INCREMENTAL THEORIES OF INTELLIGENCE INCREASE SENSE OF BELONGING AND ACADEMIC ACHIEVEMENT

By

JORDAN JEAN VOSSEN

A thesis submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE IN PSYCHOLOGY - EXPERIMENTAL

WASHINGTON STATE UNIVERSITY
Department of Psychology

MAY 2017

To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of JORDAN JEAN VOSSEN find it satisfactory and recommend that it be accepted.

Joyce Ehrlinger, Ph.D., Chair

Paul Strand, Ph.D.

Andrew Perkins, Ph.D.

INCREMENTAL THEORIES OF INTELLIGENCE INCREASE

SENSE OF BELONGING AND ACADEMIC ACHIEVEMENT

Abstract

by Jordan Jean Vossen, M.S.
Washington State University
May 2017

Chair: Joyce Ehrlinger

Students' theories of intelligence range from the belief that intelligence is malleable (incremental) to believing intelligence is fixed (entity). While ample evidence suggests that an incremental view predicts greater academic success compared to an entity view, less is known about the mechanisms underlying this relationship. We proposed that an incremental theory of intelligence would lead to increased feelings of belongingness, in turn, leading to greater sustained learning in math. Six hundred and fifty-seven high school math students completed two computer-based math tutorials, a set of questionnaires, and a test of sustained learning one week later. As hypothesized, a stronger incremental perspective, compared to an entity perspective, was more beneficial for students' learning through their feelings of belongingness to the math domain. This suggests that adopting an incremental view can help students' learning by inspiring feelings of belongingness in a math setting.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Introduction

Many students find math to be a particularly challenging subject as evidenced by self-report data stating that the subject is difficult and unlikeable (Dutton, 1956) and tendencies for students to feel anxious about performing well within math classes. Indeed, this anxiety has been found to predict avoidance of taking math classes (Hembree, 1990). We suggest that these negative judgments about and avoidance of math is problematic because it inhibits students' future success. Mastery of high school level math is highly correlated with students' acceptance to college, graduation from college, and higher early-career wages (National Mathematics Advisory Panel, 2008). Thus, it seems critically importantly to find ways to motivate students to engage with, rather than shy away from, challenges when studying math.

While it is critical to motivate students to persist or even to find joy in math, it has a bit of an image problem. Anecdotal evidence suggests that people might more often think of themselves as not a "math person" than they might think that they are not "an English" or "a science person." An extensive analysis of people's perceptions of the degree to which field-specific skills are naturally inborn and fixed as opposed to changeable and able to be developed over time suggests that math, as a field, is characterized as requiring more fixed, inborn skills than most other fields of study (Leslie, Cimpian, Meyer, & Freeland, 2015). This finding suggests that, more so than with other fields of study, many people are likely to interpret struggle when studying math as a sign that they will never be able to become a "math person."

Viewing math intelligence as changeable

One successful strategy for motivating students in the face of difficulty might be to counteract this belief that math intelligence (aka math ability) is a natural, fixed trait by teaching students that it is, in fact, an acquirable and malleable skill. People differ in their beliefs about the degree to which one's basic level of math intelligence is malleable (Rattan, Good, & Dweck, 2012). Incremental, or growth, theorists view math intelligence as a malleable quality that can be improved with effort, whereas those with a more entity theory view math intelligence as fixed and unchangeable. Past research has found that students with more incremental theories show benefits with respect to persistence and motivation on math tasks (Ehrlinger, et al., 2016), views of exerting effort on math tasks, and math course grades (Blackwell, Trzesniewski, & Dweck, 2007), relative to their more entity theorist peers. Further, experimental evidence suggests an incremental view of intelligence causes rather than merely correlates with academic benefits. Interventions designed to teach students an incremental view of intelligence lead to improvements in math class grades (Blackwell et al, 2007), overall grades (Aronson, Fried, & Good, 2002), and standardized test scores (Good, Aronson, & Inzlicht, 2003), compared to controls.

While ample evidence suggests a relationship between an incremental theory of intelligence and math achievement, considerably less is known about the mechanisms underlying this relationship. Some evidence suggests that incremental theorists perform better in math than entity theorists because they more commonly endorse mastery-oriented learning goals and they have more positive views regarding expending effort to learn a new topic (Blackwell et al, 2007). We propose that another possible reason that an incremental theory of math intelligence leads to benefits in math achievement is because more incremental theories of intelligence might inspire greater feelings of being accepted and belonging in one's math classroom environment.

Feelings of acceptance and belonging

Because math is often perceived as a very difficult subject, students might expect that studying math would involve the risk of failure and struggle. For these reasons, it may be the case that few people feel as if they truly are competent at math and, relatedly, few feel that they are truly accepted and belong to their relevant math community (a group that could be as small as a math study group, the size of a math classroom, or much larger, such as the academic math community). Reducing this uncertainty about belongingness to math is another key strategy for motivating students to learn and enjoy math.

The need to belong to surrounding social groups is a basic human motivation (Baumeister & Leary, 1995), and past research suggests that feeling as if one is an accepted and valued member of a group can lead to increases in one's academic motivation and achievement (Master & Walton, 2013; Murphy & Zirkel, in press; Walton, Cohen, Cwir, & Spencer, 2012). For example, Walton et al. (2012) found that undergraduate students who read a report written by a role model that emphasized the support from the math department as contributing a large part to their success, compared to students who read a report from a role model who emphasized their own skills as the reason they were successful, reported stronger motivation to learn math and were more likely to persist on an insoluble math puzzle. Similarly, Master and Walton (2013) also found this effect of belongingness on motivation in preschool-aged children who were randomly assigned to minimal groups characterized as being either a group task or an individual task. Specifically, they found that when children were told that they belonged to a group associated with solving puzzles (i.e., “puzzles group”), they reported greater liking of the puzzle and persisted significantly longer than those that were told that their individual identity would be associated with solving puzzles (i.e., “puzzles child”). These studies suggest that increasing students’ feelings of belongingness is an effective way of motivating students to persist when facing a challenging task.

Beyond simply persisting, there is evidence that suggests that belongingness can also affect students' overall academic performance across time, particularly students who are at a higher risk of experiencing doubt or uncertainty about their belongingness within a classroom (i.e., racial minorities). In an examination of the effects of belongingness on academic performance, Murphy and Zirkel (in press) found that students of color who reported spending more time with their peers in activities outside of the classroom early on in their academic career showed a significant increase in academic performance over the academic year compared to White students.

Why might an incremental theory inspire increased feelings of belongingness in math?

Imagine an entity theorist who struggles with math. By virtue of holding an entity theory, this student will believe not only that she is not good at math now, but also that she can never become a person who is good at math. A student in that position might decide that she simply does not belong in the math class and that there is little point in putting in more effort. Similarly, that student might worry that she won't be accepted or respected by other students or the math teacher. Consider instead, that this same student holds an incremental theory of math intelligence. Now, the fact that she is struggling is a temporary state of being rather than a life sentence. She might decide that there absolutely is reason to put in effort and that being in this class is exactly the sort of thing that might help her improve. This incremental theory, thus, might inspire greater expectations that she does belong in the class and that her peers and teacher will accept and respect her, compared to how she might feel if she had an entity theory. Indeed, it has previously been theorized that an incremental theory of intelligence might lead to fewer concerns about belongingness and, consequently, might minimize the negative achievement consequences of stereotype threat (fear of confirming a negative stereotype about one's group, Steele, 1997). Although belongingness was not directly measured in this work, Aronson, Fried, & Good (2002) found that African American students assigned to a condition in which they were taught an incremental theory of intelligence reported increased academic motivation and engagement relative to control participants which, in turn, lead to higher grades. In addition, research has shown a positive relationship between perceptions of the degree to which an incremental theory is held by others in one's math classroom and feelings of belonging and being accepted within that classroom (Good, Rattan, & Dweck, 2012).

Although, to our knowledge, there exists no work that directly ties people's personal theories of intelligence to their feelings of belongingness, there are two studies suggesting that people's perceptions of how other people think about intelligence can influence their own feelings of belongingness. For example, Murphy and Dweck (2010) asked students to imagine applying to one of two academic groups-- one seemingly characterized by an entity theory of intelligence or one seemingly characterized by an incremental theory. Students asked to imagine applying to the entity group reported lower anticipated belonging than those asked to imagine applying to the incremental group. Closer to the present focus, Good, Rattan, and Dweck (2012) asked students to report their perceived beliefs of the people in their math class, that is, students were reporting on the degree to which their classmates and teacher, as a group, seemed to view math intelligence as more of a malleable or a fixed quality, not their personal beliefs regarding the changeability of math intelligence. This study found that students who perceived their classrooms to be more characterized by an incremental view also reported higher feelings of acceptance and belonging in those classrooms. Furthermore, significant mediation was found, showing that the more a classroom environment was perceived as incremental, the greater a student's feelings of belongingness in math, which, in turn, predicted higher math grades.

On the basis of this preliminary evidence, we propose that, beyond just the theory of intelligence held by those around you, holding an incremental theory of math intelligence yourself might benefit both feelings of belongingness and learning. More specifically, we predict that an incremental theory of intelligence would lead to increased feelings of belongingness in math, which, in turn, would lead to more successful sustained learning.

Methods

Participants

Seven hundred and thirty-six high school math students were recruited from a medium-sized public high school in the Northwestern U.S. A total of 48 participants were excluded from the analysis because they were absent during all three data collection sessions. Twenty-seven additional participants were excluded as a result of a programming error causing our tasks to be displayed to the students out of order. Two more students were excluded because they did not follow instructions correctly and, thus, viewed the experimental tasks out of order as well. Also, two students were enrolled in two different math classes that we were testing so, to maintain the independence of observations, we decided to keep only their line of data from the first time point in which they completed our experimental task.

Our final sample consisted of 657 participants (331 female, 80% White/Caucasian, 2% Black/African American, 3% American Indian/Alaska Native, 3% Asian, 2% Hawaiian/Pacific Islander, and 10% other). Participants were 35% freshmen, 31% sophomores, 24% juniors, and 10% seniors (Mean age = 16.46, range = 15-19) drawn from high school algebra (34%), geometry (32%), or trigonometry (34%) classes.

Procedure

The tasks in the current investigation were administered as part of a larger study that took place across three experimental sessions. All sessions were carried out during the students' scheduled math class period. Sessions one and two took place on consecutive days, and the third session was approximately one week later.

During the first two sessions on laptop devices within the classroom, students completed a set of questionnaires, two math tutorials, and a set of practice problems that they could use to study the material. In the third session, students completed the dependent variable - a test designed to measure their sustained learning of the material from the computer-based math tutorials.

Prior Math Achievement. We worked with the teachers to obtain students' official math course grades as a measure of their math achievement prior to our data collection efforts. These grades consisted of the students' overall performance, in percentage points, on tests, quizzes, and homework in their math course immediately preceding our study.

Theories of intelligence. Students completed an 8-item Theories of Math Intelligence Scale (Rattan, Good, & Dweck, 2012, $\alpha = .89$) to assess how malleable they believed math intelligence to be. This scale asked participants to rate their agreement with statements such as "You have a certain amount of math intelligence, and you can't really do much to change it" on a scale from (1) "strongly disagree" to (6) "strongly agree." In order to control for any effect that answering questions about intelligence beliefs may have on the other tasks in the study, we decided to not only randomize this scale across both session one and session two, but also within the session itself. Therefore, students could receive this scale at one of four time points (i.e., the beginning of the survey during either session one or two or at the end of the survey during session one or two).

Math tutorials. As mentioned above, students completed a set of two computer-based tutorials during their high school math class, during two consecutive class periods. We designed the tutorials using lesson material from Khan Academy and Edmentum software. Lesson topics were chosen in consultation with the math teachers to fit within their common core schedules for each class, and participants were told that the material covered in the lessons was important for them to know for their math class. After completing the tutorial in the second experimental session, participants were told that they would get an opportunity to further reinforce the material in the lessons by completing a set of 14 practice problems.

Sense of Belonging. During the first experimental session, students completed the 30-item Math Sense of Belonging Scale (Good, Rattan, & Dweck, 2012, $\alpha = .95$) to assess their feelings of belongingness to the math domain on an 8-point scale from "strongly disagree" to "strongly agree." This measure consists of 5 subscales: Membership ("I feel like I am a part of the math community"); Acceptance ("I feel accepted"); Affect ("I feel anxious"); Trust ("I have trust that I do not have to constantly prove myself"); and Desire to Fade ("I wish I could fade into the background and not be noticed").

Test of sustained learning. We returned to the classroom to conduct a third experimental session five to seven days after the second session. Students were given a paper and pencil-based exam that consisted of 10 multiple choice math questions designed to test their level of sustained learning of the tutorial material from the two previous experimental sessions. The dependent variable was students' performance on this test of their sustained learning.

Results

Covariate Criteria

Two methods were used to determine which variables would be selected as covariates in our final model. The first method involved selecting one covariate, a priori, that was expected to correlate highly with the participants' theories of intelligence and their success in sustained learning, but that was not of theoretical interest for the present investigation. Specifically, the research team decided, a priori, to include participants' prior math achievement as a covariate because past research suggests that students' acquisition of knowledge is driven their level of prior skill (Beier & Ackerman, 2005). It is also plausible that the effect of students' theories of intelligence may be stronger for students with low prior math achievement. For example, students who are already struggling with math may benefit more from holding this incremental theory of intelligence because they believe they can improve, however, for students who are already quite successful in math, the theory of intelligence that they hold is less important because there is no threat to their intelligence.

Second, we identified covariates empirically using an inclusion criteria determined by a collaborator who was blind to the data. Specifically, we included as a covariate any demographic or tutorial variable that correlated at least .20 (for categorical variables the equivalent Cohen's *d* of .40 was used) with either (a) the dependent variable (sustained learning test score) or (b) with both independent variables (theories of math intelligence and sense of belonging). These criteria were chosen because they are substantial enough to detect small to moderate effects while giving little weight to small effects that are more likely to be spurious.

We began by examining correlations between our main variables of interest (theories of math intelligence, sense of belonging, and sustained learning test score) and a set of potential continuous covariates (i.e., age and self-reported SES). The analyses revealed that none of these variables met our covariate criteria (See Table 1). For the potential categorical covariates, we conducted a set of one-way ANOVAs and t-test analyses to assess their relation to the primary study variables (See Tables 2a, 2b, 3a, and 3b). Three variables met our inclusion criteria: the specific set of tutorials that the students completed (Trigonometry, Algebra, or Geometry), race, and whether they qualified for free or reduced lunch. These variables were included as covariates in our final model.

Analytic Strategy

All analyses were conducted using Mplus statistical software (version 7.4, Muthén & Muthén, 1998–2015) with the maximum likelihood method to estimate the parameters and a bias-corrected bootstrapping procedure based on 10,000 samples to get the 95% confidence intervals for the direct and indirect effects as recommended by Preacher and Hayes (2008). Global model fit was evaluated using multiple fit indices including the chi-square test, comparative fit index (CFI; study criteria 0.95 or higher), the standardized root mean squared residual (SRMR; study criteria 0.08 or less) and the root mean square error of approximation (RMSEA; study criteria or 0.08 or less) as recommended by Hu and Bentler (1998) and Browne and Cudeck (1993).

Measurement Model

Based on the commonly endorsed two-step procedure for SEM (Anderson & Gerbing, 1988), we began by evaluating the measurement portion of the model. The goal was to have fewer than six indicators in order for the latent variables to be more stable and parsimonious (Little, Cunningham, Shahar, & Widaman, 2002), however, the factor structure of the Math Sense of Belonging Scale consists of five subscales, so we decided to let the five subscales define the *Sense of Belonging* latent variable. The *Theories of Intelligence* factor was indicated by three parcels which were created using a list pattern starting with the first item in the first parcel, the second item in the second parcel, and so on. The latent *Theories of Intelligence* variable consisted of three items in the first two parcels and two items in the third. As mentioned above, the latent *Sense of Belonging* variable was indicated by the five subscales of the Math Sense of Belonging Scale, and *Sustained Learning* was indicated by average score on the test of sustained learning. The internal consistency (Cronbach's alpha) of the measure in the current sample was used to control for the measurement error in this single manifest variable (i.e., (1 - α) times the variance of the measure, Brown, 2006) in order for *Sustained Learning* to be latent. The measurement model fit the data well: $\chi 2$ (25) = 78.34, $p < 0.001$, CFI = 0.98, RMSEA = 0.06 95%CI [0.04 to 0.07], SRMR = 0.03. The standardized factor loadings ranged from 0.60 to 0.92 demonstrating that all indicators loaded significantly and substantially onto the latent constructs.

Structural Model

Next we tested our hypothesized model (See Figure 1), which proposes that an incremental view of math intelligence will predict increased feelings of belonging to the math domain, which in turn will predict greater learning in math, as indicated by sustained learning of the lesson material. Our predicted model fit the data well: $\chi 2$ (25) = 80.94, $p < 0.001$, CFI = 0.98, RMSEA = 0.06 95%CI [0.05 to 0.07], SRMR = 0.03, and revealed that a stronger incremental theory does, in fact, predict a greater sense of belonging to math, which, in turn, predicts increased sustained learning. This indirect path was significant, $\beta = 0.15$ 95%CI [0.09 to 0.22], suggesting that the reason incremental math theory leads to greater learning in math is because students with a greater incremental theory have a stronger sense of belonging in math.

As mentioned above, we decided to control for several variables including participants' prior achievement in math as measured by their grade in math prior to the start of data collection, which lesson they received (one dummy-coded variable coded as Trigonometry = 1 and Algebra/Geometry = 0), their race (one dummy-coded variable coded as White = 1 and Non-White = 0), and whether they qualified for free lunch (one dummy-coded variable coded as "I don't know" = 1 and Yes/No = 0). Only significant covariate paths were retained in the model along with our hypothesized paths between the primary variables. This final model remained largely unchanged: $\chi 2$ (55) = 108.89, $p < 0.001$, CFI = 0.97, RMSEA = 0.05 95%CI [0.04 to 0.06], SRMR = 0.04. More importantly, it demonstrated that the indirect effect of students' theories of intelligence on their sustained learning through their sense of belongingness to math emerges above and beyond their prior achievement in math, which lesson they received, their race, and whether they qualified for free lunch, $\beta = 0.05$ 95%CI [0.01 to 0.11] (See Figure 2).

We ran an alternative model to examine whether, instead of the proposed causal model, a higher sense of belongingness promoted learning through more incremental theories of intelligence. One could argue that a math environment that inspires greater feelings of belongingness could potentially lead that student to adopt a more incremental theory of intelligence because a student who feels that they belong they may take a more positive attitude toward math in many ways. This positive attitude could lead them to believe that they can improve in the subject which, in turn, might lead to increased learning relative to those who are unsure of their belongingness. We found that while the alternative model provided a good fit for the data, $\chi 2$ (53) = 100.81, $p < 0.001$, CFI = 0.97, RMSEA = 0.05 95% CI [0.03 to 0.06], SRMR = 0.03, the indirect effect of students' feelings of belongingness to math on their sustained learning through their theory of intelligence was not significant, $\beta = -0.02$ 95%CI [-0.02 to 0.08]. This provides stronger evidence that the relationship of theories of intelligence on sustained learning through belongingness occurs in the direction that we hypothesized.

Discussion

The primary purpose of this research was to examine students' feelings of belongingness as a mechanism that underlies the relationship between their theories of intelligence and learning. We also investigated whether a direct link exists between students' personal theories of intelligence and their feelings of belongingness. As hypothesized, and consistent with previous research on students' perceptions of their peers' theories of intelligence (Good, et al., 2012; Murphy & Dweck, 2010), students' sense of belonging to math mediated the effect of their own theories of math intelligence on their sustained learning in math. More specifically, a stronger incremental theory of math intelligence was more beneficial for students in terms of their learning by increasing their feelings of belongingness to the math domain.

Limitations and Future Directions

It should be noted that there are limitations to this study. First, the data presented is correlational; therefore, alternative explanations for the relationships between these variables may exist. It could be possible that when a student feels as if they are accepted within a group, this may lead them to develop more of an incremental theory of intelligence because they may adopt the mindset of the group within themselves, which could then lead to improvements in students' learning. Previous research by Ryan, Deci, & Grolnick (1995) suggests that being a member of a group can lead to the internalization of aspects of the group such as the shared mindset or goals of the group. This has many benefits in terms of improving students' motivation, for example, a student who joins a study group may experience a boost in motivation because of the extrinsic rewards of being a part of that group. However, as they become further entrenched within the group, the shared goals may start to bleed into their self-concept leading them to internalize and integrate the ideals of the group within themselves. We tested and found no support for this alternative model in the current, cross-sectional investigation. That said, future research utilizing experimental and longitudinal designs should be conducted in order to provide more direct evidence for the causal relationship between these important variables.

In this study, we also examined the relationship between these variables specifically in the domain of math. Past research suggests that math is a field in which there is a strong endorsement of an entity theory of intelligence (Leslie, et al. 2015). This widespread belief that math is a fixed trait also suggests that when referring to math intelligence it is believed that there are two dichotomous groups which people can fall into (i.e., people who understand math and people who don't). This has interesting implications for both theories of intelligence and belongingness because if math intelligence is inherently believed to be fixed, we may see that this is in fact detrimental to students' success in this domain and could perhaps be leading to avoidance of math. Also, seeing math intelligence as two dichotomous groups automatically means that in every classroom there are going to be people who belong to that group and people who don't feel that they belong, which we know has consequences for students' motivation and achievement. However, it is possible that this phenomenon could be extended to other domains, or even occur with intelligence and belongingness in general, therefore, future research should explore whether the relationship is limited to the math domain or if it is more domain general.

Implications

Our findings provide further evidence that encouraging students to adopt an incremental theory of intelligence may have a greater impact on their learning above and beyond simply improving their academic achievement. Past research on stereotype threat has focused on the potential the benefits of promoting an incremental theory of intelligence on improving academic achievement for underrepresented minorities (Aronson, Fried, & Good, 2002; Good, Rattan, &

Dweck, 2012). Our findings build on this previous research to suggest that students' beliefs about intelligence can have an important impact on their sense of belonging and, in turn, their success in math for both minority and majority students.

Math is a difficult subject for many students, so any way that educators can help to make students feel more comfortable within a math classroom environment will be beneficial in terms of improving their attitudes toward math, motivation to learn math, and overall learning within math. Interventions designed to foster an incremental theory of intelligence may not only help to improve students' learning, but also inspire greater feelings of acceptance and belonging in a math setting leading to increased sustained learning for all students.

References

Anderson, J.C., & Gerbing, D.W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411-423.

Aronson, J., Fried, C. B., & Good, C. (2002). Reducing the effects of stereotype threat on African American college students by shaping theories of intelligence. *Journal of Experimental Social Psychology, 38*, 113–125.

Baumeister, R., & Leary, M. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117,* 497–529.

Biere, M.E., & Ackerman, P.L. (2005). Age, ability, and the role of prior knowledge on the acquisition of new domain knowledge: Promising results in a real-world learning environment. *Psychology and Aging, 20*(2), 341-355.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child development*, *78*(1), 246-263.

Brown, T.A. (2006). *Confirmatory Factor Analysis for Applied Research.* New York, NY: Guilford Press.

Browne, M.W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K.A. Bollen & J.S. Long (Eds.), *Testing structural equations models* (pp. 136–162). Newbury Park, CA: Sage.

Dutton, W.H. (1956). Attitudes of junior high school pupils toward arithmetic. *School Review*, *64*, 18-22.

Ehrlinger, J., Hartwig, M.K., Harrold, M.L., Vossen, J.J., Mitchum, A.L., Biermann, A.L., & Trzesniewski, K.H. (2016). *Incremental theories of intelligence predict persistence and, in turn, sustained learning*. Manuscript Submitted for Publication.

Good, C., Aronson, J., & Inzlicht, M. (2003). Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat. *Journal of Applied Developmental Psychology, 24,* 645–662.

Good, C., Rattan, A., & Dweck, C. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102*(4), 700-717.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46.

Hu, L., & Bentler, P.M. (1998). Fit indices in covariance structure modelling: Sensitivity to underparameterized model misspecification. *Psychological Methods, 3,* 424–453.

Leslie, S.J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science 347*(6219), 262-265.

Little, T. D., Cunningham, W. A., Shahar, G., & Widaman, K. F. (2002). To parcel or not to parcel: Exploring the question, weighing the merits. *Structural Equation Modeling, 9*, 151-173.

Master, A. & Walton, G.M. (2013). Minimal groups increase young children's motivation and learning on group-relevant tasks. *Child Development, 84*(2), 737-751.

Murphy, M., & Dweck, C. (2010). A culture of genius: How an organization's lay theory shapes people's cognition, affect, and behavior. *Personality and Social Psychology Bulletin, 36*(3), 283-296.

Murphy, M.C. & Zirkel, S. (in press). Race and belonging in school: How anticipated and experienced belonging affect choice, persistence, and performance. *Teachers College Record.*

Muthén, L.K. & Muthén, B.O. (1998–2015). *Mplus statistical software*. Los Angeles, CA: Muthén & Muthén.

National Mathematics Advisory Panel (NMAP). (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC, U.S. Department of Education.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40*, 879-891.

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.

Ryan, R. M., Deci, E. L., & Grolnick, W. S. (1995). Autonomy, relatedness, and the self: Their relation to development and psychopathology. In D. Cicchetti & D, J. Cohen (Eds.), *Developmental psychopathology: Theory and methods* (pp. 618-655). New York: Wiley.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52***,** 613–629.

Walton, G.M., Cohen, G.L., Cwir, D., & Spencer, S.J. (2012). Mere belonging: The power of social connections. *Journal of Personality and Social Psychology, 102*(3), 513-532.

Table 1: Correlations of Potential Continuous Covariates with Primary Study Variable Composites.

Variable	1	2	3	4	5	6
Primary study variables						
1. Theory of math intelligence	—					
2. Belongingness	**.35***	—				
3. Sustained learning test score	.11*	**.31***	—			
Covariates						
4. Prior math achievement	**.23***	**.35***	.13*	—		
5. Age	-.09	-.07	.09	-.17*	—	
6. SES	.12*	**.24***	.07	.13*	-.04	—
M	4.29	5.38	5.06	83.32	16.45	4.79
SD	.88	1.30	2.45	14.06	1.18	1.16

Note: Covariates with correlations above .20 with either the DV (Sustained Learning) or the IV and Mediator (Theory of Math Intelligence and Belongingness were included as covariates. * $p < .05$

Table 2a: Tests of Potential Categorical Covariates with Primary Study Variable Composites.

Demographic Variable	Dependent Variable	Level	n	Mean (SD)	Test Statistic	*d*
Gender	Incremental Theory of Math	Female	275	4.25 (.87)	*t*(548) = -.88, *p* = .38	-.08
		Male	275	4.32 (.89)		
	Belongingness	Female	292	5.15 (1.27)	*t*(572) = -3.98, *p* < .01**	.33
		Male	282	5.57 (1.27)		
	Test of Sustained Learning Score	Female	283	5.00 (2.48)	*t*(560) = -.66, *p* = .51	-.06
		Male	279	5.13 (2.42)		
Race	Incremental Theory of Math	White	302	4.22 (.86)	*t*(372) = .06, *p* = .96	.01
		Non-White	72	4.22 (.92)		
	Belongingness	White	286	5.11 (1.35)	*t*(355) = 1.45, *p* = .15	.20
		Non-White	71	5.36 (1.14)		
	Test of Sustained Learning Score	White	294	4.87 (2.47)	*t*(359) = -2.87, *p* < .01**	**-.42**
		Non-White	67	3.96 (1.80)		
Ethnicity	Incremental Theory of Math	Hispanic	28	4.06 (.73)	*t*(366) = -.97, *p* = .33	.20
		Non-Hispanic	329	4.22 (.89)		
	Belongingness	Hispanic	28	5.01 (1.21)	*t*(347) = -.53, *p* = .56	.11
		Non-Hispanic	340	5.15 (1.34)		
	Test of Sustained Learning Score	Hispanic	27	3.96 (2.27)	*t*(355) = -1.76, *p* =.08	.35
		Non-Hispanic	322	4.78 (2.37)		
Language Spoken At Home	Incremental Theory of Math	English	351	4.22 (.87)	*t*(368) = -1.12, *p* = .27	-.26
		Not English	19	4.45 (.86)		
	Belongingness	English	336	5.15 (1.31)	*t*(353) = -.85, *p* = .40	.21
		Not English	19	5.40 (1.05)		
	Test of Sustained Learning Score	English	340	4.66 (2.38)	*t*(356) = .00, *p* = .99	.00
		Not English	18	4.67 (1.78)		
Free or Reduced Lunch	Incremental Theory of Math	Yes	64	4.33 (.88)[a]	*F*(2,367) = .75, *p* = .48	—
		No	235	4.23 (.85)[a]		
		Unsure	71	4.15 (.91)[a]		

	Belongingness	Yes	60	5.18 (1.29) [a]	$F(2,352) = .03$, $p = .97$	—
		No	227	5.15 (1.29) [a]		
		Unsure	68	5.13 (1.36)[a]		
	Test of Sustained Learning Score	Yes	56	4.23 (2.31)[ab]	$F(2,355) = 7.14$, $p < .01$**	—
		No	232	5.00 (2.40)[a]		
		Unsure	70	3.91 (2.03)[b]		

Note: Due to lack of variation in responses to Race, responses were converted into two variables (White and Non-White). Covariates with Cohen's *d* effect sizes above .40 with either the DV (Sustained Learning) or the IV and Mediator (Theory of Math Intelligence and Belongingness were included as covariates. Means with differing superscripts were shown, in post hoc analyses, to be significantly different.

* $p < .05$

** $p < .01$

Table 2b: Pairwise Comparisons of Qualification of Free/Reduced Lunch and Primary Study Variable Composites.

Dependent Variable	Comparison	Significance Value	Cohen's *d*
Theory of Math Intelligence	Yes vs. No	$p = .70$	.12
	Yes vs. Unsure	$p = .42$	.20
	No vs. Unsure	$p = .75$	.09
Belongingness	Yes vs. No	$p = .98$	.02
	Yes vs. Unsure	$p = .96$	.02
	No vs. Unsure	$p = .99$	.04
Score on Test of Sustained Learning	Yes vs. No	$p = .07$	-.33
	Yes vs. Unsure	$p = .72$	.15
	No vs. Unsure	$p < .01$**	**.49**

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

Table 3a: Test of Lesson Set with Primary Study Variable Composites as a Covariate.

Dependent Variable	Lesson Set	n	Mean (SD)	Test Statistic
Theory of Math Intelligence	Algebra	197	4.22 (.89)[a]	F(2,547) = .95, $p = .39$
	Geometry	162	4.34 (.87)[a]	
	Trigonometry	191	4.30 (.89)[a]	
Belongingness	Algebra	200	5.03 (1.23)[a]	$F(2,571) = 15.57$, $p < .01$
	Geometry	173	5.32 (1.27)[a]	
	Trigonometry	201	5.72 (1.27)[b]	
Score on Test of Sustained Learning	Algebra	198	4.23 (2.04)[a]	$F(2,559) = 126.0$, $p < .01$
	Geometry	166	3.86 (1.75)[a]	
	Trigonometry	198	6.90 (2.25)[b]	

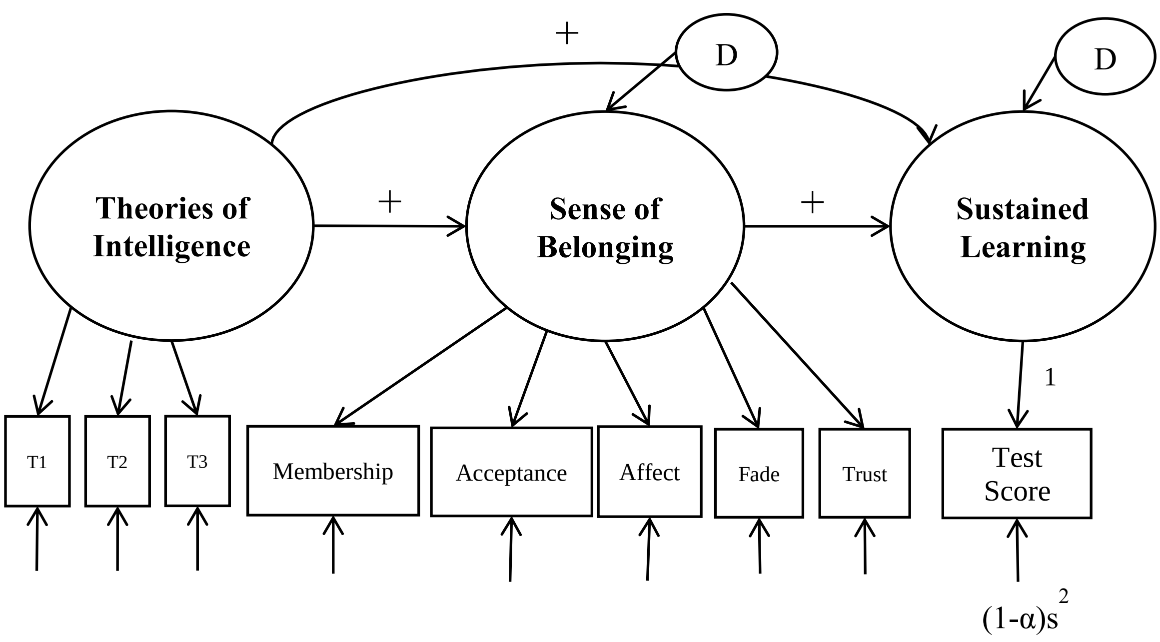
Note: Covariates with Cohen's *d* effect sizes above .40 with either the DV (Sustained Learning) or the IV and Mediator (Theory of Math Intelligence and Belongingness were included as covariates. Means with differing superscripts were shown, in post hoc analyses, to be significantly different.
* $p < .05$
** $p < .01$

Table 3b: Pairwise Comparisons of Lesson Set and Primary Study Variable Composites.

Dependent Variable	Comparison	Significance Value	Cohen's *d*
Theory of Math Intelligence	Algebra vs Geometry	$p = .38$	-.14
	Algebra vs Trigonometry	$p = .60$	-.09
	Geometry vs Trigonometry	$p = .92$	.05
Belongingness	Algebra vs Geometry	$p = .07$	.23
	Algebra vs Trigonometry	$p < .01$**	**.55**
	Geometry vs Trigonometry	$p = .01$*	.31
Score on Test of Sustained Learning	Algebra vs Geometry	$p = .20$	.19
	Algebra vs Trigonometry	$p < .01$**	**-1.24**
	Geometry vs Trigonometry	$p < .01$**	**-1.51**

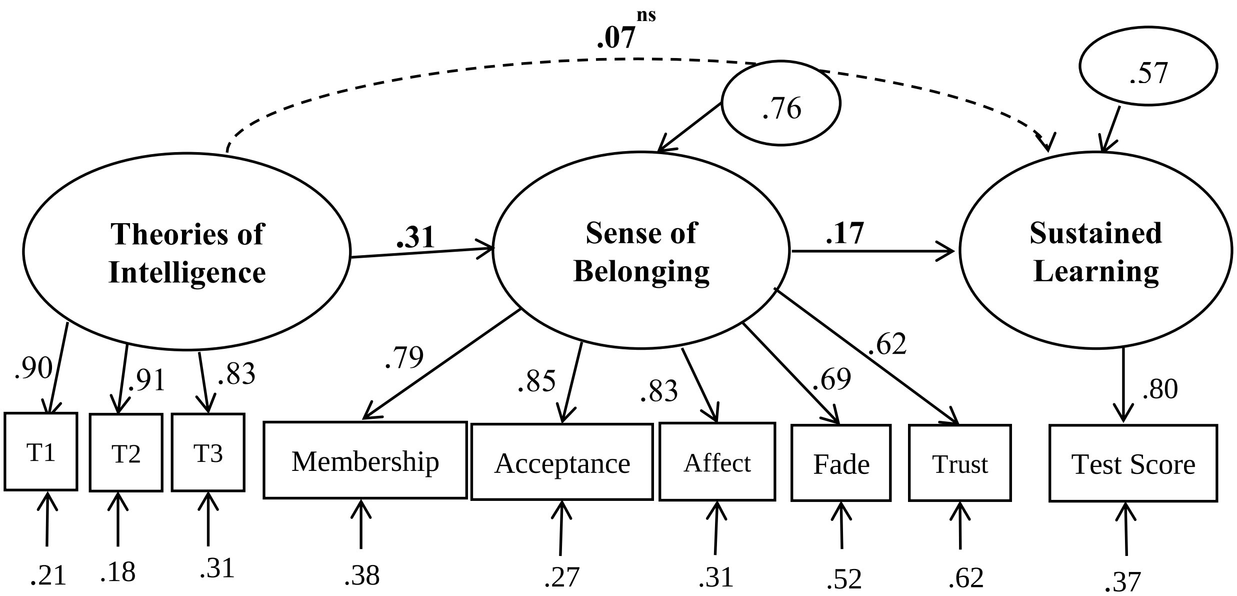
* $p < .05$
** $p < .01$

Figure 1: Hypothesized Structural Model.



Note: Predicted structural model (not including covariates). Positive scores on Theories of Intelligence = stronger incremental theories, positive scores on Sense of Belonging = greater feelings of belongingness, and positive scores on Sustained Learning = greater sustained learning.

Figure 2: Standardized Parameter Estimates for the Final Model.



Note: Positive scores on Theories of Intelligence = stronger incremental theories. T1-T3 = three parcels of Theories of Intelligence. All paths are significant at $p < .01$ unless otherwise specified. This model includes all the specified covariates being controlled for. Standardized indirect effect ($\beta = 0.05$ 95%CI [0.01 to 0.11]).