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Intellectual humility predicts mastery behaviors when learning☆

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ABSTRACT

Mastery behaviors—such as seeking challenges and persisting after setbacks—can advance learning, but less is known about dispositions that promote them. In five studies (N = 1074), we find intellectual humility predicts mastery behaviors independent of a growth mindset. In Study 1, those higher in intellectual humility invested more effort to learn about a topic they initially failed to master. In Studies 2 and 3, high school students with more intellectual humility had higher mastery responses and higher teacher-reported mastery behaviors. In Study 4, intellectually humble high school students had higher mastery behaviors on a performance task. In Study 5, participants encouraged to be more intellectually humble invested more effort to learn about a topic they initially failed to master. The overall effect size across studies was 0.17 after accounting for growth mindset and gender, suggesting that intellectual humility boosts pursuit of mastery.

1. Introduction

Jessica and Jamie are doing math homework. Jessica comes across a difficult problem and quickly decides she cannot do it. She copies the answer from the back of the textbook and moves on to the next question. Jamie comes across the same problem and gets to work, relishing the challenge. Her first, second, and third solutions are incorrect, but she continues working until she has the answer. Common sense suggests Jamie's mastery response will propel success, while Jessica's helpless one will not, and research supports this prediction. Mastery behaviors, such as persisting after setbacks, exerting effort, and embracing challenges, lead to effective problem solving, learning from difficult material, and higher grades in school (Blackwell, Trzesniewski, & Dweck, 2007; Diener & Dweck, 1978, 1980; Mueller & Dweck, 1998; Yeager et al., 2016). A recent meta-analysis showed that mastery behaviors promote achievement in many domains, including academics, leadership, management, and health (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013).

What determines whether someone will engage in mastery behaviors when learning? In the current investigation, we propose a role for *intellectual humility*, defined here as a willingness to acknowledge the current limitations of one's knowledge and value others' intellect (Porter & Schumann, 2018). Those high in intellectual humility want to be informed and accurate. Consequently, they scan for limitations in their knowledge (Deffler, Leary, & Hoyle, 2016), are curious and motivated to learn more (Haggard et al., 2018; Krumrei-Mancuso, Haggard, Labouff, & Rowatt, 2019; Leary et al., 2017), and interact more with opposing views (Krumrei-Mancuso & Newman, 2020; Porter & Schumann, 2018). We predict those higher in intellectual humility will behave in mastery-oriented ways so that they can become more knowledgeable and accurate.[1]

1.1. Mastery behaviors

Dweck and Leggett (1988) described mastery behaviors as "the seeking of challenging tasks and the maintenance of effective striving under failure" (p. 256). Specific instantiations include investing effort, preferring challenging activities that can expand learning (rather than easy ones that cannot), persisting through difficulty, and showing resilience after failure (Dweck & Leggett, 1988). Such responses were identified in a series of studies by Diener and Dweck (1978, 1980) who found that some children became less effortful when they encountered obstacles, whereas others (of equal ability) embraced challenges and sustained engagement. Subsequent work documented similar patterns

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in adolescents and adults, showing consistent linear associations between mastery behaviors and achievement (Burnette et al., 2013; Robins & Pals, 2002; Yeager et al., 2016).

Although the benefits of mastery responses are well established, we know less about the psychological factors that promote them. To date, many studies examining their psychological precursors have focused on a growth mindset of intelligence—the belief that intelligence is a malleable attribute that can be developed. There is consistent evidence that those with more of a growth mindset enact mastery behaviors to a greater degree (Blackwell et al., 2007; Burnette et al., 2013; Dweck & Leggett, 1988; Robins & Pals, 2002). Yet, as growth mindset has become more popular (particularly in schools), individuals may endorse a growth mindset without fully aligning their behavior with their espoused belief, potentially attenuating the link between mindsets and mastery behaviors; this phenomenon has been termed the "false growth mindset" (Dweck & Yeager, 2019, p. 490; Fotuhi, 2020). We need to learn more about the dispositions that give rise to mastery behaviors in order to better understand how to promote these important responses.

1.2. Intellectual humility and mastery behaviors

Intellectually humble learners are driven to pursue knowledge, understanding, and truth because they want to be informed and accurate. As a result, they are curious (Krumrei-Mancuso et al., 2019; Leary et al., 2017), have a high need for cognition (Krumrei-Mancuso et al., 2019; Leary et al., 2017; Porter & Schumann, 2018), engage in actively open-minded thinking (Krumrei-Mancuso et al., 2019), and are motivated to learn (Haggard et al., 2018; Krumrei-Mancuso et al., 2019). Likewise, intellectually humble learners should behave in ways that increase their likelihood of learning and mastery. When they receive feedback that they have misunderstood something, they should take action to redress their misunderstanding so they can be better informed. When they are given a choice between easy and challenging material, they should opt for challenge because it is more likely to expand their knowledge. When they encounter a difficult problem, they should persist because they want to reach a correct response.

Despite a potential association, to our knowledge no study has investigated the relation between intellectual humility and mastery responses. Although adults and college students who are high in intellectual humility report a higher drive to learn, we do not know whether this drive manifests in actual mastery behaviors and, if so, whether these benefits apply to adolescents. Targeting investigations in adolescence is particularly important because educators and parents might hesitate to encourage intellectual humility, thinking that doing so could harm self-confidence and result in helplessness, the opposite of mastery.[2] Discovering that intellectual humility promotes mastery behaviors could reveal novel pathways for enhancing mastery and learning. We designed five studies to investigate the potential link.

1.3. Conceptualizing and measuring intellectual humility

Psychological study of intellectual humility has grown dramatically since the first empirical research was published by Kross and Grossmann (2012).[3] Rapid growth has meant that multiple contrasting conceptualizations and measures of intellectual humility have been advanced simultaneously. According to our recent review, 15 different intellectual humility questionnaires have been used in published research (Porter et al., 2020b).

Some scholars have argued that intellectual humility is a purely cognitive phenomenon where internal awareness of one's intellectual fallibility is its only essential feature (Church & Barrett, 2017; Hoyle, Davisson, Diebels, & Leary, 2016; Leary, 2019; Leary et al., 2017). Under this view, behavioral manifestations of intellectual humility and other-directed attitudes are associated features that should not be considered essential to intellectual humility nor included in intellectual humility questionnaires.

By contrast, other scholars have defined and measured intellectual humility as encompassing a broader range of psychological and behavioral phenomena (Alfano et al., 2017; Danovitch, Fisher, Schroder, Hambrick, & Moser, 2019; Hagá & Olson, 2017; Haggard et al., 2018; Krumrei-Mancuso & Rouse, 2016; Whitcomb, Battaly, Baehr, & Howard-Snyder, 2015; Zachry, Phan, Blackie, & Jayawickreme, 2018). In line with these scholars, we conceptualized intellectual humility as both a personal awareness of intellectual fallibility and valuing others' intellect (see Porter & Schumann, 2018 for a rationale for including both self- and other-directed components). We also measured intellectual humility as involving both internal awareness and public expression of intellectual limitations. Yet, mindful of the compelling account offered by those who view the construct as a purely cognitive phenomenon, for two studies in the current investigation we included an additional measure of intellectual humility (Leary et al., 2017) that assessed only cognitive awareness of intellectual fallibility.

1.4. Overview of research

We conducted five studies to test our hypothesis that intellectual humility is associated with and can promote mastery behaviors. Following recommendations for increasing the generalizability and reliability of results (Abrahams et al., 2019; Duckworth & Yeager, 2015), we ran studies in both lab and real-world settings using self-reported, teacher-reported, and task-based measures of an array of mastery behaviors. Throughout, we examined associations between intellectual humility and mastery behaviors independent of growth mindset of intelligence (hereafter referred to simply as growth mindset) and gender, because both intellectual humility and mastery behaviors have been linked to a growth mindset (Burnette et al., 2013; Porter & Schumann, 2018), and because many of the mastery behaviors we assessed were in domains vulnerable to gender stereotypes (e.g., math, spatial reasoning) (Bian, Leslie, & Cimpian, 2017). We also tested for replication of the findings across two different conceptualizations and measures of intellectual humility, and conducted an internal meta-analysis to estimate the overall effect size across studies, results reported in the Robustness Tests section of the manuscript. Data, materials, and the code used for analysis are available on the Open Science Framework: https://osf.io/tmfcz/.

2. Study 1

If intellectual humility promotes mastery behaviors, those higher in intellectual humility may be more inclined to invest effort in learning what they have not yet mastered. In Study 1 we asked: Do those higher in intellectual humility show more effort to learn after receiving corrective feedback than those lower in intellectual humility?

2.1. Method

2.1.1. Participants

We recruited 142 American adults from the online panel Amazon Mechanical Turk (M age = 34.75, SD = 12.88; 71 women, 58 men, 13 unspecified). Additional demographic information for all participants is available in the Supplementary Online Materials (SOM, p. 2). A sensitivity power analysis in G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) showed that based on the sample size, an alpha probability of 0.05, and power of 80%, the study was powered to detect a small-to-medium effect (bivariate regression coefficient of $\beta = 0.23$). The Institutional Review Boards of Stanford University and the University of

[2] We thank Reviewer Five for helping us identify this contribution.

[3] Grossmann et al. (2010) published an earlier study that examined "recognition of uncertainty and the limits of knowledge" p. 2746, but they did not use the term "intellectual humility" until 2012.

California Davis approved the current research, and all research complied with the APA ethical guidelines for doing research with human subjects.

2.1.2. Materials and procedure

2.1.2.1. Intellectual humility and other questionnaires. Participants completed a 6-item measure of *intellectual humility* from Porter and Schumann (2018)[4] rated from 1 = *not at all true of me* to 7 = *extremely true of me*: "I am willing to admit it if I don't know something"; "I acknowledge when someone knows more than me about a subject"; "I like to compliment others on their intellectual strengths"; "I sometimes marvel at the intellectual abilities of other people"; "I actively seek feedback on my ideas, even if it is critical"; and "I try to reflect on my weaknesses in order to develop my intelligence." This measure was internally consistent, $\alpha = 0.75$, $\omega = 0.76$, and a confirmatory factor analysis had the following fit for a one-factor solution: $\chi^2(9) = 16.50$, $p = .06$; RMSEA = 0.08; CFI = 0.95; SRMR = 0.05.

Participants then completed an 8-item measure of *growth mindset* from Dweck (2000) rated from 1 = *strongly disagree* to 7 = *strongly agree* (e.g., "You can always substantially change how intelligent you are"). The items had an internal reliability coefficient of $\alpha = 0.91$.

2.1.2.2. Effort investment. Next, participants completed the effort investment measure introduced with the following text: "You will now complete the final study, which is a spatial reasoning test. There are three modules: shapes, cubes, and angles. Each of these modules is important and reflects current spatial reasoning abilities."

Participants were then presented with nine questions, three each on shapes, cubes, and angles (see Fig. 1). Following Nussbaum and Dweck (2008), we chose questions from dental school admissions tests so that it was difficult to determine whether answers were correct or not, making low and high scores equally plausible.

After completing all questions, participants read, "Please hold on while your scores are calculated…" Predetermined feedback was then displayed such that all questions on the shapes and angles modules were correct (success modules), but only one of three questions on the cubes module was answered correctly (failed module).

The next screen read "You will now have an opportunity to complete a tutorial for one of the modules. After completing the tutorial, you will be given another test on material specific to the module you selected for the tutorial. Please indicate your interest in learning more about each of the three modules." *Interest in learning* was rated from 1 = *not at all interested* to 9 = *extremely interested* for each module.

Participants then read "Now please indicate which module you would like to do your tutorial on." *Choosing the tutorial on the failed module* was coded 1 if the cubes module was chosen and 0 if the shapes or angles modules were chosen. Interest in the failed module and choosing the tutorial on the failed module comprised the measures of effort investment (given that more effort would be required to learn about the failed than mastered modules).

2.2. Results and discussion

Consistent with our predictions, those higher in intellectual humility were willing to invest more effort in learning what they had yet failed to master than those lower in intellectual humility, as indicated by correlations between intellectual humility and both interest in learning about the failed module ($r = 0.19$, $p = .033$), and choosing to take a tutorial on the failed module ($r = 0.22$, $p = .017$; see Table 1).

In regression models that controlled simultaneously for growth mindset and gender, the associations between intellectual humility and interest in the failed module ($\beta = 0.19$, $SE = 0.09$, $p = .034$) and selecting a tutorial on the failed module (standardized $OR = 1.62$, $SE = 0.40$, $p = .016$) were maintained (Table 2). We also tested for curvilinear associations in this and all studies, but found no effects (SOM, p. 2).

In Study 1, participants higher in intellectual humility pursued mastery of content they initially failed to grasp. However, mastery behaviors were measured in a domain that did not necessarily matter for participants' personal success. In a personally meaningful context, learners may be more sensitive to setbacks and less resilient following failure (see Fryberg, Covarrubias, & Burack, 2013; Hong, Chiu, Dweck, Lin, & Wan, 1999; Nussbaum & Dweck, 2008). In Studies 2 and 3, we tested whether the association between intellectual humility and mastery behaviors would replicate in a domain that mattered to participants.

3. Study 2

Study 2 investigated the relationship between intellectual humility and mastery behaviors in high school, a context where success and failure influence students' future academic prospects. Students self-reported their intellectual humility and then responded to a vignette asking how they would react if they failed a quiz.

3.1. Method

3.1.1. Participants

A total of 103 students in grades 9 through 12 attending a public high school in the Southeastern United States were recruited by the Character Lab Research Network (*M* age = 15.62 years, *SD* = 1.08; 50 girls, 37 boys, 2 unspecified). Sample size was determined by the Research Network's availability. A sensitivity power analysis indicated 80% power to detect medium effects (bivariate regression coefficient of $\beta = 0.28$).

3.1.2. Materials and procedure

At the beginning of the third marking period (in early January), we administered a battery of self-report questionnaires during a typical class session. This included the 6-item measure of intellectual humility used in Study 1 ($\alpha = 0.62$; $\omega = 0.64$) rated from 1 = *strongly disagree* to 5 = *strongly agree*. A confirmatory factor analysis had the following model fit for a one-factor solution, $\chi^2(9) = 17.57$, $p = .04$; RMSEA = 0.10; CFI = 0.88; SRMR = 0.06.

We also administered a 3-item growth mindset scale from Dweck, 2000, $\alpha = 0.90$. Students then responded to Blackwell et al.'s (2007) measure of mastery behaviors. It read: "Imagine you start a new class and you really like the subject and the teacher. You think you know the subject pretty well, so you study a medium amount for the first quiz. Afterward, you think you did okay, even though there were some questions you didn't know the answer for. Then the class gets their quizzes back and you find out your score: you got a 54, and that's an F. What would you do next?" This was followed by three mastery and two helpless items rated from 1 = *extremely unlikely* to 5 = *extremely likely*. *Mastery behaviors* were: "I would try to understand what I did wrong"; "I would spend more time studying"; "I would work harder in the class from now on", $\alpha = 0.79$. *Helpless behaviors* were: "I would try not to take this subject ever again" and "I would spend less time on this subject from now on," $r = 0.57$, $p < .001$.

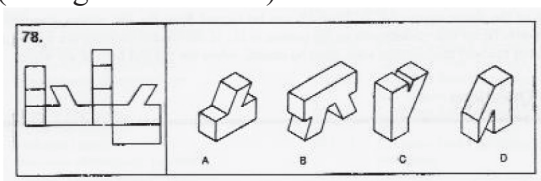
3.2. Results

Students higher in intellectual humility reported that they would engage in higher mastery behaviors ($r = 0.33$ $p = .001$). Intellectual humility was not significantly associated with helpless behaviors ($r = -0.12$, $p = .242$; see Table 3). The association between

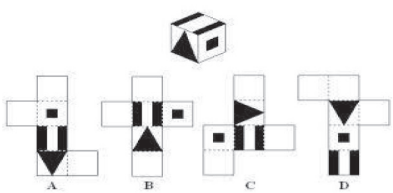
[4] The scale does not include three reverse-coded items used in the original measure (Porter & Schumann, 2018) due to reliability problems when including these three items. Please see the SOM (p. 3) for a rationale for using the shorter scale and results using the 9-item scale.

Shapes Module

Which of the shapes on the right (A, B, C, or D) could be made by folding pattern 78 (the figure on the left)?

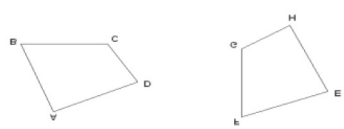


Cubes Module



Which of the patterns (A, B, C, or D) fold into the cube depicted above?

Angles Module



Match the angles in the two figures.

Fig. 1. Sample questions from each spatial reasoning module.

Table 1
Descriptive statistics and intercorrelations of main Study 1 variables.

Variables	1	2	3	4	5	6
1. Intellectual humility						
2. Growth mindset	0.19*					
3. Interest in success module 1	0.11	−0.05				
4. Interest in success module 2	0.05	0.05	0.79**			
5. Interest in failed module	0.19*	0.02	0.45**	0.34**		
6. Choosing tutorial on failed module	0.22*	0.04	−0.14	−0.25**	0.39**	
M	5.43	4.66	4.48	4.46	4.65	0.43
SD	0.87	1.41	3.04	3.16	2.99	0.50
Observed range	3.17–7.00	1.00–7.00	1.00–9.00	1.00–9.00	1.00–9.00	0–1.00

Note.
* $p < .05$.
** $p < .01$.

intellectual humility and mastery behaviors was maintained in a regression model that controlled for growth mindset and gender ($\beta = 0.30$, $SE = 0.10$, $p = .004$) (Table 4).

In Study 2, the link between intellectual humility and mastery behaviors was evident in a context that mattered for students' personal success. However, the failure scenario in this study was imagined, leaving open the question of whether intellectual humility predicts pursuit of mastery in response to *actual* feedback. We addressed this question in the next study.

Table 2
Regressions predicting interest in failed module and failed tutorial selection in Study 1.

Predictor variables	Interest in failed module[a]		Selection of failed tutorial	
	β	*SE*	*OR*	*SE*
Intellectual humility	0.19*	0.09	1.62*	0.40
Growth mindset	−0.02	0.09	1.02	0.24
Male	−0.001	0.09	1.55	0.83

Note. *SE* = standard error. *OR* = standardized odds ratio.
[a] $R^2 = 0.04$ ($n = 123$).
* $p < .05$.

Table 3
Descriptive statistics and intercorrelations of main Study 2 variables.

Variables	1	2	3	4
1. Intellectual humility				
2. Growth mindset	−0.16			
3. Mastery behaviors	0.33**	−0.09		
4. Helpless behaviors	−0.12	−0.31**	0.21**	
M	3.79	3.40	3.73	2.37
SD	0.59	1.16	0.99	0.99
Observed range	1.67–5.00	1.00–5.00	1.00–5.00	1.00–5.00

Note.
** $p < .01$.

Table 4
Regressions predicting mastery behaviors in Study 2.

Predictor variables	β	*SE*
Intellectual humility	0.30**	0.10
Growth mindset	−0.03	0.10
Male	−0.03	0.10

Note. *SE* = standard error. $R^2 = 0.10$ ($n = 91$).
** $p < .01$.

4. Study 3

Study 3 expanded upon Study 2 in three important ways: (a) rather than reporting how they would respond to failing an imagined quiz, students reported how they were going to respond after receiving real feedback on an actual math test; (b) intellectual humility and mastery behaviors were measured several months apart to ensure associations did not depend on simultaneous assessment; and (c) teacher reports of students' mastery behaviors were collected to corroborate students' self-reports.

4.1. Method

4.1.1. Participants

We recruited 88 freshmen and sophomores with the same math teacher from a public high school in the Midwestern United States (*M* age = 14.52 years, *SD* = 0.57; 50 girls, 37 boys, 2 unspecified). All of the teacher's students were invited to participate and sample size was determined by those who returned a signed parental consent form (63% response rate). A sensitivity power analysis indicated 80% power to detect medium effects (bivariate regression coefficient of β = 0.29).

4.1.2. Materials and procedure

In December of the first semester, we administered a battery of self-report questionnaires during a typical math class. This included the measure of intellectual humility used in Study 1 ($\alpha = 0.63$; $\omega = 0.66$). A confirmatory factor analysis had the following model fit for a one-factor solution: $\chi^2(9) = 15.99$, $p = .07$; RMSEA = 0.09; CFI = 0.89; SRMR = 0.06.

We also administered the 3-item measure of growth mindset used in Study 2 ($\alpha = 0.86$), and a 2-item measure of growth mindset of math ability ($r = 0.72$, $p < .001$), both rated from 1 = *strongly agree* to 7 = *strongly disagree*. The math mindset items were taken from Rattan, Good, & Dweck, 2012, and read, "You have a certain amount of math intelligence and you can't really do much to change it" and "To be honest, people can't really change how intelligent they are in math". We included these items to control for math-specific beliefs.

Four months later, the teacher returned graded unit tests and handed out a short survey to assess mastery responses. To capture students' subjective interpretations of their test scores, the survey asked them to, "Please circle ONE statement that is most true about you." Students indicated *success* by circling "On my last test in this class, I did well" and *failure* by circling "On my last test in this class I did not do very well." Students then read, "Now think about what you will do for your next test in this class." Students then rated 11 mastery and helpless behavior items from 1 = *not at all likely* to 7 = *extremely likely*. Items were adapted from those used by Blackwell et al. (2007) so that students who either succeeded or failed could endorse them. For example, the item, "For my next test, I will try to determine what I don't understand well", could be endorsed equally by someone who either succeeded on the previous exam or not.

Mastery behaviors following feedback were "Try to determine what I don't understand well"; "Try to figure out things that confuse me"; "Pay close attention in class"; "Ask myself questions to make sure I understand the material"; "Ask my teacher for help to learn the material"; "Ask my classmates for help to learn the material"; and "Work hard to learn the material". The items had an internal reliability coefficient of $\alpha = 0.83$. One additional item, "Spend more time studying", was not included in the composite because it was endorsed less by those who succeeded ($M = 3.88$, $SD = 1.95$) than by those who failed ($M = 5.36$, $SD = 1.62$), $t(78) = 3.42$, $p = .001$ (students who succeeded may not have seen a need to study *more* for the next test). The results were slightly weaker when this item was included in the composite ($r = 0.19$, $p = .098$). The other items were endorsed equally by those who succeeded or failed, all $ts < 1.60$.

Helpless behaviors following feedback were "Try to cheat"; "Give up studying"; and "Only study the easy parts." Items had an internal reliability coefficient of $\alpha = 0.60$.

At the end of the school year, the teacher (who did not know students' intellectual humility scores) rated each student on two mastery behavior items from 1 = *strongly disagree* to 7 = *strongly agree*: "This student is eager to learn"; "This student seeks out challenges at school." The items were correlated at $r = 0.89$, $p < .001$.

4.2. Results and discussion

Students' perceptions of their performance on the test were well calibrated to their actual performance: those with higher scores were more likely to report that they did well, $r = 0.74$, $p < .001$; *M* "did well" score = 89%, *SD* = 6.93, and *M* "did not do well" score = 70%, *SD* = 10.36.

Intellectual humility was associated with higher self-reported mastery behaviors following test feedback ($r = 0.23$, $p = .039$), and higher teacher-reported mastery behaviors ($r = 0.29$, $p = .007$), but not with helpless behaviors ($r = -0.08$, $p = .492$) (Table 5). The associations were largely maintained when simultaneously controlling for growth mindset of intelligence, growth mindset of math ability, and gender, for both mastery behaviors following feedback (β = 0.18, *SE* = 0.11, $p = .089$), and teacher-reported mastery behaviors (β = 0.26, *SE* = 0.11, $p = .017$) (Table 6). Further, the association between intellectual humility and mastery behavior following feedback was not moderated by perceptions of success and failure on the math test (β = 0.07, *SE* = 0.10, $p = .481$), or actual scores on the math test (β = 0.14, *SE* = 0.12, $p = .227$).

Table 5
Descriptive statistics and intercorrelations of main Study 3 variables.

Variables	1	2	3	4	5	6
1. Intellectual humility						
2. Growth mindset	0.24*					
3. Growth mindset of math ability	0.10	0.62**				
4. Mastery behaviors following feedback	0.23*	0.22*	0.20†			
5. Helpless behaviors following feedback	−0.08	−0.02	−0.27*	−0.40**		
6. Teacher-reported mastery behaviors	0.29**	0.16	0.13	0.13	−0.28*	
M	4.68	5.21	5.14	5.19	1.98	4.82
SD	0.93	1.58	1.69	1.10	1.01	1.64
Observed range	2.33–6.50	1.00–7.00	1.00–7.00	1.71–7.00	1.00–5.33	1.00–7.00

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

Table 6
Regressions predicting mastery behaviors and teacher-reported mastery behaviors in Study 3.

Predictor variables	Mastery behaviors[a]		Teacher-report mastery behaviors[b]	
	β	*SE*	β	*SE*
Intellectual humility	0.18†	0.11	0.26*	0.11
Growth mindset of intelligence	0.09	0.13	0.09	0.14
Growth mindset of math ability	0.10	0.13	0.02	0.13
Male	−0.09	0.11	−0.23	0.10

Note. *SE* = standard error.
[a] $R^2 = 0.10$ ($n = 78$).
[b] $R^2 = 0.15$ ($n = 85$).
† $p < .10$.
* $p < .05$.

Results from Study 3 support the hypothesis that intellectual humility is associated with mastery responses. Intellectually humbler students pursued mastery after receiving feedback on an actual math test, and teachers rated these students as having higher mastery behaviors.

5. Study 4

Studies 1–3 established an association between intellectual humility and mastery behaviors in three samples using behavioral, self- and teacher-report measures. Because we were also interested in predicting how students react to challenges in the moment, Study 4 tested whether intellectual humility was associated with high school students' mastery behaviors assessed by an online performance task.

5.1. Method

5.1.1. Participants

A total of 601 adolescents in grades 7 through 11 were recruited from the Qualtrics commercial survey panel (*M* age = 15.10 years, *SD* = 0.81; 304 girls, 290 boys). Sample size was determined by having 80% power to detect effects of 0.15 or larger, an effect size informed by correlations between questionnaires and performance tasks in previous studies (*r*s from 0.08 to 0.20; Duckworth & Kern, 2011; Galla et al., 2014).

5.1.2. Materials and procedure

5.1.2.1. Mastery behaviors. Students began by completing an adaptation of the Persistence, Effort, Resilience, and Challenge-seeking Task (Porter et al., 2020a). This computer-based measure was inspired by Mueller and Dweck's (1998) laboratory paradigm that assessed an array of mastery behaviors in one session.

In this task, students worked through a series of Raven's progressive matrices that were embedded in an overall task narrative. We assessed challenge-seeking (choice of hard or easy puzzles), effort (time spent on medium-difficulty puzzles and puzzle-solving tips), persistence (time spent on hard puzzles), and resilience (accuracy on solvable puzzles after failing a set of hard puzzles) over the course of the activity. We computed an aggregate measure of mastery behaviors that summed the scores from the various indicators. We also assessed baseline puzzle-solving ability, which was percent correct on an introductory set of three puzzles. A higher mastery behavior score indicated that students sought challenge and maintained higher persistence, effort, and resilience throughout the task. See the SOM (p. 5) for a detailed task description and additional scoring information.[5]

5.1.2.2. Self-report questionnaires. Next, students completed the 6-item intellectual humility scale used in previous studies, rated from 1 = *strongly disagree* to 5 = *strongly* agree. The measure was internally consistent, $\alpha = 0.75$, $\omega = 0.75$, and a confirmatory factor analysis had the following model fit for a one-factor solution, $\chi^2(9) = 33.30$, $p < .001$; RMSEA = 0.07; CFI = 0.96; SRMR = 0.03. Students also completed a 3-item measure of growth mindset adapted from Dweck (2000) *rated from 1 = a lot correct to 5 = not at all correct* ($\alpha = 0.86$).

5.2. Results and discussion

Intellectual humility was positively correlated with mastery behaviors ($r = 0.13$, $p = .001$; Table 7). The association between intellectual humility and mastery behaviors held in a regression that controlled for growth mindset, gender, and baseline puzzle-solving ability ($\beta = 0.09$, $SE = 0.04$, $p = .015$) (Table 8). The association between intellectual humility and mastery behaviors did not fluctuate on the basis of students' performance on the task: It was not moderated by the percentage of correct trials on the practice puzzles, test puzzles,

[5] Two minor task variations were tested for a separate investigation in a 2 × 2 randomized design. The first variation was rating (or not rating) after each puzzle how sure one was in the answer. The second variation was alternating when students were offered puzzle-solving tips in the effort section of the task (before or after receiving feedback on their answers). There was no effect of either condition or their interaction on mastery behaviors (all *F*s (1, 593) < 1.65, all *ns*). Nor was there an interaction between conditions and intellectual humility in predicting mastery behaviors (all *F*s (1, 593) < 2.00, all *ns*). Results were no different when controlling or not controlling for these conditions. We included controls for condition in the regression analyses.

Table 7
Descriptive statistics and intercorrelations of main Study 4 variables.

	1	2	3	4
1. Intellectual humility				
2. Growth mindset	0.12**			
3. Baseline puzzle-solving ability	0.06	0.07†		
4. Mastery behaviors	0.13**	0.22**	0.42**	
M	3.78	4.03	0.92	2.24
SD	0.73	1.02	0.17	0.75
Observed range	1.00–5.00	1.00–5.00	0–1.00	0–4.00

† $p < .10$.
** $p < .01$.

Table 8
Regressions predicting mastery behaviors in Study 4.

Predictor variables	β	*SE*
Intellectual humility	0.09*	0.04
Growth mindset	0.18**	0.04
Male	0.02	0.04
Baseline puzzle-solving ability	0.40**	0.04

SE = standard error. $R^2 = 0.22$ ($n = 579$).
* $p < .05$.
** $p < .01$.

or on the task as a whole, β = −0.005, *SE* = 0.03, *p* = .882; β = −0.04, *SE* = 0.03, *p* = .105; β = −0.03, *SE* = 0.03, *p* = .278.

Collectively, Studies 1 through 4 suggest that learners who are higher in intellectual humility seek challenge, exert more effort, and persist more than their less intellectually humble peers. However, these studies are correlational and therefore do not address whether intellectual humility causally influences mastery behaviors. Study 5 takes a step towards addressing this limitation.

6. Study 5

The goal of Study 5 was to test the causal link between intellectual humility and mastery behaviors. We randomly assigned participants to read an article encouraging either intellectual humility or intellectual certainty. Participants then completed the same effort investment measure from Study 1. We predicted that those in the intellectual humility (vs. intellectual certainty) condition would be more eager to invest effort in learning and, thus, would select the tutorial on the failed (vs. mastered) module. Intellectual humility has some degree of trait-like continuity and also fluctuates across situations (Zachry et al., 2018). Thus, although we anticipated temporary increases, we did not expect trait levels of intellectual humility to be permanently changed by the manipulation.

6.1. Method

6.1.1. Participants

We recruited 149 American adults from Amazon Mechanical Turk (*M* = 35.79 years, *SD* = 11.77; 77 women, 72 men). Nine participants failed a comprehension check and were excluded from analyses. The analytic sample comprised 140 participants (*M* = 36.09 years, *SD* = 11.87; 73 women, 67 men). A sensitivity power analysis indicated 80% power to detect medium effects using an independent samples *t*-test and chi-square ($d = 0.48$; $w = 0.30$).

6.1.2. Materials and procedure

6.1.2.1. Manipulation. Following protocols used successfully in past research (Hong et al., 1999; Nussbaum & Dweck, 2008), we randomly assigned participants to read one of two articles matched for length and content ostensibly written for *USA Today*. The key message of the *intellectual humility* article was that acknowledging the limits of what you know is advantageous: "Admitting what you don't know can have profound benefits." In contrast, the key message of the *intellectual certainty* article was that showing what you know is advantageous: "Being very vocal in showing how much you know can have profound benefits."

Next, participants completed a few questions about the appropriateness of the reading for adolescents, which was the cover story used to frame part one of the study. Questions included a *comprehension check*: "In one sentence, please describe the main idea expressed in this article."

6.1.2.2. Self-report questionnaires. Participants then read "Thank you for participating in the first study. You will now complete the second study of personality, attitudes, and beliefs." To provide a manipulation check, participants responded to the same 6-item measure of intellectual humility from Studies 1–4 ($\alpha = 0.77$). This scale has demonstrated sensitivity to manipulations in past research (Porter & Schumann, 2018). We administered the same 8-item measure of growth mindset from Study 1 as a control variable ($\alpha = 0.95$). Finally, we used Big Five personality items from John and Srivastava (1999) to distract from the purposes of the study. Items began "I see myself as someone who is" followed by a series of descriptors (e.g., talkative) rated from 1 = *strongly disagree* to 7 = *strongly agree*. Two items each assessed *Openness*, *Agreeableness*, *Conscientiousness*, *Extraversion*, and *Emotional Stability* with bivariate correlations of *rs* = 0.48, 0.35, 0.53, 0.74, and 0.69.

6.1.2.3. Effort investment. Next, participants read, "Thank you for participating in the second study. You will now complete the final study, which is a spatial reasoning test." We administered the effort measure from Study 1, in which *interest in the failed module* and *choosing the tutorial on the failed module* were the target outcomes.

6.2. Results and discussion

The manipulation was successful: Individuals in the intellectual humility condition had higher self-reported intellectual humility (*M* = 5.63, *SD* = 0.82) than those in the intellectual certainty condition (*M* = 5.33, *SD* = 0.93), *p* = .054, *d* = 0.34.

As predicted, the intellectual humility condition boosted mastery responses. Those in the intellectual humility condition reported more interest in learning about the failed module (*M* = 6.49, *SD* = 2.77) than those in the intellectual certainty condition (*M* = 5.44, *SD* = 3.03), *d* = 0.35, *p* = .033 (see Table 9). Those in the intellectual humility condition were also more likely to choose the tutorial on the failed module than those in the intellectual certainty condition (85% vs. 64%), *d* = 0.47, *p* = .006; 95% CI for intellectual humility condition [76%, 94%]; 95% CI for intellectual certainty condition [53%, 75%].

The effects of the intellectual humility condition were independent of growth mindset and gender for both interest in the failed module (β = 0.17, *SE* = 0.08, *p* = .039) and selecting the tutorial on the failed module (standardized OR = 1.77, *SE* = 0.46, *p* = .007) (Table 10).

Overall, findings from Study 5 supported our hypothesis that encouraging intellectual humility can increase mastery behaviors, at least in the short term. Upon hearing that they failed one module of a test, 85% of those encouraged to be intellectually humble chose to invest greater effort by selecting to learn about the failed subject. This pattern was not as strong among those in the intellectual certainty condition, where just under two thirds (64%) of participants chose a tutorial on the unmastered material.

7. Meta-analysis of studies 1–5

To test the overall magnitude of effects across studies, we conducted an internal meta-analysis (McShane & Bockenholt, 2017). We used

Table 9
Mean differences between the intellectual certainty condition and the intellectual humility condition.

Measures	Variables	Intellectual certainty		Intellectual humility		$t(138)$	p
		M	*SD*	*M*	*SD*		
Self-report	Intellectual humility	5.33	0.93	5.63	0.82	−1.95	0.05
	Growth mindset	4.74	1.51	4.79	1.59	−0.22	0.83
	Extraversion	3.31	1.73	3.47	1.76	−0.55	0.58
	Emotional stability	4.65	1.72	4.48	1.67	0.61	0.54
	Openness	5.53	1.18	5.72	0.98	−1.02	0.31
	Agreeableness	5.43	1.29	5.18	1.26	1.16	0.25
	Conscientiousness	5.76	1.24	5.60	1.27	0.75	0.45
Spatial reasoning	Interest in success module 1	4.08	2.84	4.19	2.67	−0.22	0.82
	Interest in success module 2	3.94	2.71	4.00	2.48	−0.12	0.90
	Interest in failed module	5.44	3.03	6.49	2.77	−2.13	0.03
	Choosing tutorial on failed module	0.64	0.48	0.85	0.36	−2.82	0.01

Table 10
Regressions predicting interest in failed module and failed tutorial selection in Study 5.

Predictor variables	Interest in failed module[a]		Selection of failed tutorial	
	β	*SE*	*OR*	*SE*
Intellectual humility condition	0.17*	0.08	1.77**	0.46
Growth mindset	0.13	0.08	1.28	0.31
Male	−0.09	0.08	1.00	0.60

Note. *SE* = standard error. *OR* = standardized odds ratio.
[a] $R^2 = 0.06$ ($n = 139$).
* $p < .05$.
** $p < .01$.

meta-analysis software (Borenstein, Hedges, Higgins, & Rothstein, 2009) to convert all effects to correlations and partial correlations between measured or manipulated intellectual humility and mastery behaviors, controlling for gender and growth mindset in partial estimates. We then averaged effects within study to account for the interdependence of these outcomes (Borenstein et al., 2009). Because of the heterogeneity across our samples, we used random effects models to calculate an overall effect size across studies (Borenstein et al., 2009). The mean effect size controlling for growth mindset and gender was $pr = 0.17$, 95% CI [0.09, 0.26], $z = 4.06$, $p < .001$. The effect was similar without controlling for covariates, $r = 0.19$, 95% CI [0.12, 0.25], $z = 5.27$, $p < .001$ (see SOM, p. 7, for detailed results).

8. Robustness Test

In a final set of analyses, we examined whether associations between intellectual humility and mastery behaviors held when using a different intellectual humility questionnaire that conceptualized intellectual humility as "the degree to which people recognize that their beliefs might be wrong" (Leary et al., 2017, p. 1). We administered Leary et al.'s (2017) 6-item General Intellectual Humility Scale in Studies 2 and 4 (the scale had not yet been published when we ran Studies 1, 3, and 5).

The General Intellectual Humility Scale tapped only awareness of personal intellectual limitations and recognition that one might be wrong: "I question my own opinions, positions, and viewpoints because they could be wrong"; "I reconsider my opinions when presented with new evidence"; "I recognize the value in opinions that are different from my own"; "I accept that my beliefs and attitudes may be wrong"; "In the face of conflicting evidence, I am open to changing my opinions"; "I like finding out new information that differs from what I already think is true". This scale was positively correlated with the Porter and Schumann (2018) intellectual humility scale in Study 2 ($r = 0.54$, $p < .001$) and Study 4 ($r = 0.49$, $p < .001$). These correlations are comparable to those that Haggard et al. (2018) observed between the General Intellectual Humility Scale and the Limitations Owning Intellectual Humility scale ($r = 0.35$, $p < .001$), the Comprehensive Intellectual Humility scale ($r = 0.67$, $p < .001$), and the Biola Intellectual Humility scale ($r = 0.48$, $p < .001$).

The General Intellectual Humility scale was correlated with both self-reported mastery behaviors (Study 2: $r = 0.25$, $p < .001$) and actual mastery behaviors assessed with the PERC task (Study 4: $r = 0.29$, $p < .001$). Associations in Studies 2 and 4 held in regressions that controlled for growth mindset and gender, and baseline puzzle-solving ability (Study 4 only) (βs = 0.21 and 0.17, *SE*s = 0.10 and 0.04, *p*s < 0.05). The link between intellectual humility and mastery behaviors is therefore consistent across at least two measures of intellectual humility.

9. General discussion

The current investigation shows those higher in intellectual humility are more likely to pursue mastery. In four studies using cross-sectional and longitudinal designs, individuals with more intellectual humility sought challenge, exerted more effort, and persisted more than those with less intellectual humility. Findings were consistent with adults and adolescents in lab settings and with high school students surveyed in school. The link replicated across self-reported, teacher-reported, and task-based measures of mastery behaviors, and when using a different measure of intellectual humility. Individual differences in intellectual humility accounted for significant variance in mastery behaviors over and beyond that explained by gender and growth mindset. In a fifth study, an experimental manipulation of intellectual humility increased effort to learn following a failure, suggesting intellectual humility offers a promising pathway for fostering mastery behaviors.

Effect sizes ranged from *pr*s = 0.09 to 0.30, with an average effect of $pr = 0.17$, after partialing out the influence of gender and growth mindset. These effect sizes are comparable to meta-analytic estimates of the association between growth mindset and behavioral and self-reported mastery responses ($r = 0.23$; Burnette et al., 2013), and to a meta meta-analysis of 709 meta-analytic effects across personality and social psychology research (average $r = 0.19$; Gignac & Szodorai, 2016). Effects are also comparable to meta-analytic estimates of the association between behavioral and self-report measures of self-control (*r*s from 0.10 to 0.21; Duckworth & Kern, 2011), behavioral measures of effort and self-reported grit, conscientiousness, and self-control (*pr*s from 0.08, to 0.16; Galla et al., 2014), and behavioral challenge-seeking and self-reported growth mindset ($r = 0.13$; Yeager et al., 2016). Finally, the effects are within range of other published associations between intellectual humility and behavioral measures, including cognitive flexibility ($\beta = 0.20$; Zmigrod, Zmigrod, Rentfrow, & Robbins,

2019), and behavioral openness to the opposing view ($\beta = 0.11$; Porter & Schumann, 2018; see also Deffler et al., 2016).

What is the practical significance of an effect of $pr = 0.17$? Funder and Ozer (2019) recommended gauging practical importance using phenomena that are commonly experienced and intuitively understood. For example, the effect of an antihistamine on a runny nose and sneezing is around $r = 0.11$, and the effect of ibuprofen on pain is about $r = 0.14$ (Meyer et al., 2001, as cited in Funder & Ozer, 2019). Effects can also accumulate over time. Abelson (1985), as described in Funder and Ozer (2019), found that success in one Major League Baseball player's at bat correlated with overall batting average at $r = 0.056$, but this effect across 550 at bats had substantial implications for players' salaries. We would expect a similar accumulation of effects for intellectual humility and mastery behaviors. To illustrate, if an intellectually humble high school student embraced challenge, invested effort, persisted, or showed resilience even 10 times during each school day (an eight-class schedule would typically provide more opportunities than this), she reaches 275 events in just over one month, and over 3000 events in a school year – many more than Abelson's 550 at bats. Even if mastery behaviors were correlated with achievement at $r = 0.06$ as in Abelson's example (the estimated lower-bound correlation between mastery behavior and achievement is larger, $r = 0.10$; Burnette et al., 2013), we would expect notable increases in achievement and presumably learning as well. Higher achievement should also increase educational attainment and lifetime earnings (Chetty, Friedman, & Rockoff, 2014).

Although the link between mastery behavior and growth mindset was not the focus of the current investigation, it is notable that we observed unexpected null correlations between these constructs in Studies 1 and 2. The null findings in Study 1 do not appear to be attributable to the mastery behavior measure because we observed small positive associations between growth mindset and the same measure in Study 5: The correlation between growth mindset and interest in the failed module was $r = 0.14$, $p = .105$, and that for selecting the tutorial on the failed module was $r = 0.11$, $p = .212$. The false growth mindset (where espoused beliefs do not necessarily align with behavior) may have contributed to the null effects, particularly in Study 2 because it was conducted in a school during a time when growth mindset was popular and well known (Dweck & Yeager, 2019; Fotuhi, 2020). Yet, it is worth noting that we observed the expected positive correlations between growth mindset and mastery behaviors in Studies 3 and 4.

The current research advances understanding of intellectual humility in two key ways. First, prior empirical work linking intellectual humility to learning has relied almost exclusively on self-reported attitudes, goals, and dispositions. Our findings provide consistent evidence that intellectual humility also relates to learners' actions, not just their *reported* attitudes and beliefs. Second, nearly all empirical research on intellectual humility has focused on adults and (to our knowledge) no published studies have tested intellectual humility in adolescents, though adolescents are the targets of educational efforts to increase intellectual humility (Baehr, 2013, 2015). The current findings demonstrate that adolescents higher in intellectual humility are more engaged, effortful, and persistent when learning.

The evidence from Study 5 also suggests that increasing intellectual humility can enhance mastery behaviors in adults. If substantiated in adolescent samples, this finding has several implications: First, parents and teachers should consider embracing the view that mistakes and failures (i.e., experiences that reveal our intellectual limitations) are enhancing rather than debilitating (Haimovitz & Dweck, 2016). They could do so by modeling ways to learn from their own mistakes and by emphasizing how mistakes and failures lead to growth and improvement. Second, teachers who want to promote mastery behaviors should consider intellectual humility a pedagogical objective along with other desirable habits of mind. Third, systemic school practices that effectively run in opposition to intellectual humility by harshly penalizing intellectual limitations (e.g., high stakes test with little opportunity to grow or improve) could be replaced with practices more supportive of intellectual humility (e.g., formative assessments that allow students to revise and improve their work). Of course, more research is needed to test these approaches.

9.1. Limitations and future directions

The current studies also have limitations. We relied exclusively on self-report questionnaires to measure intellectual humility, the limitations of which are well-known (Abrahams et al., 2019; Duckworth & Yeager, 2015; McElroy-Heltzel, Davis, DeBlaere, Worthington, & Hook, 2018). We mitigated response biases by assessing non-self-reported mastery behaviors in Studies 3 and 4, and by using a manipulation of intellectual humility in Study 5. Although a multimethod approach to measurement is generally preferable, finding non-self-report ways of assessing intellectual humility is also challenging because intellectual humility involves a personal recognition of limitations, which may not be observable from the outside.

Additional research is also needed to improve measurement of intellectual humility over the course of development. We encountered lower internal consistencies when trying to measure intellectual humility in two of three adolescent samples. It is not clear whether these challenges resulted from teens' lack of experience taking surveys (adolescents in Study 4 with presumably more survey experience given their association with Qualtrics had a reliable measure), or general developmental differences in cognitive ability, self-knowledge, or orientation towards ignorance that may have influenced responses to the scale. For example, adults might be more solidified in thinking about their own ignorance, making adolescents' intellectual humility less coherent by comparison. Studies that dig deeper into the measurement of intellectual humility across development are needed as the field continues to grapple with conceptual and measurement issues.

Our measure of intellectual humility tapped some behavioral manifestations of the construct, which may be occasional expressions of intellectual humility and not essential features (Church & Barrett, 2017; Leary, 2019; Leary et al., 2017). The pattern of results was the same when using a measure of intellectual humility that did not contain behavioral items. However, future studies of intellectual humility should either measure the construct separate from its behavioral manifestations, or provide a clear conceptual rationale for including behavioral items in measures of intellectual humility. Relatedly, our manipulation of intellectual humility in Study 5 focused on expressions of intellectual humility rather than private awareness of intellectual fallibility. It is possible that we changed a desire to self-present as intellectually humble without changing private awareness. Future research should replicate our finding by manipulating private awareness of intellectual limitations.

The current results do not shed light on how intellectual humility works together with other variables thought to predict mastery behaviors, such as self-efficacy (Bandura, 1977), intrinsic motivation (Ryan & Deci, 2000), and openness to experience (Sorrenti, Filippello, Buzzai, Buttò, & Costa, 2018). Future research is needed to test whether these variables are distal factors that have an effect on mastery through intellectual humility or vice versa. For example, intellectual humility might buffer self-efficacy during struggles thereby enhancing mastery behaviors. In general, research is needed to identify the specific processes set in motion by intellectual humility and other variables associated with mastery.

Beyond addressing the limitations of the current studies, there are many other directions for research in this area. We found that encouraging learners to be intellectually humble boosted mastery behaviors in the short term. More work is needed to examine the dynamic between intellectual humility and mastery behaviors over time, with respect to particular domains (Hoyle et al., 2016) and as the variables interact in daily life (Zachry et al., 2018). Although we found evidence for the hypothesized effect from intellectual humility to mastery

behaviors, it is possible that bidirectional or recursive effects could occur. Pursuing mastery entails facing challenging and difficult tasks. Repeated engagement with such tasks could enhance recognition and awareness of intellectual limitations. Just as intellectual humility boosts pursuit of mastery, pursuit of mastery could also enhance intellectual humility.

10. Conclusion

Challenges and struggle are inherent to learning. Those who embrace challenge and persist through difficulty tend to learn more and achieve at higher levels. The current research demonstrates that learners higher in intellectual humility behave in a mastery-oriented way: they take on challenge, exert greater effort, and persist despite setbacks. Boosting intellectual humility thus offers a promising way to foster mastery behaviors and advance learning.

Appendix A. Supplementary Analyses

Supplementary data to this article can be found online at https://doi.org/10.1016/j.lindif.2020.101888.

References

Abelson, R. P. (1985). A variance explanation paradox: When a little is a lot. *Psychological Bulletin, 97*, 129–133.

Abrahams, L., Pancorbo, G., Primi, R., Santos, D., Kyllonen, P., John, O. P., & De Fruyt, F. (2019). Social-emotional skill assessment in children and adolescents: Advances and challenges in personality, clinical, and educational contexts. *Psychological Assessment*. https://doi.org/10.1037/pas0000591 Advance online publication.

Alfano, M., Iurino, K., Stey, P., Robinson, B., Christen, M., Yu, F., & Lapsley, D. (2017). Development and validation of a multi-dimensional measure of intellectual humility. *PLoS One, 12*(8).

Baehr, J. (2013). Educating for intellectual virtues: From theory to practice. *Journal of Philosophy of Education, 47*(2), 248–262.

Baehr, J. (Ed.). (2015). *Intellectual virtues and education: Essays in applied virtue epistemology*. New York, NY: Routledge.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191.

Bian, L., Leslie, S. J., & Cimpian, A. (2017). Gender stereotypes about intellectual ability emerge early and influence children's interests. *Science, 355*(6323), 389–391.

Blackwell, L., Trzesniewski, K. H., & Dweck, C. (2007). Theories of intelligence and achievement across the junior high school transition: A longitudinal study and an intervention. *Child Development, 78*(1), 246–263.

Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2009). *Introduction to meta-analysis.* Hoboken, NJ: John Wiley & Sons Inc.

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

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014). Measuring the impacts of teachers II: Teacher value-added and student outcomes in adulthood. *American Economic Review, 104*(9), 2633–2679.

Church, I. M., & Barrett, J. L. (2017). Intellectual humility. In E. L. WorthingtonJr., D. E. Davis, & J. N. Hook (Eds.). *Handbook of intellectual humility* (pp. 62–75). New York: Routledge.

Danovitch, J. H., Fisher, M., Schroder, H., Hambrick, D. Z., & Moser, J. (2019). Intelligence and neurophysiological markers of error monitoring relate to children's intellectual humility. *Child Development, 90*(3), 924–939.

Deffler, S. A., Leary, M. R., & Hoyle, R. H. (2016). Knowing what you know: Intellectual humility and judgments of recognition memory. *Personality and Individual Differences, 96*, 255–259.

Diener, C. I., & Dweck, C. S. (1978). An analysis of learned helplessness: Continuous changes in performance, strategy, and achievement cognitions following failure. *Journal of Personality and Social Psychology, 36*(5), 451–462.

Diener, C. I., & Dweck, C. S. (1980). An analysis of learned helplessness: II. The processing of success. *Journal of Personality and Social Psychology, 39*(5), 940–952.

Duckworth, A. L., & Kern, M. L. (2011). A meta-analysis of the convergent validity of self-control measures. *Journal of Research in Personality, 45*(3), 259–268.

Duckworth, A. L., & Yeager, D. S. (2015). Assessing personal qualities other than cognitive ability for educational purposes. *Educational Researcher, 44*(4), 237–251.

Dweck, C. (2000). *Self-theories: Their role in motivation, personality and development.* Philadelphia, PA: Taylor & Francis.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*(2), 256–273.

Dweck, C. S., & Yeager, D. S. (2019). Mindsets: A view from two eras. *Perspectives on Psychological Science, 14*(3), 481–496.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191.

Fotuhi, O. (2020). The rise of a false growth mindset, and how to combat it. *Inside higher education* (manuscript in press).

Fryberg, S. A., Covarrubias, R., & Burack, J. A. (2013). Cultural models of education and academic performance for Native American and European American students. *School Psychology International, 34*(4), 439–452.

Funder, D. C., & Ozer, D. J. (2019). Evaluating effect sizes in psychological research: Sense and nonsense. *Advances in Methods and Practices in Psychological Science, 2*(2), 156–168.

Galla, B. M., Plummer, B. D., White, R. E., Meketon, D., D'Mello, S. K., & Duckworth, A. L. (2014). The Academic Diligence Task (ADT): Assessing individual differences in effort on tedious but important schoolwork. *Contemporary Educational Psychology, 39*(4), 314–325.

Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences, 102*, 74–78.

Grossmann, I., Na, J., Varnum, M. E., Park, D. C., Kitayama, S., & Nisbett, R. E. (2010). Reasoning about social conflicts improves into old age. *Proceedings of the National Academy of Sciences, 107*(16), 7246–7250.

Hagá, S., & Olson, K. R. (2017). "If I only had a little humility, I would be perfect": Children's and adults' perceptions of intellectually arrogant, humble, and diffident people. *The Journal of Positive Psychology, 12*(1), 87–98.

Haggard, M., Rowatt, W. C., Leman, J. C., Meagher, B., Moore, C., Fergus, T., ... Howard-Snyder, D. (2018). Finding middle ground between intellectual arrogance and intellectual servility: Development and assessment of the limitations-owning intellectual humility scale. *Personality and Individual Differences, 124*, 184–193.

Haimovitz, K., & Dweck, C. S. (2016). Parents' views of failure predict children's fixed and growth intelligence mind-sets. *Psychological Science, 27*(6), 859–869.

Hong, Y., Chiu, C., Dweck, C. S., Lin, D. M.-S., & Wan, W. (1999). Implicit theories, attributions, and coping: A meaning system approach. *Journal of Personality and Social Psychology, 77*(3), 588–599.

Hoyle, R. H., Davisson, E. K., Diebels, K. J., & Leary, M. R. (2016). Holding specific views with humility: Conceptualization and measurement of specific intellectual humility. *Personality and Individual Differences, 97*, 165–172.

John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In L. Pervin, & O. John (Eds.). *Handbook of personality* (pp. 102–138). New York, NY: Guilford Press.

Kross, E., & Grossmann, I. (2012). Boosting wisdom: Distance from the self enhances wise reasoning, attitudes, and behavior. *Journal of Experimental Psychology: General, 141*(1), 43.

Krumrei-Mancuso, E. J., Haggard, M. C., Labouff, J. P., & Rowatt, W. C. (2019). Links between intellectual humility and acquiring knowledge. *The Journal of Positive Psychology*. https://doi.org/10.1080/17439760.2019.1579359 Advance online publication.

Krumrei-Mancuso, E. J., & Newman, B. (2020). Intellectual humility in the sociopolitical domain. *Self and Identity,* 1–28.

Krumrei-Mancuso, E. J., & Rouse, S. V. (2016). The development and validation of the Comprehensive Intellectual Humility Scale. *Journal of Personality Assessment, 98*(2), 209–221.

Leary, M. R. (2019). The psychology of intellectual humility. Retrieved from https://www.templeton.org/wp-content/uploads/2018/11/Intellectual-Humility-Leary-FullLength-Final.pdf.

Leary, M. R., Diebels, K. J., Davisson, E. K., Jongman-Sereno, K. P., Isherwood, J. C., Raimi, K. T., ... Hoyle, R. H. (2017). Cognitive and interpersonal features of intellectual humility. *Personality and Social Psychology Bulletin, 43*(6), 793–813.

McElroy-Heltzel, S. E., Davis, D. E., DeBlaere, C., Worthington, E. L., & Hook, J. N. (2018). Embarrassment of riches in the measurement of humility: A critical review of 22 measures. *The Journal of Positive Psychology, 14*(3), 393–404.

McShane, B. B., & Bockenholt, U. (2017). Single-paper meta-analysis: Benefits for study summary, theory testing, and replicability. *Journal of Consumer Research, 43*(6), 1048–1063.

Meyer, G. J., Finn, S. E., Eyde, L. D., Kay, G. G., Moreland, K. L., Dies, R. R., ... Reed, G. M. (2001). Psychological testing and psychological assessment: A review of evidence and issues. *American Psychologist, 56*, 128–165.

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.

Nussbaum, A. D., & Dweck, C. (2008). Defensiveness versus remediation: Self-theories and modes of self-esteem maintenance. *Personality and Social Psychology Bulletin, 34*(5), 599–612.

Porter, T., & Schumann, K. (2018). Intellectual humility and openness to the opposing view. *Self and Identity, 17*(2), 139–162.

Porter, T., Catalán Molina, D., Blackwell, L., Roberts, S., Quirk, A., Lee Duckworth, A., & Trzesniewski, K. (2020a). Measuring Mastery Behaviors at Scale: The Persistence, Effort, Resilience and Challenge-Seeking Task (PERC). *Journal of Learning Analytics, 7*(1), 5–18.

Porter, T, et al. (2020b). *Conceptual and operational challenges in the empirical study of intellectual humility.* NA (Manuscript in preparation).

Rattan, A., Good, C., & Dweck, C. S. (2012). "It's ok—Not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students. *Journal of Experimental Social Psychology, 48*(3), 731–737.

Robins, R. W., & Pals, J. L. (2002). Implicit self-theories in the academic domain: Implications for goal orientation, attributions, affect, and self-esteem change. *Self and Identity, 1*(4), 313–336.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54–67.

Sorrenti, L., Filippello, P., Buzzai, C., Buttò, C., & Costa, S. (2018). Learned helplessness

and mastery orientation: The contribution of personality traits and academic beliefs. *Nordic Psychology, 70*(1), 71–84.

Whitcomb, D., Battaly, H., Baehr, J., & Howard-Snyder, D. (2015). Intellectual humility: Owning our limitations. *Philosophy and Phenomenological Research,* 1–31.

Yeager, D. S., Hulleman, C. S., Hae Yeon Lee, C. H., O'Brien, J., Romero, C., Paunesko, D., … 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.

Zachry, C. E., Phan, L. V., Blackie, L., & Jayawickreme, E. (2018). Situation-based contingencies underlying wisdom-content manifestations: Examining intellectual humility in daily life. *Journal of Gerontology: Psychological Sciences, 23*(8), 1404–1415. https://doi.org/10.1093/geronb/gby016.

Zmigrod, L., Zmigrod, S., Rentfrow, P. J., & Robbins, T. W. (2019). The psychological roots of intellectual humility: The role of intelligence and cognitive flexibility. *Personality and Individual Differences, 141*, 200–208.