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When Teachers Become Students: Impacts of Neuroscience Learning on Elementary Teachers' Mindset Beliefs, Approach to Learning, Teaching Efficacy, and Grit

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Abstract: Previous research suggests that learning basic neuroscience constructs, especially about the malleability of the brain, impacts middle school and older students' academic mindset, response to failure and academic persistence. This research targets teacher beliefs using a similar model. Teachers were taught introductory neuroscience concepts related to how the brain learns. Session topics included: basic neurodevelopment, neuroplasticity, sleep and the brain, stress and the brain, exercise and the brain, growth mindset, growth mindset feedback, self-control and grit. Results of this school level intervention suggest significant impacts on teachers' mindset, teaching efficacy, teachers' approach to learning and grit. In particular, teacher mindset beliefs significantly increased after the teachers were taught the concepts. Implications for schools and teacher preparation are discussed.

Keywords: *Neuroscience learning, teacher mindset beliefs, teacher efficacy.*

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Introduction and Literature Review

In school-aged populations, beliefs and behaviors distinct from academic skills but related to school and learning success are often broadly referred to as non-cognitive factors (Farrington et al., 2012; Snipes et al., 2012). These non-cognitive factors or "soft skills" are positive contributors to student educational and motivational outcomes and include constructs such as academic mindset beliefs, learning goals, grit, self-control and academic efficacy (Farrington et al., 2012). Building off previous research where learning about the malleability of the brain impacts students' non-cognitive beliefs including academic mindset, response to failure and academic persistence (Blackwell et al., 2007), this research targets teacher beliefs by highlighting the malleability of the human brain and how the brain learns in schools as a framework for teacher learning examining the impact on pedagogy and beliefs.

Academic Mindset Beliefs and Learning Goals

Mindset theory (Dweck, 2006) suggests that people hold implicit beliefs about their intelligence that fall somewhere on a continuum ranging from fixed (ie. intelligence is not something that can really change) to growth (ie. intelligence can always be grown and changed). Moreover, "what students believe about their brains and whether they see their intelligence as fixed/stable or as a trait that can grow and change has profound effects on their motivation, learning and school achievement" (Dweck, 2006). Research suggests that once the concept of neuroplasticity (that the brain is malleable) is explained and made salient to students they are more likely to view their intelligence as improvable, given their new understandings about the plastic nature of the human brain (Tirri & Kujala, 2016).

Teacher and student mindset beliefs are important because beliefs about ability (fixed or growth) offer a clue as to why students with apparently equal abilities in similar situations have different goals for learning and classroom behaviors, particularly in response to failure (Dweck & Leggett, 1988; Tirri & Kujala, 2016). Research suggests that most teachers,

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about 63%, endorse a growth mindset with much smaller numbers of teachers espousing a fixed mindset (Gutshall, 2013; Snipes & Tran, 2017) however, the impact of teacher mindsets on student mindsets is not fully understood (Patterson et al., 2016; Gutshall, 2016). In at least one study, it appeared that college age participants who were asked to imagine themselves in the role of teacher provided more sympathy to students who were struggling if they held a fixed mindset compared to if teachers' held growth mindset beliefs (Rattan et al., 2012). In addition, holding a fixed mindset belief predisposes teachers to classify or stereotype students more readily than holding a growth mindset belief (Jonsson & Beach, 2010).

In addition, student learning goals as well as teachers' approach to classroom student learning (mastery or performance) have been linked to academic mindsets (Ames, 1992; Midgely et al., 2000; Elliot, 2005; Meece et al., 2006; Shim et al., 2013). Students with fixed mindsets are more likely to emphasize looking smart or proving their abilities (performance approach for learning) and tend to avoid challenges or respond poorly in response to mistakes, failure or setbacks. Related, teachers with performance approaches in the classroom are more likely to recognize and reference innate talents and emphasize student competition. They are also more likely to point out comparisons among students' grades and scores. Conversely, teachers with growth mindsets are more likely to emphasize the process of learning, praise effort and persistence and reference working hard toward personal improvement of knowledge and skills over grades or performing better than peers (mastery approach for learning) (Ames, 1992; Meece et al., 2006; Midgely et al., 2000). In sum, teachers with a mastery approach to student learning emphasize the importance of demonstrating competence to their learners; whereas teachers with a performance approach to learning emphasize the important of developing competence to their learners (Ames, 1992; Elliot, 2005; Midgely et al., 2000; Meece et al., 2006; Shim et al., 2013). In general, research suggests that beliefs about ability are linked to both mastery and helpless responses in the classroom (Moller et al., 2009). Instructional practices consistent with mastery goal structures and approaches appear to be positively related to high teacher efficacy (Midgely et al., 1995; Wolters & Daughtery, 2007). Mastery goal classroom structures and approaches are related to positive teaching efficacy. Likewise, classroom learning approaches with a mastery focus may help students to adopt a mastery goal orientation as well. Importantly, students with mastery goals for learning are more resilient in the face of setbacks, failure and mistakes since they tend to value effort over easy answers and they are more likely understand that failure can be a learning opportunity to grow and learn (Ames, 1992; Dweck & Leggett, 1988; Duckworth & Seligman, 2005; Mangels et al., 2006;). Remarkably, mindset beliefs after failure can even impact neurobiology. In a recent study, high school students with growth mindsets have been shown to have lower cortisol in their saliva, a known measure of stress response, when they earn poor grades than do students with fixed mindset beliefs (Lee et al., 2018).

In sum, students with fixed mindsets and performance learning goals are more concerned with appearing smart whereas students with growth mindsets and mastery goals are more concerned with becoming smart (Tirri & Kujala, 2016; Patterson et al., 2016). Being concerned with the process of becoming smart results in a more motivated learner than one concerned with looking smart. Research suggests that teachers may contribute to student mindset beliefs and student learning goal orientations in multiple ways including their pedagogical practices (Rattan et al., 2012), personal beliefs (Gutshall, 2016), classroom learning approaches (Ames, 1992; Midgely et al., 2000; Meece et al., 2006; Shim et al., 2013) and strategies for giving feedback and praise to students, especially after failure (Blackwell et al., 2007; Haimowitz & Dweck, 2016).

Self-efficacy beliefs

Self-efficacy is generally described as the extent to which a person believes he or she can make an impact on something (Bandura, 1977). In schools, the belief that a teacher can positively impact students' learning or their lives, is referred to as teaching efficacy. Teaching efficacy is a well -known correlate with teacher effectiveness (Bandura, 1993, Donohoo, 2017; Hattie, 2017 ; Schmidt, 2018). Asking questions such as "If I try really hard I can get through to even the most difficult student" and "I am certain that I am making a difference in the lives of my students" has been shown to give reliable and valid measurements of teacher self- efficacy (Midgely, et. al, 2000). Teacher efficacy impacts teacher "persistence, effort, willingness to try new approaches and stay actively engaged and attentive to students who are not progressing" (Donohoo, 2017, p. xv). Moreover, when groups of teachers demonstrate high teaching efficacy together, known as Collective Teacher Efficacy (CTE), there are remarkable outcomes for students. Collective teacher efficacy was recently ranked as the number one factor influencing student achievement" (Hattie, 2017, p. xv). For context, the classroom impact of something as important as classroom management has been determined to have an effect size ($d=.52$) but the impact of CTE on student achievement has an effect size of ($d=1.57$) resulting in impacts on student achievement larger than variables like class size, curriculum and socioeconomic status (Hattie & Zierer, 2018). A teacher's understanding that her students' brains are malleable and that their skills and abilities can be grown through effort and persistence should influence the extent to which a teacher believes she can influence her students' learning. However, there is a gap in the research explicitly connecting teacher neuroscience understandings, mindset beliefs and teaching efficacy, especially for elementary level teachers.

Grit

Related to academic mindset beliefs, efficacy and learning goal orientations, grit has also been shown to be important for student academic outcomes and teacher behavior in school settings (Shechtman et al., 2013.) Grit was originally conceptualized in an attempt to explain why some people persist in the face of adversity or failure while others do not (Duckworth & Seligman, 2005). According to Duckworth, grit is “passion and perseverance for long term goals” (p.2016) and can be measured using a scale which asks respondents to rate themselves on items such as, “I often set a goal but later choose to pursue a different one”, “I finish whatever I begin” and “Setbacks don’t discourage me” (Duckworth & Seligman, 2005). Researchers tested the importance of grit in six separate contexts and found that grit accounted for 4 % of the variance in adult educational attainment including the following: GPA average among Ivy League undergraduates, retention in classes at the Military academies and ranking in the National Spelling Bee (Duckworth et al., 2007). In more recent work, Eskreis-Winkler et al. (2014) found similar results that suggest grit is a key factor in salespeople keeping their jobs, men who stay married and high school juniors who graduate from high school. Teachers with tenacity (or grit) may adopt advantageous pedagogical practices (Duckworth et al., 2009). More specifically, a propensity toward teaching and re-teaching concepts until struggling students achieve mastery has been observed in teachers who are tenacious, or “gritty” (Schmid, 2017). Among novice teachers, a key ingredient in predicting teacher effectiveness and the likelihood of staying in the profession is grit (Robertson-Kraft & Duckworth, 2014).

While grit appears to have links to both student academic success and teacher success, persistence and longevity in the field, less is known about how learning about neuroscience along with the global constructs of mindset and grit influences teacher beliefs, if at all.

Interventions Highlighting Neuroscience for Students and Teachers

Given the importance of student self-reported beliefs and behaviors including academic mindset beliefs, self-efficacy, performance/mastery goal orientations, and grit, it is not surprising that there is considerable interest in ways to positively impact these beliefs in students. There has been significant research in the area of improving growth mindset beliefs in students, especially students in middle school, high school and post-secondary settings and students from high poverty schools (Aronson et al., 2002; Paunesku et al., 2012; Sisk et al., 2018). Research suggests that effective interventions for learners are those that highlight basic neuroscience and the principles underpinning the science of learning because they develop the knowledge that intelligence is malleable versus the belief that intelligence is a fixed, unchangeable trait (Yeager & Dweck, 2012). In the seminal research study in this area, Blackwell et al. (2007), found that middle school students who attended an 8- week session teaching basic neuroscience principles including the idea that the brain is like a muscle that grows with effort, displayed a sharp increase in mathematics achievement compared with learners who received traditional study skills.

Consistently, simple, inexpensive interventions directly addressing student beliefs and knowledge, either in person or via web based programs, with a clear focus on teaching concepts related to neuroplasticity and the malleability of the human brain, positively impact academic mindset beliefs and student academic efficacy, especially for middle school age and older learners. Yeager et al. (2019); and Snipes et al., (2012) summarize the general findings by stating, “Improving a student’s orientation toward learning and her beliefs about the nature of intelligence sparks a positive recursive process that fundamentally changes what she absorbs from the available learning opportunities” (p.11).

While there is abundant research explaining the scaling of student mindset interventions, there has been much less research interest in classroom teachers. Despite the strong suggestions by Carew & Magsamen (2010) that neuroscience and education are “an ideal partnership for producing evidenced based solutions” many teachers are not aware of even the most basic neuroscience findings that so deeply impact classroom learning and teaching (Brabeck, 2008). Bellert and Graham (2013) note several neurofacts that are essential for teachers to know including: Synaptic plasticity underpins the brain’s ability to acquire, store and retrieve information (Bellert & Graham, 2013, p. 10); Memory is dynamic and embedded in learning and reinforced by assessment (Bellert & Graham, 2013; Carew & Magsamen, 2010); Music enhances abilities in verbal and non- verbal areas; Sleep and exercise are essential for learning and memory and chronic or severe stress is prohibitive to learning and memory (Carew & Magsamen, 2010). Given the relevance of neuroscience to the field of education and teaching practice, professional development provided by school psychologists are perfectly prepared to disseminate current neuroscience in applied school settings.

There are clear links between neuroscience and teaching practice, however, there is limited research focused on understanding whether or not teachers’ beliefs might also respond to professional development focused on basic neuroscience principles as has been repeatedly demonstrated in students (Bellert & Graham, 2013; Carew & Magsamen, 2007). Dubinsky et al.,(2013) used neuroscience literacy as foundational to BrainU, a professional development series for secondary teachers that stretched across three consecutive summers. The researchers noted improvements in neuroscience content as well as pedagogical practices for secondary and some middle grades teachers. However, measurement of corresponding teacher beliefs and approaches to student learning was not included in this research (Dubinsky et al., 2013). While infusing the neuroscience of learning into teacher professional

development resulted in changes in secondary teachers' content knowledge and pedagogical practices (Dubinsky, et. al, 2013) much less is known regarding elementary school teachers (grades K-5) and how neuroscience instruction could impact teacher beliefs and/or student beliefs, if at all. Moreover, 3 consecutive summers of professional development is a heavy commitment for teachers and there is a need for professional development for teachers with less time commitment, but equally effective. Dubinsky et al. (2013) summarize their thinking by stating, "The neurobiology of learning, and in particular the core concept of plasticity, have the potential to directly transform teacher preparation and professional development and ultimately to affect how students think about their own learning" (2013, p, 17). While there is consensus that teachers and future teachers need to understand basic neuroscience related to the science of learning, however, empirical research designed to understand the impact of improving teacher understandings of the neuroscience of learning via school psychologist led professional development sessions is lacking.

Methodology

Research Goal

Building off previous research with middle school, secondary and college age students where learning about neuroplasticity and the malleability of the brain and/or growth versus fixed mindset concepts impacts student academic mindset beliefs, learning goal orientations and academic persistence (Blackwell et al., 2007; Meece et al., 2006) the current study uses a similar model to teach teachers about these concepts in an effort to improve teacher knowledge in key neuroscience areas to measure the impact of this instruction on elementary teacher beliefs and classroom learning approaches to answer the following question:

What is the impact of learning about neuroscience including basic neurodevelopment, neuroplasticity, sleep, stress, exercise, growth mindset, growth mindset feedback, self -control and grit on teachers' beliefs in the following areas: mindset, teaching efficacy, performance approaches to learning, mastery approaches to learning and grit?

Sample and Data Collection

Teachers (n=103) from 3 separate elementary schools in the southeastern United States participated in a year- long school wide professional development project called BrainBuilders (see Gutshall & Attafi, 2020 for a complete description of the BrainBuilders intervention protocol). Each school participated in a year -long partnership with the principal investigator (PI), a school psychologist and academic professor. For year 1 (School A) the PI approached to school to see if they would like to participate in the program. For years 2 and 3 (Schools B and C) the schools contacted the PI and requested to take part in the program. Table 1 depicts the years of experience, grade level assignments of the teachers as well as the demographic characteristics of the schools.

Table 1. Descriptive characteristics of teachers, schools and students

	School A	School B	School C
Teacher/School Characteristics			
number of teachers	34	37	32
range of years teaching	1-28	1-43	1-30
average years of teaching	12,4	13,86	10,58
type of school	charter	Public	public
grades	PreK-5	K-5	3-5
Student Demographic Characteristics			
Ethnicity*			
White/Caucasian students	5%	39.70%	59.40%
Black/African-American	92%	26.20%	17.50%
Hispanic/Latino students	0%	24%	11%
Multiracial/other	3%	0%	0%
Free and reduced price lunch*	96%	100%	53.20%

Note: *Demographic characteristics are school-wide

Data Collection

Over 3 consecutive school years, teachers (n=103) at each 3 separate schools were administered paper and pencil surveys measuring mindset beliefs teaching efficacy, mastery/performance approach to instruction, and grit at the beginning (August) and at end (May) of the school year, referred to as Time 1 and Time 2. Data collection timeframes were: 2016-2017 for school A, 2017-2018 for school B and 2018-2019 for school C.

Survey items were compiled from 4 previously validated and extensively well- known surveys including: mindset survey (Hong et al., 1999), Teacher Self Efficacy Scale (short form) (Tschannen-Moran) , the performance and mastery

orientation teacher approach to instruction items from PALS (Midgely et al., 2000) and the 8 item Grit Scale (Duckworth & Quinn, 2009). All teachers were administered the survey by the PI during their regularly scheduled professional development sessions.

During regularly scheduled staff meetings, teachers took part in six professional development sessions designed and implemented by the principal investigator, a school psychologist. Sessions were constructed to teach the group of teachers the following concepts: Neuroplasticity, Growth Mindset, Sleep and Stress impacts on Memory/Learning, Giving Growth Mindset Feedback, Self-Control and Grit. Each session lasted approximately 45 minutes (270 total minutes) and included instruction for the teachers during regularly scheduled teacher professional development times. In addition to the professional development sessions, the teachers were given unlimited access to a PI created BrainBuilders website. Teacher independent use of materials and resources was not measured however, teachers were encouraged to teach their students what they had just learned by the school leaders.

Analyzing of Data

Surveys were hand scored and relationships between and among variables at Time 1 and Time 2 were calculated to understand what if any impacts the professional development sessions designed to improve teachers' understandings about basic neuroscience might have had on their beliefs and approaches to student learning. More specifically, means and standard deviations for each measure were calculated at Time I and Time 2. Next, paired sample t-tests were conducted to determine if significant change in beliefs occurred post intervention

Findings / Results

Figure 1. depicts the average percentage of teachers holding a fixed, neutral or growth mindset at Time 1 and Time 2 as well as the average percentage of teachers' teaching efficacy and grit scores at Times 1 and Times 2.

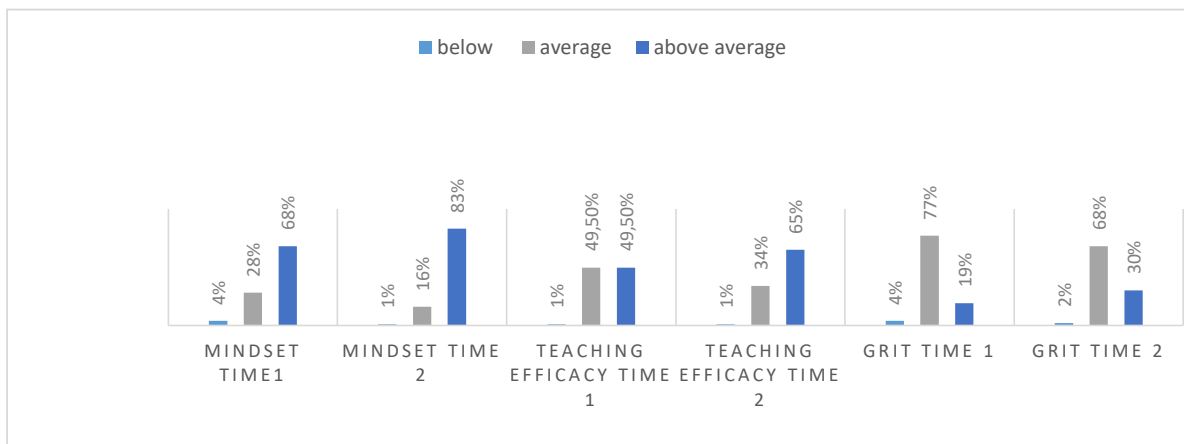


Figure 1. Percentages of teachers' mindset, efficacy, and grit at Time 1 and Time 2.

Correlational analysis (two tailed, pearson r) for all 5 areas assessed were conducted at Time 1 and Time 2. Findings depicted in Table 2 for time 1 and 2 suggested a moderate correlation ranging from (.19 to .48) between dependent variables both for Time 1 and Time 2, with increases in significant relationships noted at time 2, post intervention.

Table 2. Correlations among variables

Outcome Variables	1	2	3	4	4	5
Time 1						
1. Teacher Mindset	-					
2. Teacher Efficacy	0.44*	-				
3. Mastery Orientation	0.31*	0.45*	*	-		
4. Performance Orientation	-0.18*	-0.43*	*	-0.18*	-	
5. Grit	0.26*	0.38*	*	0.42	-0.19*	-
Time 2						
1. Teacher Mindset	-					
2. Teacher Efficacy	0.39*	-				
3. Mastery Orientation	0.25*	0.48**		-		
4. Performance Orientation	-0.26**	-0.32**		-0.21*	-	
5. Grit	0.29**	0.35**		0.22*	-0.14	-

Note. p ≤ .05*, p ≤ .01**

To answer the research question of whether or not teacher beliefs were changed post intervention, a parametric comparison of the pairs of mean scores using a paired t-test for each belief area was performed (Table 3). Teachers' scores in all areas changed in the predicted positive direction in every area assessed. In addition, paired sample t-tests between Time 1 and Time 2 reached the level of significance in all 5 areas.

Table 3. Paired sample t-tests Time 1 and Time 2

Dependent Measure	Time 1		Time 2		t(40)	p
	M	SD	M	SD		
Teacher Mindset	4,16	0,8	4,39	0,56	2,95	.004**
Teacher Efficacy	4,05	0,53	4,2	0,51	3,15	.002**
Mastery Orientation	3,69	0,76	3,88	0,66	2,76	.007**
Performance Orientation	2,82	0,69	2,62	0,69	-2,67	.009**
Teacher Grit	3,64	0,47	3,76	0,5	3,13	.002**

Note. CI= Confidence Interval 95%. $t \leq .10$, $p \leq .05^*$, $p \leq .01^{**}$, $p \leq .001^{***}$

For mindset beliefs only, an additional Chi Square analysis was completed to determine if the differences between fixed, neutral and growth mindset scores were expected or significant pre and post intervention. Chi square analysis revealed significance, $X^2 (n=101)=6.36$, $p=.041$, suggesting true change in the proportion teachers' fixed, neutral and group mindset beliefs from Time 1 to Time 2.

Additional regression analyses (depicted in Table 4) revealed that teaching efficacy at Time 2 is particularly important with regard to mastery orientation at Time 2. Greater teaching efficacy at Time 2 predicted increased mastery instructional approaches when controlling for mastery approaches to learning at Time 1. Neither grit beliefs nor mindset beliefs at Time 2 predicted mastery orientation at Time 2. By contrast, a growth mindset at Time 2 predicted decreased reliance on the less desirable performance instructional approaches in the classroom at Time 2 when controlling for performance orientation at Time 1. Results add to the growing body of literature identifying the importance of teaching efficacy and mindset beliefs in teachers' classroom practices.

Table 4. Regressions predicting classroom approach to learning

	Classroom Goal Orientation			
	Mastery		Performance	
	b	β	b	β
Teacher Efficacy	.356**	0,276	-0,105	-0,082
Mindset	0,11	0,092	-.236 †	-0,2
Grit	-0,136	-0,103	0,078	0,059

Note. Orientations and predictors are measured at Time 2, controlling for mastery or performance orientation at Time 1; † $p \leq .10$, ** $p \leq .01$

Discussion

Results suggest that elementary school teacher beliefs can be impacted by teaching them about neuroplasticity and other basic brain concepts in six short sessions (270 minutes) designed to intentionally improve teachers' neuroscience understanding over the course of one academic year. While all belief areas assessed in each of the 3 schools changed in the predicted direction, in particular, teacher efficacy beliefs and beliefs about mindset (growth vs fixed) were especially responsive to the intervention, particularly with regard to their impacts on teacher instructional approach to learning (mastery vs performance) post intervention.

On average, 63% of teachers have a growth mindset (Gutshall, 2013; Gutshall, 2016; Snipes & Tran, 2018). In this study at time 1, 68.3% of the teachers rated themselves as having a growth mindset, 27.7% of the teachers rated themselves as having a neutral mindset and 3.9% rated themselves as having a fixed mindset. After 6 sessions of BrainBuilders, 83% of the teachers rated themselves as having a growth mindset, with only 16% of teachers rating themselves as having a neutral mindset and 1% rated themselves as having a fixed mindset. This finding suggests an average growth of 15% percentage points in the total number of teachers in the sample who held a growth mindset belief at Time 2. These findings have implications for educational practice because facilitating a teacher's mindset beliefs toward a growth mindset perspective may spark a recursive process that can have numerous positive impacts including: an improved sense of teaching efficacy, mastery goal approaches in the classroom, and increased scaffolding and support for children during failure and mistakes. Growth mindset beliefs become especially important during times of struggle or defeat and can influence not only the learners' response in these situations but also the teachers' response to the learner.

Similar growth in average teaching efficacy percentages were also found. At the beginning of the intervention, 49.5% of teachers reported average levels of teaching efficacy and the 49.5% of the teachers reported higher than average levels

of teaching efficacy. At Time 2, 34% of the teachers reported average levels of teaching efficacy and 66% of the teachers reported higher than average levels of teaching efficacy resulting in a 17 percentage point increase in above average teaching efficacy for the group. Given the demonstrated effect size on academic learning that teaching efficacy and Collective Teaching Efficacy (CTE) can have on schools (Donohoo, 2017; Hattie, 2017), raising individual teaching efficacy significantly over the course of a long school year is noteworthy. In addition, teacher efficacy (time 1 and time 2) for all teachers was related to teacher mindset (time 1 and time 2). This result confirms the work of Patterson et al. (2016), Stipek et al. (2001) and Urdan (2004), noting a clear link between mindset beliefs and teacher efficacy. For groups of teachers, believing they can and are making a difference in the lives of all of their learners, known as collective teaching efficacy (CTE) and persisting until you impact your students (grit) is considered to be the single biggest predictor of academic achievement in schools (Donohoo, 2017; Hattie, 2017). One of the key factors in improving CTE has been identified as improving teachers' causal attributions or the degree to which teachers' (Goddard, Hoy & Woolfolk-Hoy, 2000) believe that their efforts are integral to students' success. Results obtained from this study suggest that teachers may feel collectively more efficacious when they learn about and understand the enormous malleability and capacity to learn present in each and every student brain in their classrooms because it confirms and adds to their collective sense of their own impact on student learning helping them to affirm positive causal attributions.

The change in mastery and performance approaches to learning from Time 1 to Time 2 suggests change not only in teacher's beliefs, but also their classroom behavior and pedagogical practices. Teachers' significant increase in classroom mastery approaches to learning (learning and growing one's skills and knowledge, doing your personal best) while simultaneously significantly decreasing performance goals (getting the highest grade, competing against peers) is an important finding that confirms the work of Ames, 1992; Anderman & Anderman, 2006; Midgely et al., 2000; and Shim et al., 2001, suggesting that growth mindset beliefs and teaching efficacy beliefs are connected to the types of goal approaches and likely structures teachers explicitly set up in the classroom. Moreover, regression analyses (depicted in table 4) revealed that teaching efficacy at Time 2 is particularly important with regard to increasing mastery approach to learning in the classroom. Likewise mindset beliefs at Time 2 predicted a significant decrease in less desirable performance approach to learning at Time 2. Both teaching efficacy (moving from about 50% of teachers in the high average range to 66% of teachers in the high average range) and mindset beliefs (moving teachers from 68% growth to 83% growth mindset) had significant impact on teachers' classroom goal structures. This result is important and may suggest a comparable increase in mastery instructional approaches for learning.

Finally, with regard to grit, in general, prior to the intervention, this group of teachers demonstrated high levels of grit (depicted in Figure 1). Average Time 1 grit scores were in the below average range for just 4 % of the teachers, the average range for 77% of teachers and the above average range for 19% of the teachers. At Time 2, just 2% of the teachers reported below average levels of grit, 68 % reported average levels of grit and 30% reported above average levels of grit. Teachers with higher grit scores have been shown to persist in teaching and re-teaching until students achieve mastery (Duckworth et al., 2009) and to persist in the field longer than teachers with lower grit scores (Robertson-Kraft & Duckworth, 2014). In conjunction with individual teaching efficacy, grit has also been shown to be a component of Collective Teaching Efficacy (CTE), a known key factor in student achievement (Donohoo, 2017). Moreover, it has also been shown that highly efficacious groups of teachers demonstrate more grit because efficacy beliefs "influence the level of effort and persistence that individual teachers put forth in their daily work" (Goddard et al., 2000, p. 502).

Conclusion

There could be several reasons for the results. Beyond teaching teachers about neuroscience, the inclusion of effective professional development components delivered by a school psychologist may have contributed to the measured growth in teacher beliefs, especially in the area of teaching efficacy. Consistent with Hattie and Zierer's (2018) extensive body of work regarding effect sizes for successful interventions in schools, the BrainBuilders professional development sessions contained all of the components known to contribute toward large effects sizes and impactful professional development. Sessions included the principal (school leader), sessions were held at the school location, professional development gave teachers high autonomy/choice, sessions were led by an outside facilitator, provided immediate access to materials, goals for sessions were clear, concrete steps to implement with students were provided, and feedback from teachers was elicited. The fact that BrainBuilders contained each of these key components for successful professional development could provide one theoretical explanation for the measured change in beliefs.

A second explanation for the current results could be explained by the initiation of recursive process similar to those that occur in students when they learn about neuroplasticity. Not unlike the process outline by Snipes et al., 2012, where improving a student's orientation toward learning and her beliefs about the nature of intelligence sparks a positive recursive process that fundamentally changes what she absorbs from learning including her student efficacy, persistence and effort, a similar process could take place for teachers.

As depicted in Figure 2., it is possible that when a teacher learns that her learners' brains operate like a muscle getting stronger with effort and persistence, it can change a teacher's beliefs about intelligence, impact her own sense of teaching efficacy, grit and ultimately pedagogical approaches to student learning.

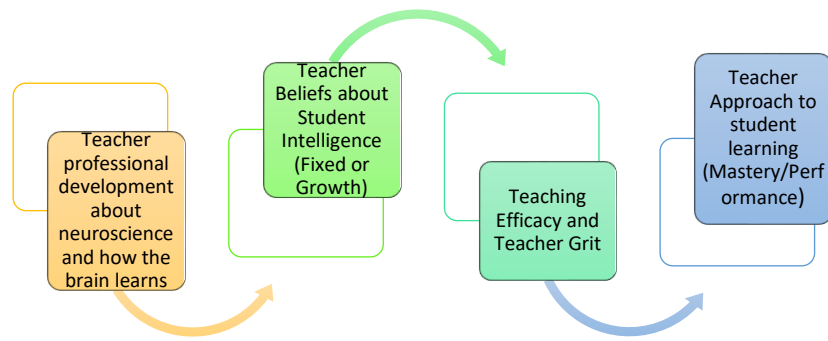


Figure 2. How neuroscience learning might impact teachers' beliefs

Suggestions

It is important to include classroom teachers in discussions and instruction related to neuroscience literacy. Interventions focusing solely on student understanding of the neuroscience concepts underlying the learning process are important, but miss out on including teachers, key contributors to educational outcomes (Hattie & Zierer, 2018). When students are taught about neuroscience their teachers should also be included in the learning to improve their own neuroscience literacy and understanding of how student brains' learn. In addition to being no cost, including teachers will positively impact teacher beliefs and instructional approaches to learning, especially in the area of growth mindset beliefs and efficacy which is essential for supporting students' learning. Moreover, information regarding learning and the brain is essential for everyone working with and caring for children.

Given the connections between teacher growth mindset beliefs and efficacy outcomes, teacher preparation programs should include explicit neuroscience literacy concepts in their curriculum, pedagogical instruction and practicum experiences. Family caregivers would also benefit from opportunities to improve their understanding in key neuroscience concepts regarding the science of how children learn and brains develop.

Taken together, teaching neuroscience concepts through brief professional development sessions can have measurable impact on teacher beliefs, especially in the important areas of teaching efficacy and mindset beliefs. These findings strengthen previous work suggesting that growth mindset, efficacy and persistence and positive response to failure or setback are positively impacted by learning about neuroplasticity and other components of the neuroscience, no matter what the learner's age.

Limitations

Questions remain regarding the impacts of teacher beliefs on their students' beliefs, outcomes, and motivation. Moreover, since this project included global information about how the brain works and learns, nuanced investigation to identify the impact of specific topics on teacher beliefs is needed. Larger and more diverse sample sizes of teachers including international settings is needed to understand the generalizability of this work. Finally, research is needed to understand how both teacher and student neuroscience literacy might be related to one another, to mindset and efficacy beliefs and to academic achievement as well as other important classroom outcomes.

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