Exploring teacher effects in outcomes of a growth mindset intervention in seventh grade science

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Abstract

This quasi-experimental study examined teacher-related differences in the effects of a widely used intervention designed to impact seventh graders' mindset. Student surveys from seven science classrooms across two teachers were analyzed to assess teacher-related differences in the degree to which the intervention affected student outcomes. Classroom observational data and teacher reports were examined to understand how multiple features of the teachers' classrooms might have differentially shaped student outcomes. Survey results revealed significant teacher effects in that students' beliefs about the malleability of intelligence, their learning goals, and their grades improved and/or were sustained more in one teachers' classes than in the other. Data gathered from observations and teacher reports were generally consistent with the teacher effects found in student surveys. Specifically, the teacher whose students reported greater improvement in outcomes placed more emphasis on mastery, learning, growth, and conceptual development, and modeled and encouraged more strategy use in her daily interactions with students, relative to the other teacher. The results suggest that teachers play a critically important role in supporting classroom interventions, and that program developers may want to design and study ways to impact teachers' practices in order to maximize program impact.

Exploring Teacher Effects for Mindset Intervention Outcomes

in Seventh Grade Science Classes

The purpose of this study was to examine teacher-related variation in the effects of a classroom intervention designed to impact seventh graders' beliefs about the nature of ability in science as fixed or malleable. Our goal was to promote the belief that ability is malleable in an attempt to ultimately enhance young adolescents' motivation for science. Using quantitative data we tested for teacher-related differences in the degree to which the intervention was effective as measured by several student outcomes. We then examined classroom observational data and teacher reports to understand how multiple features of teachers' classrooms may have shaped any differences in outcomes by teacher.

Beliefs about the Malleability of Intelligence

Dweck and others have found that significant numbers of school-age children believe that ability is fixed, particularly in STEM areas, and that these beliefs predict achievement (Dweck, 2006; Hill, Corbett, & St. Rose, 2010). Incremental theories of intelligence (growth mindsets) have been found to predict greater achievement and effort in school than entity theories (fixed mindsets) from early childhood through college (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2008). Much of the prior research has been conducted in the context of mathematics; we extended those findings to the context of science during middle school.

Importantly, in multiple lab studies, researchers have shown that mindset can be changed (see Dweck, 1999). Those lab studies led to attempts to promote growth mindsets among students in schools. A mindset intervention with seventh graders, which was similar to the one used in this study, was successful at influencing students' beliefs about the malleability of intelligence, increasing their mastery learning goal orientation, and improving their mathematics

grades. Mastery goal orientation refers to the degree to which students take on academic tasks with the goal of learning something new, developing skills and improving understanding. Mastery goal orientation is often contrasted with performance goal orientation, which refers to a focus on demonstrating one's ability or competence, and a concern with how one's ability will be judged compared to others (Ames, 1992; Dweck & Leggett, 1988; Elliott & Dweck, 1988; Nichols 1984). Students with a growth mindset tend to adopt a mastery orientation when approaching academic tasks (Dweck, 1999).

Consistent with prior findings, participants in our mindset intervention conducted in two middle schools developed more of a growth mindset (pre to post) than did students in the control group (Author, 2013). For example, participants developed significantly stronger beliefs about the malleability of intelligence in science over the course of the intervention, while students in the control group did not. There was also a significant change in mastery goal orientation as a result of the intervention; students who participated in the intervention reported an increase in mastery goal orientation over the course of the intervention whereas nonparticipants in the control group reported a decrease in mastery goal orientation. The two teachers in whose classrooms (n=7) the intervention was conducted are the focus of this study.

Outcomes of Interventions by Teacher

The present study investigated whether the students who participated in the intervention differed in outcomes by teacher. Studies have not yet fully considered the role that the teacher plays in implementing mindset interventions in classrooms, particularly in domains such as science. There are several reasons to expect that student outcomes will vary by teacher. First, teacher characteristics such as educational background, experience, and beliefs might add to or detract from the impact of the intervention. Second, the instructional and classroom management

practices that teachers use in their classrooms have been shown to contribute to student achievement and motivation in ways that might amplify or lessen the effects gained from participation (Muijs, 2008; Patrick, Mantzicopoulos, & Sears, 2012). Variation in the extent to which the teachers reinforce, elaborate on, and send messages about mindset and other concepts related to the intervention during daily instruction also is expected to boost or curtail outcomes of the intervention (Cimpian, Arce, Markman, & Dweck, 2007; Kamins & Dweck, 1999; Mueller & Dweck, 1998).

Teacher characteristics. Without a doubt, the classroom teacher is a critical component of students' learning context in a given classroom. There has been a tremendous amount of research conducted on whether teacher characteristics like years of experience, amount and quality of education, and certification impact students (Harris & Sass, 2011; Nye, Konstantopoulos, & Hedges, 2004). We asked teachers to provide such background information about themselves because those qualities continue to be considered important teacher characteristics despite the fact that studies of the impact of such characteristics on student motivation and achievement have yielded weak, mixed, and sometimes contradictory results (Kennedy, 2010).

Teacher beliefs, another type of teacher characteristic, have also been studied extensively (see Bryan, 2012 for a review of science teachers' beliefs). In this study, we measured the teachers' ability beliefs. Teachers' mindset beliefs are likely to influence their students' mindset beliefs through the teaching practices they employ as well as through their interactions with students. Teachers' fostering of learning strategies for example is an important teaching practice especially in middle school because middle school students' learning strategies has been found to mediate the relationship between their motivational orientations and academic achievement

(McClintic-Gilbert, Henderlong Corpus, Wormington, & Haimovitz, 2013). Good, Rattan, and Dweck (2007, cited in Dweck, 2008) conducted a laboratory experiment and found that teachers who had been influenced to believe in a growth mindset in mathematics encouraged students who had failed to work harder and furthermore recommended specific learning strategies that would help them improve. On the other hand, teachers who had been influenced to believe in a fixed mindset tended to comfort students who had failed by telling them that some students are good in mathematics and others are not, thus reinforcing a fixed mindset. Possible teacher differences within the group of teachers who had been influenced to believe in a growth mindset were not analyzed in that study.

We also queried teachers' beliefs about how to best motivate students to learn, because such beliefs likely impact their instructional practice. Specifically, we asked for teachers' beliefs about the effectiveness of various approaches that are most aligned with mastery and performance goal orientations. A recent study (Shim, Cho, & Cassady, 2013) found that teachers' mastery and performance approach goal orientations for teaching predicted which type of goal orientation they established in their classrooms. Thus, we gathered indicators of teachers' beliefs before we turned to investigating their actual teaching practices.

Instructional practices and interactions. Teachers exert influence on student motivation and achievement through the instructional practices they use, the feedback they give students, and other day-to-day interactions with students (Stipek, 1996). It has been found that middle school students whose teachers co-construct learning experiences with them in a supportive classroom environment demonstrate improvements in their cooperation with peers and teachers, engagement with academic tasks, and sense of progress (Strahan, Faircloth, Cope, & Hundley, 2007). It stands to reason that the classroom climate and the learning context that teachers and

their students co-create will impact the effectiveness of any intervention that is introduced with the intent of improving student outcomes.

Teachers who facilitate a positive emotional climate, organize and manage the classroom effectively, and express enthusiasm have been shown to provide a context in which student learning and motivation flourishes and in which students are primed to cooperate and participate in lessons (Hattie, 2009; Patrick, Mantzicopoulos, & Sears, 2012). In this study, researchers observed in classrooms on multiple occasions during times that the regular science curriculum was being taught and learned; observers recorded global ratings of the classroom climate, organizational management, and teacher enthusiasm during the class period.

In the current study, classroom observers also recorded the types of instructional activities that teachers used, the amount of time students were engaged in various activities, and then rated each instructional activity on several dimensions. At the most basic level, student learning is impacted by how time is used in the classroom (Kyriakides & Creemers, 2008). In a recent study of high school science classrooms, we found that teachers used lecture and seatwork more than any other practice and that considerable time was spent in non-instructional activities like taking attendance, making announcements, or distributing and collecting papers (Authors, 2011). We further found that teacher-student interaction, students' reported learning, and students' motivational states varied by the type of instructional activity the class was engaged in (Authors, 2013).

Within each activity recorded in the classrooms, we rated students' time on-task as well as the conceptual development, direct instruction, and instructional feedback provided by the teacher. Each of those factors has been found to contribute to students' perceptions of their

ability, their learning goals, and their academic success (Hattie, 2009; Muijs, 2008; Patrick, Mantzicopoulos, & Sears, 2012).

Mindset messages. Our interest in mindset led us to focus specifically on mindset messages within classrooms. Dweck and her colleagues have found that the messages students receive from teachers from preschool through college impact their mindsets, their goal orientation, and, consequently, their academic achievement (Cimpian, Arce, Markman, & Dweck, 2007; Kamins & Dweck, 1999; Mueller & Dweck, 1998). For example, when teachers praised students for their intelligence or talent and made ability comparisons among students, performance goal orientations were fostered (Dweck, 2007, 1999; Patrick, Mantzicopoulos, & Sears, 2012). On the other hand, teachers who recognized students' effort and study skills helped students develop a growth mindset, mastery goals, and tenacity in the face of challenge (Dweck, 2008, 2010). During our observations of classroom instruction, we recorded instances and descriptions of events in which the teachers' verbalizations or behavior communicated mindset messages and then later coded whether those messages were associated with fixed or growth mindsets. Specifically, we noted: (a) references teachers made to learning or performance goals, (b) how teachers responded when students experienced challenge, (c) the way teachers talked about effort with their students, (d) the types of persuasive comments teachers made to encourage student effort and engagement with the class work, (e) teachers' use of and encouragement of specific strategies, and (f) references to student ability or task difficulty/ease.

Students' beliefs about the nature of ability have been related to a variety of motivational and achievement outcomes. In the context of a mindset intervention, this study investigated whether student beliefs about the malleability of intelligence, their goal orientation, and their grades in science improved more in one science teacher's classes than in another's.

Characteristics and practices of the teachers are then compared using multiple sources of data to understand features of classroom context that may enhance the efficacy of classroom interventions designed to impact students' beliefs about science ability.

Method

Context

The larger study from which these data were drawn was conducted in 14 middle school science classrooms in a diverse, public school district, and included 363 seventh graders and four teachers. The two teachers who participated in a mindset intervention are the focus of the present study. In the classrooms of the other two teachers, students who were not part of the mindset intervention completed writing tasks reflecting on their learning once per week for six weeks. The two teachers who are the focus of the study were responsible for seven seventh grade science classes (Celia = 3 classes and Donna = 4 classes).

The school district in which the study took place was located on the fringe of a large metropolitan area. Sixty percent of students in the school district were considered "low income." The student population in the district was over fifty percent Hispanic (specific sample characteristics are provided below).

Sample

The present study focuses on the students in seven classrooms (n=160) and their teachers (n=2) who participated in a mindset intervention. The student sample for the study was 42 % male, and 58 % female. Racial and ethnic distribution was as follows: 34.4% Hispanic, 13.8 % Black, 25% White, and 22.5 % multiracial (4% did not report race/ethnicity). Fifty percent of the student sample received free or reduced lunch.

Teachers. We refer to the teacher participants as Celia and Donna (both are pseudonyms). Donna was a white female who was 54 years old at the time of the study. She held a master's degree and had 20 years of teaching experience (eighteen years at her current school); she had taught 6th, 7th, & 8th grade science classes. Celia, who was also a white female, had been Donna's student teacher. At the time of the study Celia was 28 years old and had been at the school for six years, which comprised her total teaching experience. She held a bachelor's degree and had experience teaching 6th, 7th & 8th grade science classes. Donna and Celia taught in different schools in the same district.

Procedures

Intervention. The mindset intervention consisted of the *Brainology*™ program – a six-week, web-based tutorial that teaches students that the brain is like a muscle and can grow in intelligence. Students are provided with information about how the brain responds to learning and how they can improve their learning through effort, study strategies, and behavioral choices (sleep, diet, and stress management). The researchers met with student participants once per week and took primary responsibility for delivering the web content and for leading both anticipatory and follow-up activities to each lesson. Teachers were always present during these 'Brainology days'. The program also included teacher education activities; teachers met on several occasions with the researchers for individualized sessions to discuss the mindset concept, how mindset develops, and practical details about implementation including discussion of extension activities to be done in class. The central role of the teacher in fostering mindset and in emphasizing the concepts during instruction and through statements made to students was emphasized. Teachers received a teacher's manual containing numerous extension activities,

online access to the Brainology program and to students' work in the program, and two brief (3-5 page) supplementary readings on mindset.

Data collection. Students completed surveys that measured their beliefs about the malleability of intelligence, goal orientation, and interest in science before (pre), immediately after (post), and several months after (follow up) the intervention. Prior to the start of data collection in classrooms, participant teachers completed a survey in which they provided information about their demographic characteristics, professional training, and current teaching assignment. Also included in the survey was a series of questions used by Blackwell, Trzesniewski & Dweck (2007) to assess mindset. These items exactly mirrored those in the student survey.

Classrooms were observed on 11 different occasions before, during, and after the intervention which was significantly more than the sufficient number of observations suggested by some studies (e.g., Shih, 2013) therefore allowing us to effectively capture the qualities of these classrooms. On each of these 11 occasions, a team of two to three observers recorded instructional activities, and multiple dimensions of classroom context including event sampling of explicit and implied messages conveyed by teachers and students regarding goals, effort, evaluation, feedback, encouragement and study strategies. Reliability on the ratings among coders was very high, and notes from all coders present were used to compile a comprehensive set of field notes documenting mindset messages expressed by teachers and students in the classroom. These field notes were later coded (see description of coding below).

Teachers also participated in a formal semi-structured interview immediately following the intervention. Schools provided information from student records including demographic information and student grades.

Student Measures

Malleability of Intelligence. Four items were used to measure students' beliefs about the *malleability of intelligence* or mindset. The items asked students to report on a six-point scale (disagree a lot = 1, agree a lot =6) whether they believed it was possible to change one's intelligence in science (two items) or whether science intelligence is fixed (two items which were reverse scored to create this variable). A factor analysis provided evidence of the construct validity of this subscale. Cronbach's alpha for these items was: .60 in the initial survey, and .74 in both the post intervention and follow-up surveys. Items were drawn from published studies (Aronson, Fried & Good, 2002; Blackwell et al., 2007), which reported test-retest reliabilities ranging from .77 to .82.

Mastery goal orientation. A *mastery goals* scale was created from four items on the student survey (I do science work to learn new things, I want to work on hard science work, hard assignments mean I'll learn, and my goal in science is to learn as much as possible). Three of these items were measured on a six-point scale (1=disagree a lot, 6=agree a lot), and one item was measured on a five-point scale (1=strongly disagree, 5=strongly agree), therefore all scores were converted to z-scores to create a composite score. Cronbach's alpha was .79, .79, and .82 on the pre, post, and follow-up surveys respectively.

Grades. School officials provided students quarterly grades in science from school records. First quarter grades served as the initial grade, second quarter grades served as the post-intervention grade, and third quarter grades (which aligned with follow up surveys and observations) served as the follow-up.

Teacher and Classroom Measures.

Endorsement of motivational strategies. Teachers were asked to rate the efficacy of a number of different motivational strategies for males and for females on a scale of 1= not at all to 5 = very effective. Items on this rating list generally represented strategies that foster intrinsic or mastery goals on the one hand or curtail them in favor of extrinsic motivation on the other. For the purpose of this study, the teacher ratings of strategies that were effective for males and females were averaged.

Global ratings by class period. Immediately following the class period, observers rated three aspects of the overall classroom environment during the class period observed. *Emotional climate* of the class described overall interaction patterns between teachers and students in the class and was rated on a three-point scale as negative (indicating unpleasantness, anger, or hostility), neutral (generally flat, not emotionally charged), or positive (respectful, friendly, caring, helpful). *Productivity/Organization* indicated how well the class was organized and run in terms of routines, directions, and time management and was rated on a four point scale from 1= chaotic to 4 = highly efficient. *Teacher enthusiasm* described the interest and passion communicated by the teacher during the class period using a four point scale from 1 = projects boredom to 4 = passionate.

Classroom activities. The instructional method that the teacher was using and the type of work that students were doing were recorded by observers on an observational form. We adopted the criteria of Duke (2000) in classifying the instructional practices that the majority of students were doing in the classroom (p. 210). The time when the activity began and when the activity code changed was recorded. Activities were categorized and coded as: 1. *teacher presentation,* 2. *individual seatwork,* 3. *group seatwork,* 4. *tests/quizzes,* 5. *whole-class discussion,* 6. *student*

presentations/demonstrations, 7. *Video/movie*, 8. *lab work*, 9. *non instructional time*, 10. *off task-activity*, 11. *activities related to study* (completing brief surveys or writing tasks).

Global ratings by activity. For each instructional activity (excluding non-instructional and off task activities), observers made global ratings on four dimensions. *On Task* referred to the proportion of students who appear to be on task during the classroom activity (1=< ¼ of students on task, 2 = ¼-1/2 of students on task, 3= more than ½ to ¾ of students on task, 4= More than ¾ of students on task). This global rating was dependent upon attention and participation. *Conceptual development* indicated the degree to which teachers promoted higher order thinking, critical thinking, elaboration (why, how, compare), and problem solving, leading students to go beyond fact and recall to make inferences, hypothesize, analyze, interpret, reason on a four point scale from 1= almost none to 4 = extensive. *Direct Instruction* indicated the degree to which rote learning is emphasized and was rated on a scale from 1 = almost none to 4 = extensive. *Instructional Feedback* described the extent to which teachers support and extend student learning through responses, scaffolding, promotion of student skills, and participation in activities on a scale from 1 = almost none to 4 = extensive.

Mindset messages. Observational event sampled field notes were coded for the purpose of coding teacher-provided messages related to mindset. For each teacher, we coded field notes from a total of 11 days per teacher: one day of regular instruction per week in each classroom for two weeks prior to the intervention, the six weeks in which the Brainology program was being implemented, and three weeks post intervention later in the school year. The day of the week we observed varied from week to week. Field notes were coded using the NVivo10 software program. Mindset messages were identified as any explicit statement or behavior that referred to Brainology program content, task difficulty/ease, effort, study strategies, ability, or performance

criteria, regardless of whether the reference explicitly mentioned mindset. Each mindset message was coded along multiple dimensions which recorded the nature of the messages as promoting or undermining a growth orientation. Messages that were coded as promoting a growth mindset specifically mentioned growth of intelligence, referenced Brainology content, emphasized effort, or suggested/modeled study strategies. Messages that were coded as undermining a growth mindset included those that clearly mentioned a fixed view of intelligence, valued low effort, and focused on task ease, difficulty, and ability without reference to effort. Once coding in NVivo10 was completed, data were analyzed using SPSS.

Results

Outcomes by Teacher

Malleability of intelligence. A mixed between-within subject analysis of variance was conducted to assess whether the Brainology program impacted students' beliefs about the malleability of intelligence differently by teacher between the pre-intervention and follow-up period. There was a significant interaction between teacher and time, Wilks' Lamda = .91, F (2, 134) = 6.87, p =.001, partial eta squared = .09, indicating a moderate effect size for the difference in increase in belief about the malleability of intelligence by teacher. Figure 1 displays the results of this analysis. Table 1 presents the pre-test, post-test and follow-up scores. As seen in the table, students in both classes developed stronger beliefs about the malleability of intelligence after participating in the intervention with Donna's students growing more than Celia's. During the follow-up period, Celia's students regressed nearly to the point where they had been prior to the intervention whereas Donna's fell slightly but nevertheless, maintained considerable gains.

Mastery goal orientation. A mixed between-within subject analysis of variance was conducted to assess whether the Brainology program impacted students' mastery goal orientation differently by teacher from pre-intervention to follow-up. There was a marginally significant interaction between teacher and time, Wilks' Lambda = .96, F (2, 135) = 2.83, p =.06, partial eta squared = .04, indicating a small effect size for the difference in change in belief about mastery goals by teacher. As can be seen in Figure 2, students in Donna's classroom increased in mastery goal orientation from pre to post-intervention and maintained those gains through follow-up, whereas, students in Celia's classroom increased from pre to post-intervention, but decreased back to their pre-intervention levels at follow-up. Means and standard deviations can be seen in Table 1.

Grades. A mixed between-within subject analysis of variance was conducted to assess whether the grades of students in the mindset condition differed by teacher between the pre-intervention and follow-up period. There was a significant interaction between teacher and time Wilks' Lambda = .79, F (2, 135) = 17.9, p = .000, partial eta squared = .21, indicating a large effect size for the change in students' science grades by teacher from before intervention to follow-up. Figure 3 displays the results of this analysis. Table 1 presents the pre-intervention, post-intervention, and follow-up grades. Donna's students' grades improved during the intervention and were maintained across the course of the study whereas Celia's did not.

Teacher Beliefs

Celia expressed deep interest in the mindset intervention; it was new information for her and she saw it as exciting. Donna was also committed to the project because she was familiar with the importance of the content students would learn during the intervention. She was also

using her participation in the study as part of the professional development plan that her district required of all post-tenured teachers.

Donna's and Celia's score on the mindset measure identified each of them as having a growth mindset in terms of science intelligence. As can be seen in Table 2, both teachers moderately endorsed practices associated with mastery goals (e.g. "teaching them strategies for learning"). In contrast to Donna's weak endorsements of such strategies, Celia endorsed using strategies often associated with fostering a performance approach goal orientation (Patrick, Mantzicopoulos, & Sears, 2012). For example, she moderately endorsed comparing students to one another and strongly endorsed telling students that they were one of the best in the class as a means of motivating them. Neither teacher recommended strategies such as embarrassing students for poor performance as being motivational. Celia was more affirming of the motivational value of using consequences like rewards and contacting parents than Donna was. Both teachers endorsed the motivational value of praise.

Teacher Instructional Practices.

General classroom climate. Observers rated Donna as more enthusiastic than Celia. Donna and Celia's classrooms did not differ in terms of either the emotional or organizational climate of the classroom (see Table 3). The emotional climate in both teachers' classes fell between neutral and positive with both leaning toward the positive pole. Both also were rated more often as being well organized as opposed to inefficient in managing their classrooms.

Instructional activities. The teachers both covered the state and district curriculum for seventh grade science and the percent of time each teacher's classes spent in various instructional activities was very similar. Although both spent similar amounts of time making teacher presentations, during Donna's presentations, she more often questioned the students and

conducted demonstrations of phenomena they were studying. Ratings given by observers during the activities indicated that Donna was more likely than Celia to use direct instruction and to facilitate students' conceptual development (see Table 3). These tendencies might explain why Donnas' students were more likely to be on task than Celia's.

Individual seatwork was assigned a similar amount of time by Celia and Donna. Although Celia was more frequently seen circulating among the students looking at their work than Donna, there were no differences in ratings for instructional feedback provided to the students. Neither teacher spent much time doing labs. Our observations further indicated that the labs were not inquiry based.

Teacher involvement/role in mindset intervention. In discussing her role during the intervention, we asked Celia to use the first class period of each day in which the unit was implemented to familiarize herself with the lesson, what the students were asked to do, and what they were actually doing (recall that the intervention was done in 3 of Celia's classes). Further, she was asked to use the next two class periods to review the logs that displayed students' responses to the unit lesson, which were available to her through the teacher login. Celia did not use the class time in that way, however. She was frequently observed using the computer to catch up on record keeping. Each week of the intervention, however, Celia extended the Brainology unit in her science classes by using a supplementary lesson from the guide provided for teachers by Mindset Works, the developer of the Brainology program. She also responded to several individual students who had strong fixed mindsets. She chose one male student in particular as her own special project; he manifested an extreme fixed mindset and she was determined to change it.

Donna was invited to participate in the same way as Celia was. Donna played a more active role with students on the intervention days than did Celia by monitoring the class and encouraging student engagement. We have little evidence that Donna monitored the logs of students' work in the program, even though this information was available to her. We did not observe her accessing it and she did not talk about it with us. The content of the program was not new to Donna and, as will be seen in the next section, she applied the content, using the vocabulary during her teaching. In contrast to Celia, Donna appeared to take little interest in the teacher guide provided.

Mindset feedback when teaching science. Analysis of field notes suggests that the two teachers differed in terms of the way they communicated with their students about goals, effort, evaluation, feedback, encouragement, and study strategies. The reader will recall that field notes were taken on an ordinary instruction day – not on a day when the Brainology program was a focus. The purpose of these analyses was to examine the degree to which each teacher was supporting a growth mindset outside of the designated 'Brainology days.' As seen in Table 4, Donna made more frequent references that could be construed as generally supporting a growth mindset by emphasizing the idea that ability can grow, focusing on mastery rather than performance goals, and highlighting the value of effort and strategy use. Moreover, on average, Donna referenced Brainology once during every class period (e.g. 'remember, we are doing this to make more neural connections in your brain like we learned in Brainology last week'), while Celia made such statements infrequently.

Celia's comments, while well-intentioned, are unlikely to promote a growth mindset. During the class periods we coded, she rarely mentioned Brainology explicitly or referred to a strategy mentioned in the program. She was generally supportive of her students, and genuinely wanted

to help them succeed, but her supportive comments did not emphasize effort. Rather than arming her students with strategies to help them complete their work as Donna did, Celia tended to alert students to whether particular tasks were 'easy' or 'hard.' Another example of undermining was that when Celia's students were challenged academically, her reaction was to offer immediate assistance, rather than emphasize the importance of challenge and effort for learning. This might send the message to students that they are incapable of addressing these challenges on their own.

Discussion

Student Outcomes by Teacher

In this study, we considered the role of the teacher in a widely used intervention to impact student mindset. There were significant teacher effects in that students' beliefs about the malleability of intelligence, their learning goals, and their grades improved and/or were sustained more in one teacher's classes than in the other. The positive results of the intervention at follow-up compared to the control group (Authors, 2014) appear to be largely accounted for by Donna's students. Thus, we found evidence that the teacher is an important factor in the outcomes of a popular mindset intervention.

The findings are especially salient because the intervention with the students was implemented by researchers. The teachers received some brief education about mindset, resources for learning about and fostering mindset, and access to each student's Brainology log. Some teachers implement the intervention themselves and studies should be conducted to examine possible teacher effects in their students; it seems reasonable to assume that teacher influence would be an even greater factor in those cases than in this one.

Teacher Characteristics

There were considerable differences between the two teachers in terms of years and breadth of teaching experience and their educational backgrounds. The impact of those characteristics on student motivation and achievement has been difficult to substantiate in large-scale studies using general measures, but might be particularly important in specific contexts (Kennedy, 2010). In this small study, Donna, the teacher with more experience and education, was more effective in promoting growth mindset, mastery orientation and student learning (as measured by grades) than was Celia. Donna also was observed promoting greater student engagement (time on-task), as well as facilitating students' conceptual development and growth mindset more than Celia. Our finding warrants continued fine-grained analysis of teacher characteristics and practices in the context of mindset interventions and expected outcomes.

In terms of teacher beliefs, both teachers had a strong growth mindset regarding intelligence in science on the survey measure. However, their practices reflected differences in the degree to which they promoted a growth mindset among their students. The teachers were very likely aware of the social desirability of endorsing a growth mindset, so the survey items might not have been an accurate measure of their beliefs. When it came to their beliefs about the motivational value of different practices, greater differences were found between the teachers. Celia endorsed a greater number of performance-oriented motivational practices than did Donna. For example, Celia reported to us at the outset of the study that she believed that comparing students to one another, emphasizing grades and points, and offering rewards for performance were all effective motivational strategies.

Instructional Practices

Donna and Celia used similar instructional practices but differed in the way they communicated with their students about goals, effort, evaluation, feedback, encouragement, and study strategies. These differences are generally consistent with the differences in the two teachers' beliefs about motivational practices noted above. Donna's daily interactions with students implied an emphasis on mastery, learning, and growth more so than did Celia's. Whereas Donna more often promoted conceptual development, modeled and encouraged strategy use, Celia's classroom was rarely characterized this way and her lessons rarely promoted deep understanding. Celia was quick to help her students when they struggled with tasks, but did not often suggest strategies for dealing with these struggles, which could send the message to her students that she lacked confidence in their abilities.

Though they did not assume primary responsibility for delivering the Brainology program due to the nature of the study, the teachers supported the program in different ways. While Donna did not make much use of the program-provided supplementary materials, and did not often examine students' logs, she was very much involved in students' participation in the Brainology program itself. Celia, on the other hand made fairly regular use of the supplementary program materials, and occasionally consulted student logs, but she was completely uninvolved during the ongoing program itself. From the students' perspective, Donna probably appeared to be more actively invested in the program.

Perhaps the most striking and impactful difference between the teachers was in their usage of mindset messages in their daily interactions with students. Donna interacted with her students in a way that promoted a growth mindset, while Celia did not. Even though Celia made greater use of the supplementary Brainology materials than Donna did, she failed to reinforce the

development of adaptive beliefs about learning in the comments she made to her students. These small daily interactions may make a critical difference in the degree to which classroom interventions are effective. Donna supported the program more consistently in her daily routine than did Celia. While it is impossible to support this conclusion empirically given the current data, we believe these daily reinforcements are the likely reason that the intervention was more effective for Donna's students than Celia's. The results suggest that teachers play a critically important role in supporting classroom interventions, and that program developers may want to design and study ways to impact teachers' practices in order to maximize program impact.

References

Aronson, J., Fried, C. & 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.

Blackwell, L., Trzesniewski, K., & Dweck, C. (2007). Implicit Theories of Intelligence Predict Achievement across an Adolescent Transition: A Longitudinal Study and an Intervention. *Child Development*, Vol. 78, No. 1, pp. 246-263.

Bryan, L. (2012). Research on science teacher beliefs. In B. Fraser, K. Tobin, & C.J.McRobbie (Eds.) *Second International Handbook on Science Education* (pp. 477-495). Netherlands: Springer International Handbooks on Education.

Cimpian, A., Arce, H.-M., Markman, E. M., & Dweck, C. S. (2007). Subtle linguistic cues impact children's motivation. Psychological Science, 18, 314-316.

Duke, N. K. (2000). 3.6 minutes per day: The scarcity of informational texts in first grade. *Reading Research Quarterly, 35,* 202-224. Reprinted in Mason, P. A., & Schumm, J. S. (Eds.) (2003). Promising practices in urban reading instruction. Newark, DE: International Reading Association.

Dweck, C.S. (1999). *Self-theories: Their role in motivation, personality, and development*. Philadelphia: Taylor & Francis.

Dweck, C. S. (2006). Is math a gift? Beliefs that put females at risk. In S. Ceci & W. Williams (Eds.) *Why aren't more women in science? Top researchers debate the evidence* (pp. 47-55). Washington DC: American Psychological Association.

Dweck, C. S. (2007). The perils and promises of praise. *Educational Leadership*, 65(2), 34–39.

Dweck, C.S. (2008). Mindsets and Math/Science Achievement. Report prepared for the Carnegie

Corporation of New York-Institute for Advanced Study Commission on Mathematics and Science Education Carnegie Corporation: New York. Retrieved from http://dev.opeq.blenderbox.com/uploads/files/868cea31-5888-4e45-a832-62b4377dbbfb.pdf

Dweck, C. S. (2010). Even geniuses work hard. *Educational Leadership*, *68*(1), 16-20.

Good, C., Rattan, A., & Dweck, C.S. (2007b). Adults' theories of intelligence affects feedback to males and females in math. Unpublished data, Columbia University, 2007.

Harris, D. N., & Sass, T. R. (2011). Teacher training, teacher quality and student achievement. *Journal of Public Economics*, *95*(7), 798-812.

Hattie, J. (2009). Visible learning: A synthesis of meta-analyses relating to achievement. New York, NY: Routledge.

Hill, C., Corbett, C., & St. Rose, E. (2010). Why so few? Women in science, technology, engineering, and mathematics. Washington DC: American Association of University Women.

Kamins, M., & Dweck, C. S. (1999). Person vs. process praise and criticism: Implications for contingent self-worth and coping. *Developmental Psychology, 35*, 835- 847.

Kennedy, M. M. (2010). Attribution error and the quest for teacher quality. *Educational Researcher*, *39*(8), 591-598.

Kyriakides, L., & Creemers, B. P. (2008). Using a multidimensional approach to measure the impact of classroom-level factors upon student achievement: A study testing the validity of the dynamic model. *School Effectiveness and School Improvement, 19*, 183-205.

McClintic-Gilbert, M. S., Henderlong Corpus, J., Wormington, S. V., & Haimovitz, K. (2013). The relationships among middle school students' motivational orientations, learning strategies, and academic achievement. *Middle Grades Research Journal*, *8*(1), 1-12.

Muijs, D. (2008). Educational effectiveness and the legacy of Bert PM Creemers. *School Effectiveness and School Improvement*, *19*(4), 463-472.

Mueller, C. M., & Dweck, C. S. (1998). Intelligence praise can undermine motivation and performance. *Journal of Personality and Social Psychology, 75*, 33-52.

Nye, B., Konstantopoulos, S., & Hedges, L. V. (2004). How large are teacher effects? *Educational Evaluation and Policy Analysis*, *26*(3), 237-257.

Patrick, H., Mantzicoupoulos, P., & Sears, D. (2012). Effective classrooms. In K. Harris, S., Graham, & T. Urdan. (Eds.). *APA Educational Psychology Handbook.* APA Books (pp. 443-469). Washington DC: American Psychological Association.

Shih, J. C. (2013). How many classroom observations are sufficient? Empirical findings in the context of a longitudinal study. *Middle Grades Research Journal, 8* (2), 41-49.

Shim, S. S., Cho, Y., & Cassady, J. (2013). Goal structures: The role of teachers' achievement goals and theories of intelligence. *The Journal of Experimental Education*, *81*(1), 84-104.

Stipek, D.J. (1996). Motivation and instruction. In D.C. Berliner & R.C. Calfee (Eds.) Handbook of educational psychology (pp. 85-113). New York: Macmillan.

Strahan, D., Faircloth, C. V., Cope, M., & Hundley, S. (2007). Exploring the dynamics of academic reconnections: A case study of middle school teachers' efforts and students' responses. *Middle Grades Research Journal, 2* (2), 19-41.

Figures

FIGURE 1. STUDENT REPORTS OF MALLEABILITY OF INTELLIGENCE BY TEACHER

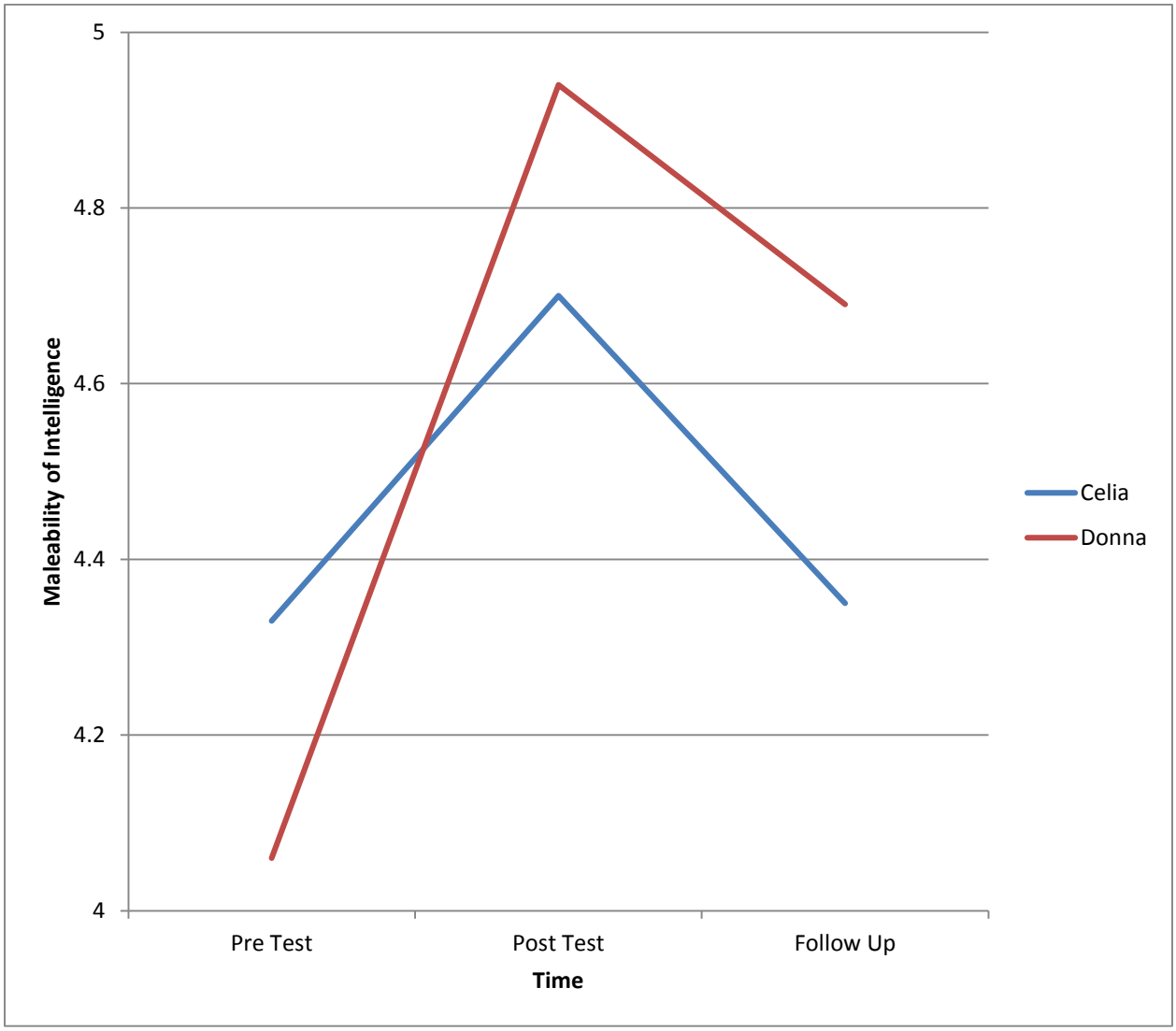


FIGURE 2. STUDENTS' MASTERY GOAL ORIENTATION BY TEACHER

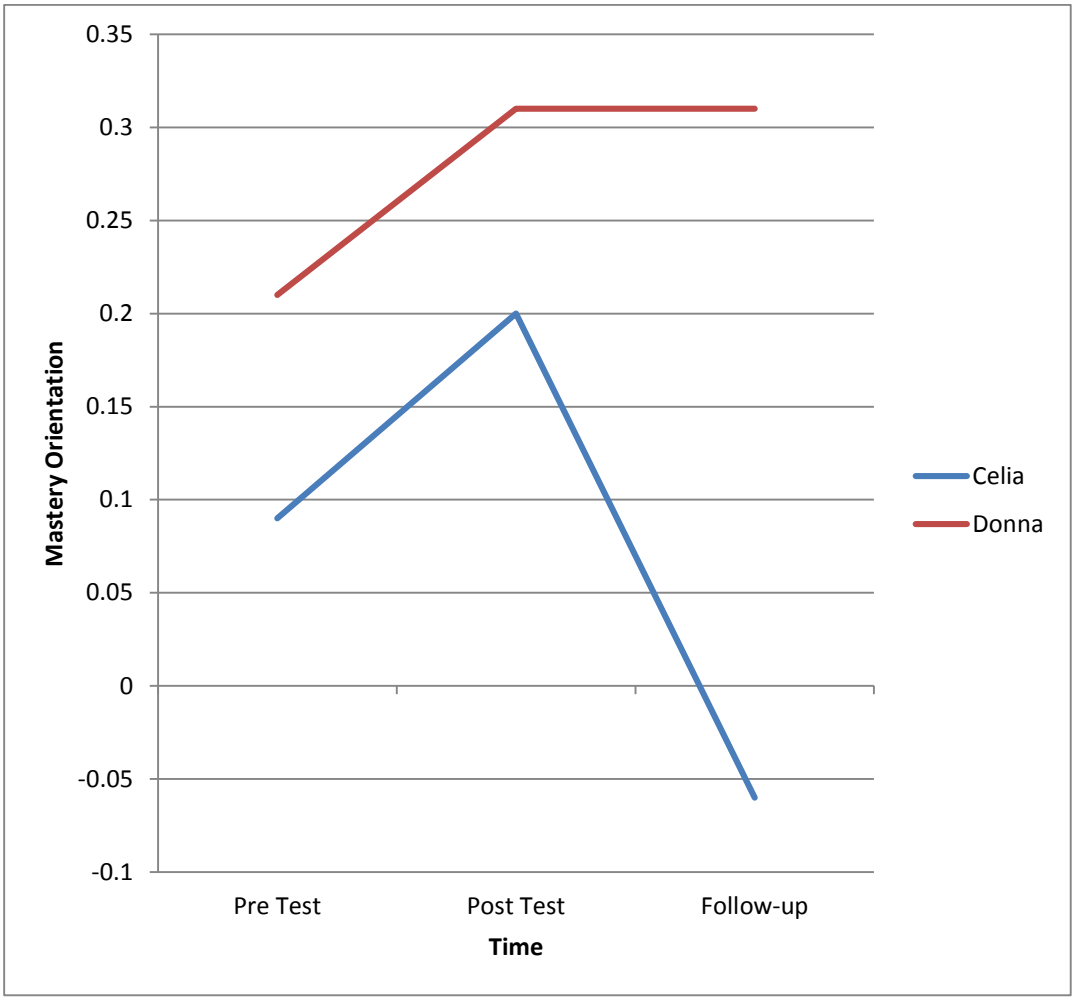
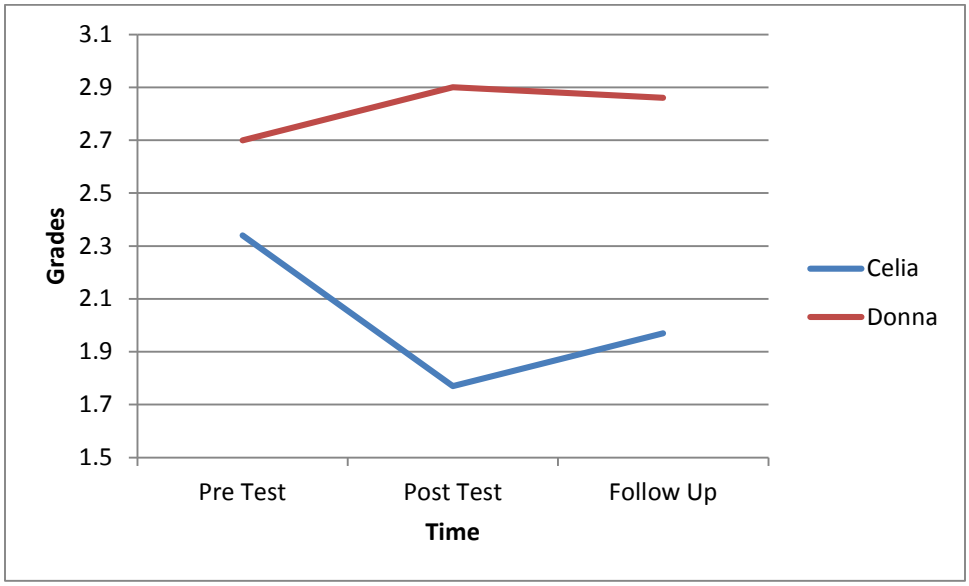


FIGURE 3. STUDENTS' SCIENCE GRADES BY TEACHER



Tables

Table 1

Means and Standard Deviations for Outcome Measures by Teacher	Celia	Donna
Malleability Beliefs about Science Intelligence		
Pre-intervention	4.33 (.83)	4.06 (.96)
Post-intervention	4.70 (.94)	4.94 (.86)
Follow-up	4.35 (1.15)	4.69 (1.17)
Mastery Goal Orientation		
Pre-intervention	.09* (.69)	.21* (.74)
Post-intervention	.20* (.72)	.31* (.70)
Follow-up	-.06 (.76)	.31 (.73)
Grades		
Pre-intervention	2.34 (1.3)	2.7 (1.1)
Post-intervention	1.77 (1.3)	2.9 (1.1)
Follow-up	1.97 (1.44)	2.86 (1.28)

*z scores

Table 2

Teachers' Level of Endorsement of Effectiveness of Motivational Strategies

	Celia	Donna
Comparing them to other students	3.0	1.0
Emphasizing that they are one of the best students	5.0	2.0
Reminding them of points or grades	4.5	3.0
Offering a reward	5.0	3.0
Praising them	5.0	4.0
Embarrassing them for poor performance	1.5	1.0
Telling them that hard work is the key to success	3.0	2.0
Allowing them to revise	3.5	3.0
Teaching them strategies for learning	5.0	3.0
Teaching them strategies for managing stress or anxiety	3.0	3.0
Contacting their parents with a negative report	5.0	1.5
Contacting their parents with a positive report	5.0	3.0

Note. 1 = not at all, 3 = somewhat, 5 = very

Table 3

Observational Rating Scores for Celia and Donna

Characteristic	N	Celia	N	Donna	Independent sample t-test
Mean Ratings by Each Class Period					
Emotional Climate	33	2.45 (.51)	44	2.45 (.70)	NS
Productive Organization	33	2.73 (.51)	44	2.91 (.29)	-1.96, p =.054
Enthusiasm	33	2.48 (.51)	44	2.70 (.46)	-1.98 *
Ratings by Each Instructional Activity					
Proportion Class on-task	144	3.40 (.63)	208	3.58 (.54)	-2.85**
Instructional Level Relative to skill of class	122	2.99 (.38)	167	3.02 (.28)	NS
Conceptual Development	122	1.69 (.90)	167	1.96 (1.0)	-2.37*
Direct Instruction	121	1.59 (.92)	167	1.95 (1.0)	-3.132**
Instructional Feedback	121	1.78 (.94)	167	1.95 (.99)	NS

Note. * p<.05, **p<.01

Table 4

Mindset Messages by Teacher during Regular Instruction

Statement Categories	Celia Average per 50 min. class period	Donna Average per 50 min. class period
Promotes Growth Mindset	Approximately once per class	Nearly twice per class
- Focuses on Study Skills	Less than every other class	Once every class
- Refers to Brainology	Once every third class	Once every class
Undermines Growth Mindset	Approximately twice per class	Approximately once per class