram for SEM analyses using imputed grades.

Models Comparing Teachers with True Growth Mindsets to Those with Entity Theories

As a robustness-check for the profile analysis, we ran an additional set of models comparing teachers classified as true growth mindset theorists with teachers classified as entity theorists, mirroring the more typical analysis of the effect of teacher beliefs on the beliefs and

outcomes of their students (e.g. *8*). While we found no main effect of teacher mindset on end-of-year student grades (b = 0.069 [-0.22, 0.36], $t(96.21) = 0.47$, $p = .64$, using 3950 students nested within 101 teachers), we found results consistent with theory (using 3,605 students nested within 103 teachers), where teachers with true growth mindsets were directionally less likely to endorse entity theories at time-2 (*a* path): b = -0.19 [-0.39, 0.0081], $t(82.30) = -1.88$, $p = .064$. These changes in student mindset were meaningful, as those students who had stronger entity theories (controlling for teacher mindset) had lower end-of-year GPA (*b* path): b = -0.15 [-0.18, -0.12], $t(3577.13) = -9.26$, $p < .001$; with an overall indirect effect of teacher true growth mindset predicting end-of-year GPA mediated through student mindset that was marginally significant: average causal mediation effect = 0.028 [-0.00078, 0.06], $p = .056$.

In an SEM framework, comparing teachers with true growth mindsets with those with entity theories (3309 students nested within 101 teachers), we found no evidence for an indirect effect of teacher mindset on end-of-year grades mediated through student perceptions of teacher mindset, -0.008 [-0.094, 0.077], $p = .85$; through student perceptions of teacher effort beliefs, 0.008 [-0.086, 0.10], $p = .87$, and marginal evidence for mediation through student's own mindset beliefs, 0.41 [-0.083, 0.91], $p = .10$. See Figure S5 for path-coefficients.

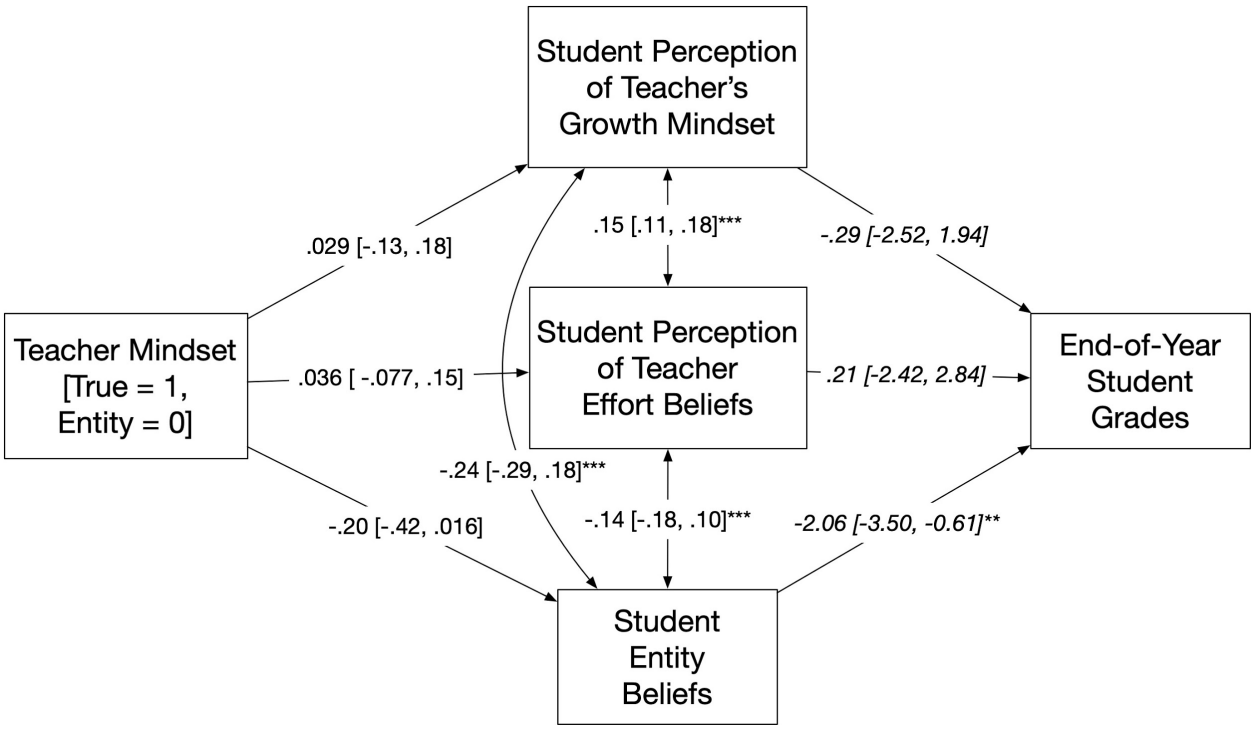

Figure S5. Path diagram for SEM analyses comparing teachers with true growth mindsets against those with entity theories.

Models Comparing Teachers with False Growth Mindsets to Those with Entity Theories

We also compared teachers with false growth mindsets to those with entity theories of intelligence. As with total end-of-year GPA, we found no direct effect of teacher mindset on student grades (4163 students nested within 102 teachers): b = -0.032 [-.33, .13], t(94.13) = -0.26, p = .84. In our SEM models (3456 students nested within 101 teachers), we found no evidence for mediation through student mindsets (indirect effect = -0.011 [-0.50, 0.48], p = .97); through student beliefs about teacher's ability beliefs (indirect effect = 0.093 [-0.12, 0.31], p = .40); or through student beliefs about teacher's effort beliefs (indirect effect = 0.001 [-.042, 0.043], p = .97). See Figure S6 for path-coefficients

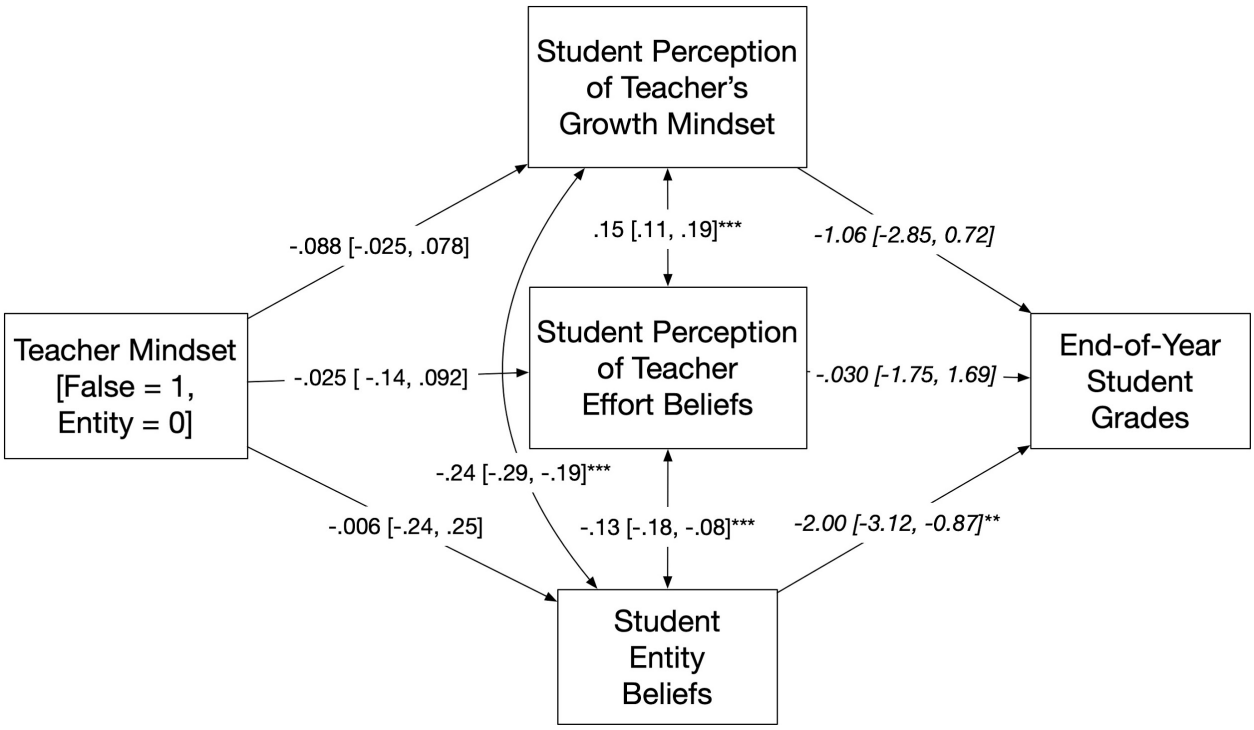

Figure S6. Path diagram for SEM analyses comparing teachers with false growth mindsets against those with entity theories.

Differences in student perceptions of teacher mindsets

We compared student perceptions of their teacher's mindsets at time-2 across the three profiles. We ran a one-way ANOVA with a random intercept for classroom, and found that students whose teachers had a false growth mindset perceived their teachers to have less of a growth mindset (M = 3.83, SD = 1.04) than students with teachers holding a true growth mindset (M = 3.96, SD = 1.00) or an entity theory (M = 3.96, SD = 0.98), albeit only marginally significantly, $F(2, 143.98) = 2.39$, $p = .095$.

Assessing moderation by intervention condition or student demographics

We investigated whether the direct relationship between teacher false growth mindset and student grades was moderated by the intervention condition that the student was assigned to, or

by other demographic characteristics. We found no evidence for moderation in any of our models. While students assigned to the growth mindset intervention condition did have higher end-of-year grades, *M* control = 2.51 [2.40, 2.62], *M* intervention = 2.60 [2.49, 2.71]; *b* = 0.095 [0.0081, 0.18], *t*(4,905) = 2.14, *p* = .032, the interaction between teacher false growth mindset (as compared to teacher true growth mindset) and student intervention condition was not significant, *b* = -0.0078 [-0.13, 0.11], *t*(4,896) = -0.13, *p* = .90.[2]

We additionally tested whether the direct relationship between teacher false growth mindset (as compared to true growth mindset) and student outcomes was moderated by gender, by whether the student was enrolled in free or reduced lunch (as a proxy for socioeconomic status), and by whether the student identified as a member of an under-represented minority ethnicity (defined as the student identifying as Black, Hispanic, Native American, Pacific Islander/Native Hawaiian, or multiracial). We do not find evidence for moderation of the relationship between teacher false growth mindset and end-of-year grades by demographics, either singly, when interacted together, or when interacted with the student's intervention condition. See Table S5.

[2] As might be expected from prior work (e.g. *8*), we do, however, find evidence, albeit marginal, for an interaction between the intervention condition and whether the students' teacher has a true growth mindset (vs. an entity theory), *b* = .14 [-0.0027, 0.29], *t*(3572.43) = 1.92, *p* = .054. For those students in the control condition, the mindset of one's teacher did not meaningfully predict one's end-of-year grades (*M* True Mindset = 2.55 [2.38, 2.72]; *M* Entity Theory = 2.54, [2.29, 2.79]), while for those students in the intervention condition, those with teachers who had true growth mindsets (*M* = 2.65 [2.48, 2.82]) outperformed those with teachers who had entity theories (*M* = 2.49 [2.24, 2.74]).

Table S1
Loadings for Student Perceptions of Teacher Beliefs, Study 1

Item	Beliefs about Ability	Beliefs about Effort
My math teacher thinks that some kids are smart and others are not.	**.74**	.08
My math teacher seems to like you better if you are good at math.	**.69**	.04
My math teacher seems to believe that only a few students will understand the hardest problems.	**.67**	.02
My math teacher calls you smart if you are good at math.	**.52**	-.24
My math teacher seems to believe students can't really change how smart they are.	**.49**	-.03
My math teacher asks questions to be sure we are following along when s/he is teaching.	.05	**.68**
My math teacher accepts nothing less than our full effort.	-.08	**.62**
My math teacher believes that everybody in my class can be very good at math.	.15	**.60**
My math teacher thinks failure helps us learn and grow.	-.07	**.48**

Table S2.
Fit statistics for non-parametric multi-level latent profile analyses

# of Level 1 Profiles	# of Level 2 Profiles	Parameters	LL	AIC	BIC	aBIC	Entropy	Smallest Profile Proportion
2	1	79	-9823.17	19804.33	20098.24	19847.69	0.96	0.38
2	2	81	-9823.17	19808.33	20109.68	19852.79	0.82	0
2	3	83	-9823.17	19812.33	20121.12	19857.88	0.59	0
2	4	85	-9823.17	19816.33	20132.56	19862.98	0.55	0
2	5	87	-9823.17	19820.33	20144.00	19868.08	0.68	0
3	1	106	-9698.11	19608.21	20002.57	19666.39	0.89	0.22
3	2	109	-9698.11	19614.21	20019.73	19674.03	0.55	0
3	3	112	-9698.11	19620.21	20036.89	19681.68	0.47	0
3	4	115	-9698.11	19626.21	20054.05	19689.32	0.41	0
3	5	118	-9698.11	19632.21	20071.21	19696.97	0.38	0
4	1	133	-9603.78	19473.57	19968.37	19546.56	0.92	0.079
4	2	137	-9603.78	19481.57	19991.25	19556.75	0.66	0
4	3	141	-9603.78	19489.57	20014.13	19566.95	0.92	0
4	4	145	-9603.78	19497.57	20037.01	19577.14	0.48	0
4	5	149	-9603.78	19505.57	20059.89	19587.34	0.83	0
5	1	160	-9523.52	19367.03	19962.28	19454.84	0.93	0.033
5	2	165	-9549.07	19428.15	20042.00	19518.70	0.73	0
5	3	170	-9523.52	19387.03	20019.49	19480.33	0.70	0
5	4	175	-9549.07	19448.15	20099.20	19544.19	0.68	0
5	5	180	-9549.07	19458.15	20127.80	19556.93	0.86	0

Note: LL = Log-likelihood, AIC = Akaike Information Criterion, BIC = Bayesian Information Criterion, aBIC = Adjusted Bayesian Information Criterion

Table S3. *Regression output for direct relationship between teacher false growth mindset and student grades*

Fixed Effects					
	Estimate	SE	*df*	*t*	*p*
Intercept	2.56	0.078	129.32	33.00	< .001
False Growth Mindset Dummy	-0.10	0.11	128.55	-0.91	.37
Random Effects					
		Variance	SD		
Math Teacher ID	Intercept	0.36	0.60		
Residual		1.21	1.10		

Table S4. *Regression output for relationship between teacher false growth mindset and student grades moderated by prior-semester grades*

Fixed Effects					
	Estimate	SE	*df*	*t*	*p*
Intercept	0.38	0.088	79.45	4.28	< .001
False Growth Mindset Dummy	-0.089	0.15	57.91	-0.61	.54
Prior-Semester Grades	0.83	0.020	1,399	41.36	< .001
Interaction	0.00029	0.031	1,399	0.009	.99
Random Effects					
		Variance	SD		

Math Teacher ID	Intercept	0.079	0.28	
Residual		0.41	0.64	

Table S5: *Regression output for moderation of direct effect of teacher false growth mindset on end-of-year grades by demographics and student intervention condition*

Fixed Effects				
	Dependent variable: End of Year GPA			
	(1)	(2)	(3)	(4)
Teacher False Growth Mindset	-0.138	-0.133	-0.118	-0.171
	(-0.365, 0.090)	(-0.381, 0.115)	(-0.368, 0.132)	(-0.468, 0.126)
	t = -1.188	t = -1.054	t = -0.925	t = -1.127
	p = 0.235	p = 0.292	p = 0.356	p = 0.260
Free/Reduced Lunch	-0.455		-0.360	-0.447
	(-0.577, -0.333)		(-0.602, -0.118)	(-0.779, -0.115)
	t = -7.312		t = -2.913	t = -2.638
	p < .001***		p = 0.004**	p = 0.009**
Student Growth Mindset Intervention				-0.016
				(-0.230, 0.197)
				t = -0.151
				p = 0.881
Teacher Mindset:Free/Reduced Lunch	-0.055		-0.023	0.069
	(-0.224, 0.114)		(-0.359, 0.314)	(-0.393, 0.532)
	t = -0.633		t = -0.131	t = 0.293
	p = 0.527		p = 0.896	p = 0.770
Male:Free/Reduced Lunch			-0.126	0.077

			(-0.442, 0.190)	(-0.366, 0.520)
			t = -0.781	t = 0.343
			p = 0.436	p = 0.732
URM:Free/Reduced Lunch			0.087	0.188
			(-0.235, 0.409)	(-0.272, 0.648)
			t = 0.528	t = 0.800
			p = 0.598	p = 0.424
Teacher Mindset:Student Intervention				0.056
				(-0.252, 0.364)
				t = 0.358
				p = 0.721
Male:Student Intervention				0.158
				(-0.151, 0.467)
				t = 1.002
				p = 0.317
URM:Student Intervention				-0.008
				(-0.394, 0.377)
				t = -0.043
				p = 0.967
Free/Reduced Lunch:Student Intervention				0.096
				(-0.352, 0.543)
				t = 0.419
				p = 0.676
Male		-0.405	-0.273	-0.369
		(-0.529, -0.281)	(-0.424, -0.123)	(-0.588, -0.149)

		t = -6.386	t = -3.554	t = -3.295
		p < .001***	p < .001***	p = 0.001**
URM		-0.412	-0.318	-0.271
		(-0.556, -0.268)	(-0.509, -0.127)	(-0.552, 0.010)
		t = -5.610	t = -3.263	t = -1.888
		p < .001***	p = 0.002**	p = 0.060
Teacher Mindset:Male		0.049	-0.002	0.017
		(-0.127, 0.226)	(-0.215, 0.211)	(-0.288, 0.323)
		t = 0.550	t = -0.018	t = 0.111
		p = 0.583	p = 0.986	p = 0.912
Teacher Mindset:URM		-0.008	-0.111	-0.274
		(-0.210, 0.194)	(-0.384, 0.161)	(-0.662, 0.114)
		t = -0.077	t = -0.800	t = -1.383
		p = 0.939	p = 0.424	p = 0.167
Male:URM		-0.005	-0.105	-0.041
		(-0.195, 0.185)	(-0.371, 0.161)	(-0.433, 0.350)
		t = -0.055	t = -0.772	t = -0.207
		p = 0.957	p = 0.441	p = 0.837
Teacher Mindset:Male:URM		0.029	0.126	0.263
		(-0.233, 0.291)	(-0.252, 0.504)	(-0.283, 0.808)
		t = 0.217	t = 0.654	t = 0.944
		p = 0.829	p = 0.514	p = 0.346
Teacher Mindset:Male:Free/Reduced Lunch			-0.077	-0.078
			(-0.508, 0.355)	(-0.685, 0.528)

			t = -0.348	t = -0.253
			p = 0.728	p = 0.800
Teacher Mindset:URM:Free/Reduced Lunch			0.011	-0.031
			(-0.439, 0.460)	(-0.664, 0.603)
			t = 0.046	t = -0.095
			p = 0.964	p = 0.925
Male:URM:Free/Reduced Lunch			0.075	-0.159
			(-0.358, 0.509)	(-0.786, 0.467)
			t = 0.340	t = -0.499
			p = 0.734	p = 0.618
Teacher Mindset:Male:Student Intervention				0.017
				(-0.417, 0.452)
				t = 0.078
				p = 0.939
Teacher Mindset:URM:Student Intervention				0.203
				(-0.340, 0.747)
				t = 0.733
				p = 0.464
Male:URM:Student Intervention				-0.177
				(-0.727, 0.372)
				t = -0.633
				p = 0.527

Teacher Mindset:Free/Reduced Lunch/Student Intervention				-0.086
				(-0.721, 0.549)
				t = -0.265
				p = 0.792
Male:Free/Reduced Lunch/Student Intervention				-0.288
				(-0.918, 0.341)
				t = -0.897
				p = 0.370
URM:Free/Reduced Lunch/Student Intervention				-0.148
				(-0.786, 0.490)
				t = -0.455
				p = 0.650
Teacher Mindset:Male:URM:Free/Reduced Lunch			0.053	0.074
			(-0.545, 0.651)	(-0.783, 0.931)
			t = 0.174	t = 0.170
			p = 0.863	p = 0.866
Teacher Mindset:Male:URM:Student Intervention				-0.073
				(-0.849, 0.703)
				t = -0.184
				p = 0.855
Teacher Mindset:Male:Free/Reduced Lunch:Student Intervention				-0.220
				(-1.085, 0.645)

				t = -0.498
				p = 0.619
Teacher Mindset:URM:Free/Reduced Lunch:Student Intervention				0.146
				(-0.743, 1.035)
				t = 0.322
				p = 0.748
Male:URM:Free/Reduced Lunch:Student Intervention				0.383
				(-0.498, 1.265)
				t = 0.853
				p = 0.394
Teacher Mindset:Male:URM:Free/Reduced Lunch:Student Intervention				0.002
				(-1.218, 1.222)
				t = 0.004
				p = 0.998
Constant	2.751	2.929	3.005	3.051
	(2.591, 2.910)	(2.757, 3.102)	(2.831, 3.178)	(2.840, 3.263)
	t = 33.876	t = 33.277	t = 33.925	t = 28.279
	$p < .001^{***}$	$p < .001^{***}$	$p < .001^{***}$	$p < .001^{***}$
Random Effects				
Math Teacher ID (Intercept)	0.26 (SD = 0.51)	0.32 (SD = 0.56)	0.29 (SD = 0.48)	0.22 (SD = 0.47)
Residual	1.18 (SD = 1.08)	1.17 (SD = 1.08)	1.14 (SD = 1.07)	1.10 (SD = 1.05)

Observations	3,908	4,377	3,878	3,515
Log Likelihood	-5,969.396	-6,687.846	-5,863.478	-5,271.851
Akaike Inf. Crit.	11,950.790	13,395.690	11,762.950	10,611.700
Bayesian Inf. Crit.	11,988.420	13,459.530	11,875.690	10,821.310
Note:	*p<.05; *p<.01; ***p<.001			