Thinking about Intelligence: How Student Mindsets Influence Academic Performance

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Abstract: A common and maladaptive view is that only smart people succeed in Science, Technology, Engineering, and Mathematics (STEM) topics. The purpose of this study was to determine if student performance in an advanced physics classroom could be improved by emphasizing that students' abilities are malleable rather than fixed. Students participated in a lecture, in which they learned about brain function and how intelligence physically manifests, read a supporting article, and discussed the implications. Following the intervention, students had a slight, not significant, increase in growth mindset and academic performance. Moreover, there was a positive correlation between adoption of a growth mindset and academic performance for the high school students, as well as academic growth. This supports existing research on mindset and academic performance. However, the correlation between mindset and performance was negative for college participants, which was most likely due to extenuating circumstances.

Introduction

Views of intelligence - that is, whether students see their abilities as fixed or malleable - influence student performance in the classroom (Dweck, 1986). Students, who see intelligence as fixed, are discouraged by mistakes and encounter roadblocks while learning. A view some hold is that sciences are reserved for the smart students (Barmby & Defty, 2006); science is an ability that people can or cannot do. This is representative of a fixed mindset, which can hold people back. On the other hand, students, who see intelligence as malleable, learn from mistakes and see challenges as obstacles to be conquered. The purpose of this research was to determine if encouraging students to see their abilities as malleable improves their performance in physics in an advanced physics classroom.

All subjects, even physics, are a set of skills that need to be refined. People need to remove themselves from the fixed mindset that physics is an ability they either possess or do not possess and begin to realize that with effort they can refine skills and develop that intelligence. For this reason, students should adopt a growth mindset of refining skills and developing their intelligence. Learning is never finished; challenges and failures need to be embraced. This study was a way for students to develop a growth mindset, a view that has been shown to improve academic performance from a fixed view (Blackwell et al., 2007; Mangels et al., 2006; Birgit, 2001). A growth mindset person believes that his/her intelligence can change, either positively or negatively, depending on the effort and education (Blazer, 2011).

The myth that physics is hard (Barmby & Defty, 2006; Spall, Stanisstreet, Dickson & Boyes, 2003) also relates to students mindset in the subject as well. The impact of mindset...
on achievement does not typically emerge until students face challenges or academic difficulties (Dweck, 2008; Blackwell et al., 2007). The mindset would be related to the fact that they are or are not smart enough to do physics if they have a fixed mindset and how hard they think physics is. This is exaggerated with low academic performance (Dweck, 2008).

A student with a growth mindset would not approach physics as difficult or hard, but a skill to be developed (Jones et al., 2009). The academic performance has the potential to increase if a student believes that intelligence can grow through effort (Dweck, 2008). In addition, it is important for the students to have a growth mindset because it tells them that there is no limit to their intelligence; it does not depend on basic qualities like genes (Dweck, 1999). Intelligence depends on effort and persistence. Students’ intelligence can grow or decline depending on what they put into it (Dweck, 1999).

In this study, I addressed teacher pedagogy in how teachers can best respond to students by using it to promote a growth mindset. Teachers can do this by creating a classroom culture focused on a growth mindset. Students’ mindset has been found to influence their academic performance (Burns & Isbell, 2007; Murphy & Thomas, 2008; Jones et al., 2009). This study was a way to change students’ mindset to growth, a view that has been shown to improve academic performance from a fixed view. My project addressed teacher pedagogy in how teachers can respond to students to promote a growth mindset. This study explored the student views of physics intelligence and how it relates to their academic performance.

My project was directed towards teachers of the sciences or mathematics directly, or any subject area, including academic or practical purposes, such as sports. Fixed intelligence, “that people have different levels of ability and nothing can change that”(Dweck, 2008), is one of the mindsets. The other mindset is growth, or that “intellectual abilities can be cultivated and developed through application and instruction (Dweck, 2008).” This does not mean that everyone has exactly the same academic potential or will learn everything with equal ease. This mindset means that each student has the intellectual ability that can be expanded upon and further developed.

My research questions for this study were as follows:
1. Does my intervention change students’ views on whether physics intelligence is fixed or can grow?
2. Are students’ changes in mindset related to their academic performance?
3. Are students’ changes in mindset related to their academic performance growth?

In the next section, I will outline the existing research on this topic, as it relates to my study. I will review mindsets and how they relate to academic performance and how mindsets are changed. Then, I will describe my sample and methods for this study by reviewing my intervention and quantitative data instruments.

**Literature review/theoretical framework**

Students’ academic success has been linked to their mindsets (Blackwell et al., 2007; Dweck, 2008; Jones et al., 2009). In this section, I will discuss various topics including differences between fixed and growth mindset, evidence for how this is linked to student academic growth and, how it is linked to academic performance and physics as well as students’ views on science, technology, engineering, and mathematics (STEM) and more.
specifically, physics intelligence. For my final discussion point, I will share effective methods that have been shown to shift students’ mindsets through interventions. These interventions contained plans focusing on both students and teachers.

Mindset

Students are not all the same, which means their mindsets are not all the same. Jones, Byrd, and Lusk (2009) studied high school students’ beliefs about intelligence and found that “students have a range of beliefs about the definition of intelligence” (p. 3). The two mindsets I focus on in this study are fixed and growth; these views have been linked to the students’ characteristics. Dweck (1999) noted that students with fixed mindsets tend to avoid challenges because they want to do well. Thus, fixed mindset students avoid activities where they may fail. These challenges that the fixed mindset students avoid are external forces that get in students’ way when showing what they know. People with fixed mindsets do not see why they should make an effort because they do not possess the ability, therefore it does not move them forward or make a positive change for them, so it is seen as a waste of time.

Miele and Molden (2010) found a “tendency for [fixed mindset] theorist to become less confident as they put more effort into the task” (p. 553). For example, students with a fixed mindset usually either ignore criticism or take it as an insult to their intelligence. Because they believe intelligence cannot be changed, the criticism of intelligence is perceived as a criticism of the student. This perceived criticism of intelligence isolates students and discourages them from trying anything new, leading them to avoid more challenges over time. Also, other students’ success makes the fixed mindset student look bad in their mind. Other students’ success is seen as either luck, objectionable actions, or as tarnish to their own success as it brings about hurtful things towards the student. Because the students with fixed mindsets do not challenge themselves and do not want to try, they cannot reach their full potential and it will become very difficult for them to improve because everything they do or try to learn is who they are. Overall, fixed intelligence views are limiting and constrain the student.

On the contrary, growth mindsets are met with different characteristics (Dweck, 1999). These growth mindset students believe that intelligence can be developed because the brain is a muscle that can be trained over time. This tends to lead these students towards a desire to improve. Because they know and feel that they can improve, they embrace challenges. This new embrace occurs because growth mindset students know they can come out better on the other side, which raises the confidence of the student.

“Students who reported more [growth mindsets] on the [Implicit Theories of Intelligence Scale for Children] were more likely to report that they received higher grades on their report cards than were students with more fixed views” (Jones et al., 2009, p. 7). Students with growth mindsets significantly outperform their classmates who hold fixed mindsets (Blackwell et al., 2007; Dweck, 2010). The obstacles that are encountered are embraced because they cause growth; thus the main idea is that growth mindset students can only learn from their mistakes. Effort put forth to complete these challenges is necessary to grow and master new skills. Also, a difference between fixed mindset students and growth mindset students is that criticism and negative feedback are sources of information instead of insults (Dweck, 1999). Viewing criticism as a new source of information creates a bank of challenges for the student to change or improve. In addition,
because intelligence can change, criticism is seen as the current ability instead of a personal attack on the student. The success of others is also viewed as a sign of good things to come and where they want to strive compared to fixed mindset students that see other students’ success as luck or something that tarnishes their own success. Anything that can push a student with a growth mindset can be seen as a beneficial experience and opportunity for growth.

Link with academic achievement

As students with a fixed mindset do not like challenges, criticism or failing, these students tend not to challenge themselves, and they are more likely to avoid learning new information (Dweck, 1999). Avoiding new information reinforces their beliefs of a fixed intelligence:

Blackwell et al. (2007) found the following: Junior high school students who thought that their intelligence was a malleable quality that could be developed affirmed learning goals more strongly, and were more likely to believe that working hard was necessary and effective in achievement... motivational patterns mediated [the relation between intelligence and performance] such that students with an growth orientation had more positive motivational beliefs, which in turn were related to increasing grades (Dweck, 1999, p. 253).

Because a growth mindset has been linked to higher academic performance, teachers have a responsibility to move students from a fixed view mindset to a growth mindset. Alpay and Ireson (2006) found that changing mindsets is key in increasing student performance and fulfillment. The researchers also found that students with a growth mindset saw the advantages of group work. Students with growth mindsets were more likely to report a higher ability than fixed mindsets (Jones et al., 2009). The impact of mindset on achievement does not typically emerge until students face challenges or academic difficulties (Blackwell et al., 2007; Dweck, 2008). Thus, the impact of mindset weighs heavily on students as they advance in their academic careers. Peoples’ mindsets can also influence their interpretations of processing when making judgments of ability (Miele & Molden, 2010). Fixed mindset people have a lower self-efficacy when challenged, whereas growth mindset people showed higher self-efficacy when they devoted more time for the task (Miele & Molden, 2010). In a science classroom, the amount of challenges are great and vastly different in subject matter because the students are tasked with understanding concepts that go against common sense. Not only does the new subject matter in science subjects sometimes go against common sense, but also the judgments that need to be made during experimentation processes sometimes differ from what the student has previously experienced. This is especially true as the student moves into more advance science classrooms.

View of STEM

Students’ views on physics and STEM intelligence can be biased from popular culture. Popular culture promotes the view that STEM intelligence is an innate gift. This leads to students having different mindsets for different domains in their education. An example of this could be that students can learn vocabulary by studying but they cannot learn physics because it is too hard; this has been shown in past studies. Students may have fixed view of math skills, but believe they can improve their athletic ability (Dweck,
2008). There is also evidence that students can approach computer science in both mindsets (Murphy & Thomas, 2008). In addition, Jones et al. (2009) found that just over half of high school students have a growth mindset. This means the about half of high school students have a fixed mindset and this can be problematic when it comes to academia.

Having a growth mindset is extremely important in terms of academic performance and it seems best to have students in an environment where this type of mindset is encouraged. In order for this to occur, teachers need to emphasize effort and progress of students over the final outcome/final grade in the class (Mueller & Dweck, 1998). This means that teachers need to give students fun and exciting challenges and focus on the students’ improvement throughout the task. Also, in-depth learning increases learning and understanding at a deeper level for students (Dweck, 2010a). For teachers, creating a classroom culture in which a growth mindset is the norm can help students become more comfortable with the idea and slowly understand the benefits of a growth mindset. Praising students for their effort and not their intellect can also help students move away from a fixed mindset because it removes the idea that the students ability is a talent compared to the ability to learn (Dweck, 2010b). Instead of teachers saying things like “You’re a really good problem-solver”, which praises intelligence, teachers should praise effort such as, “You’re finding really good ways to do this.”

Differentiation is also a good way to acknowledge that not everyone is nor should be at the same level of ability and that the effort put forth is the important part. Differentiating tasks does not punish students for working at different levels on a similar task. Different students have difficulties with different topics. The purpose of teachers is to create tasks that challenge their students (Dweck, 2010a). Improving on struggling subjects or topics is a goal of growth mindset students (Dweck, 1999). If tasked with improving on struggling areas, students can approach a higher and deeper understanding of the topic in a way that they enjoy (Dweck, 2010a). This specific effort encourages students to accept challenges and learn from their mistakes as well as improve and move forward from these mistakes instead of wallowing in them or considering them as an insult. In addition, with differentiation it is important not to label the students as “smart” or “slow”. These labels stay with the students and send negative messages that they will not make it as far as other students no matter the amount of effort put into the task. Also, students labeled as “smart” may become overconfident and feel that they can put forth less effort and do not learn (Mueller & Dweck, 1998).

Changing the mindset

Actually telling the students, and teaching them about how the brain learns and how intelligence is expandable helps students see why the growth mindset is preferable. Student ambition increases when taught the growth mindset (Blackwell, Trzesniewski & Dweck, 2007). They also found that teaching students to have a growth mindset raises their grades and achievement test scores significantly. Providing tasks that challenge the students in a way where they do not fail which requires the students to put forth effort to complete a task puts into practice the growth mindset definition. Also, instead of evaluating students on whether they achieved mastery of a task, teachers should evaluate the growth of the students over time through the task or tasks. This promotes the need to try something that is difficult or something the student has yet to be introduced to.
in their studies. Teachers themselves also need to know that intelligence is always growing. Teachers’ belief in, and promotion of, growth mindsets does help students’ motivation and halting declining academic performance (Blackwell et al., 2007; Dweck, 1999). The teacher’s viewpoint on intelligence is conveyed to the students, whether intended or not. With a growth mindset, teachers see low achievers as a challenge, something they can change an influence. However, with a fixed mindset they see them as nothing they have no control over.

Interventions have been used to move people from a fixed mindset to a growth mindset. One method for doing this movement is to teach the students about the brain and the things that they can do to make their own brain work better and more efficiently. An intervention examining differences between the mindsets was found to be successful (Blackwell et al., 2007). Teaching about the brain and how it learns and grows in intelligence is a great way to do this because it is putting explanation behind the growth mindset idea. There is a website, Brainology (www.brainology.us), that is filled with experiments to see how trying and making an effort to learn something challenging makes neurons in their brains from the new connections that make them smarter, as used by Dweck (2010). A measure used in many studies is a questionnaire of Likert-type statements about intelligence, how it can change and how it is fixed. Success has been found with individuals, such as students and teachers, participating in interventions using attitude change techniques and teaching expandable intelligence (Dweck, 2008).

In the next section, I describe how I put this research to use in my own classroom for my intervention. I also describe the instruments and analysis I used in my methods.

Research Questions
1. Does my intervention change students’ views on whether physics intelligence is fixed or can grow?
2. Are students’ changes in mindset related to their academic performance?
3. Are students’ changes in mindset related to their academic performance growth?

Intervention (for action research)

Ten undergraduates and 22 high school students participated in this study. Participants were chosen by convenience. I pulled from an undergraduate course; this was an upper-divisional course taken by physics majors solely on electricity and magnetism. The high school participants were from an Advanced Placement Physics C class ranging from 11th to 12th graders. All of the students are also enrolled in the STEM Academy. This is an academy within the public school system that students can start applying to in elementary school. I physically taught the high school students with a mentor teacher, but a professor taught the undergraduate course.

The intervention consisted of an 110 minute lesson in which I taught the students about the brain’s structure and function, reading an article “You Can Grow Your Intelligence” by Blackwell et al. (2007; see Appendix B). This article describes changes that occur in the brain while learning and compared the brain to a muscle that is exercised by learning. We discussed what they learned, enforced the practice aspect of learning, and had a discussion of the significance of the fact that the brain can grow and become stronger. The posttests were administered after the electricity and magnetism section of the course.
Methods

I used two different instruments for my research. The first was the mindset evaluation. The second was the academic performance Electricity and Magnetism exam. I conducted all instruments in a pre and posttest manner. I will first describe each instrument being used in the study. I will then discuss the intervention or action strategy I used followed by my anticipated findings.

The mindset instrument tested the mindset of the participants both before and after the intervention. This was done with a 16-item (6 point) Likert-type questionnaire produced by Carol Dweck (1999; see Appendix A). A typical fixed mindset item was “You have a certain amount of intelligence, and you can’t really do much to change it.” A typical growth mindset item was “No matter who you are, you can significantly change your intelligence level.”

Participants who consistently agreed with the fixed mindset items and disagreed with growth mindset ones were classified as holding a fixed mindset. Those who consistently agreed with the growth mindset items and disagreed with the fixed mindset items are classified as holding a growth mindset. The scale is a continuous measure. This or ones like it have been used in multiple studies (Burns & Isbell, 2007; Jones et al., 2009; Miele & Molden, 2010).

The final instrument directly implemented was the growth in academic performance. Physics intelligence has been assessed for conceptual understanding in physics using standardized instruments. These instruments are tests such as the Force Concept Inventory (1992) and Brief Electricity and Magnetism Assessment developed by Chabay, Sherwood, aided by Fred Reif (1997). The test was found in 2006 to reliable, valid, and accurate (Ding et al., 2006). The test was administered both before and after the semester in electricity and magnetism to look for growth in academic achievement.

My intervention was one class period of instruction. The length of the class period was 110 minutes. This consisted of students learning about the brain structure and function, reading an article about the changes the brain goes through while learning followed by a discussion exploring the significance of the material and labels people give each other such as: “stupid” and “brainiac”. This intervention most closely resembles one used by Blackwell et al. (2007). After, I used methods that encouraged a growth mindset in the classroom. These methods emphasize effort and progress over final outcomes (Dweck, 2010a), encouraging in-depth learning (Dweck, 2010a), creating a growth mindset culture (Dweck, 2010b), praising students for their effort not their intellect (Dweck, 2008), differentiating academic tasks (Lehmann, 2002), avoiding labeling students (Jensen, 2010), evaluating students based on their growth (Dweck, 2010a), and making sure the students see that I believe in the growth mindset (Dweck, 2010b).

My hope was that the students’ mindsets would shift to growth after the intervention. I also hoped to see their academic performance increase and their mindsets move toward the growth mindset. That would mean the students know that their performance is based on effort, not ability, and know where they succeed and challenge themselves further in physics. If they know where they struggle, a growth mindset will inform them that success will come with increased effort and not for a lack of intelligence.
Methodological approach
I used quantitative methods to gather data. The intelligence questionnaires were itemized and scaled for a fixed mindset, with the growth mindset items reverse scaled to a fixed mindset. The academic performance assessment on electricity and magnetism was used to measure students’ growth in their content knowledge.

Data collection
To collect the data, I used two different tests. The pretests were administered by me on the first day of the unit to ensure that I was recording the most accurate data that I could before the intervention was implemented. I administered the posttests on the last day of the unit to ensure that I was recording the knowledge that they retained from the intervention and had time to learn all components of the content exam. The academic performance test was administered first. This was to reduce the stress of the mindset during examination. The test took 40 minutes for the students to complete. The second instrument was the mindset questionnaire. This was given to the students next and took 10 minutes to complete. The results of this test were used to evaluate whether my intervention changed the students’ mindset, the objective of the intervention.

Table 1:

<table>
<thead>
<tr>
<th>Research Questions and Data Source</th>
<th>Mindset Pre/Posttest</th>
<th>E &amp; M Pre/Posttest</th>
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<tr>
<td>Does my intervention change students' views on whether physics intelligence is fixed or can grow?</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Are students' changes in mindset related to their academic performance?</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Are students' changes in mindset related to their academic performance growth?</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

Data analysis
I used a two-tailed paired t-test to examine the changes that occurred between the mindset pre and posttests. Academic performance was evaluated using a one-tailed paired t-test between the pre and posttests. The mindset instrument was scaled for mindset relation. This means that the growth mindset questions were reverse scored and a mean mindset score was calculated for the 16 items, with the low end representing a pure fixed mindset and the high end representing a pure growth mindset. All of the participants scored as having a growth mindset on the pretest. I used a Pearson correlation to examine
the relationship between the academic performance and changes in mindset as well as changes in academic performance and changes in mindset.

Validity concerns
To minimize the effect of my own biases, I blindly collected and evaluated data while the study was in progress. This helped me to eliminate any bias I would have during the teaching of electricity and magnetism unit, trying to focus on low averaging mindsets or academic scorers. The instruments I am using have also been validated in previous studies and have found to be psychometrically strong.

Findings and interpretations
In this section, I have organized the findings to answer each of my three research questions. Following the statistical results of my analysis for each question are my interpretations of the meanings of the findings.

Does my intervention change students' views on whether physics intelligence is fixed or can grow?

To answer this question, I analyzed the students' responses on the six point Likert-type scale items (one being strongly agree, six being strongly disagree) from the pretest (see Table 2) and the posttest (see Table 3) mindset surveys. A paired, two-tailed t-test was conducted to analyze students' growth mindset beliefs before the action strategy \((M = 4.6)\) and after the action strategy \((M = 4.6)\). There was no significant difference between students' views on physics intelligence before and after the intervention \((p = .93)\). Both before and after the intervention, students continued to hold a mid-range growth mindset.

Then I looked at the responses for the fixed mindset and growth mindset items separately. Items 1, 2, 4, 6, 9, 10, 12, and 14 all measured fixed mindset beliefs. There was no significant difference in students' fixed mindset beliefs before \((M = 4.8)\) and after \((M = 4.7)\) the intervention \((p = .85)\) for the high school participants. However, the responses for the fixed mindset items did tend to decrease after the intervention compared to before. The remaining items were measuring growth mindset beliefs. There was no significant difference in students' growth mindset views of physics intelligence from pre- to post-intervention \((p = .95)\). The responses for the growth mindset items remained the same from pre- to post-intervention \((M = 4.6)\) for the high school participants.

There was no significant difference in students' mindsets from pre- to post-intervention \((p = .18)\), for the college participants. However, the response of growth mindset increased from before the intervention \((M = 4.5)\) to after \((M = 4.8)\). The change in responses for the fixed mindset items was not significant \((p = .19)\), though there was an increase from before the intervention \((M = 4.5)\) to after \((M = 4.9)\). The change in responses for the growth mindset items was not significant \((p = .20)\), though there was an increase in mean from before the intervention \((M = 4.4)\) to after \((M = 4.8)\).

**Interpretation.** The findings of the mindset survey resulted in almost no change in mindset for the high school participants and a not significant increase in the college participants. The college participants tended to adopt more of a growth mindset belief
after the intervention compared with before. During the discussion in the intervention, some high school participants were voicing opinions of people being able to grow their intelligence but only to a certain extent. This supports the growth mindset in that intelligence is malleable, but not to the extent that it is purely and effort based drive. This is supported by the high school students scoring slightly lower than the college students on the mindset survey.

The college students’ change in mindset was found both in more disagreement with the fixed mindset items and more agreement with the growth mindset items. In this case, the non-significant results mean that it is highly likely that any change in data from pre to posttest is due to chance or random fluctuations. Although teaching students about the changes in the brain due to learning did not significantly increase their growth mindset beliefs, I can infer from the results that students already held moderately strong growth mindset beliefs before the implementation of the intervention.

It is also possible that, because that the researcher was also the one administering the mindset survey, a social desirability effect took place in which the students responded in the way that they thought I wanted them to respond, even though they were assured anonymity through random number codes. This is may have occurred, but can also be due to chance due to lack of significance in the change.

Table 2:

<table>
<thead>
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<th>Measurement</th>
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<th>SD</th>
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<tr>
<td>Fixed Mindset</td>
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</tr>
<tr>
<td></td>
<td>10</td>
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<td>.83</td>
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<tr>
<td>Growth Mindset</td>
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<td>.85</td>
</tr>
<tr>
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<td>.81</td>
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Table 3:

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<td>Fixed Mindset</td>
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<td>.97</td>
<td>.85</td>
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<td></td>
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<td>4.9</td>
<td>.80</td>
<td>.19</td>
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<tr>
<td>Growth Mindset</td>
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<td></td>
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<td>.20</td>
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</table>
Are students’ changes in mindset related to their academic performance?

To answer this question, I analyzed the students’ responses from the pretest and the posttest mindset surveys as well as the academic performance instrument. A paired, one-tailed t-test was used to analyze students’ academic performance before the action strategy and after the action strategy (see Table 4). The change in responses for academic performance of the high school participants was not significant ($p = .42$), though there was an increase from before the intervention ($M = 31\%$) to after ($M = 60\%$). This is an increase of more than 9 points out of 30. Every high school student increased in academic performance from pre to posttest (see Figure 1). The change in responses for academic performance of the college participants was significant increase ($p < .001$) from before the intervention ($M = 41\%$) to after ($M = 42\%$). This is a significant increase of less than 1 point out of 30. Only half of the college participants increased in academic performance from pre to posttest (see Figure 2).

A Pearson correlation was used to analyze students’ change in mindset with the posttest of the academic performance instrument. I subtracted the means of the pretest from the posttest to calculate the change in mindset. The high school students’ change in mindset had a moderate strong positive correlation, $r = .52$ (see Figure 3), with the academic performance. The college participants’ change in mindset had a moderate strong negative correlation, $r = -.48$ (see Figure 4), with the academic performance.

**Interpretation.** The findings of the academic performance instrument resulted in an increase from both the high school and college participants. Even though the means for the high school participants about doubled, only the college participants increased significantly. This means that both participant groups learned more about electricity and magnetism during the spring semester.

There was a moderate strong positive correlation between mindset and academic performance for the high school participants. This means that students who had a higher growth mindset also scored higher on the academic performance instrument. Unfortunately, this was found to be opposite for the college participants. Students who scored lower on the growth mindset also scored higher on the academic performance instrument. This may be complicated by the small sample size of college participants and the fact that not all of the college participants increased in their academic performance from pre to posttest. Remember, half of the college participants scored higher on the pretest than the posttest.

The administration of the posttests was different for the college than the high school students, which could also attribute to this difference in correlation. The college students took the posttest during finals week. Because of this, in order to increase participation, students were awarded extra credit on their final if they showed up to take the posttest. This means that the students who self-selected to participate in the posttest (three people did not take the posttest) were probably students who needed the extra credit for the class. This tends to be students with lower grades, trying to increase it before the end of the semester. The high school students were not given the same opportunity.
Table 4:

_Mean Scores For Academic Performance_

<table>
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<th>Measurement</th>
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<tr>
<td></td>
<td>Posttest</td>
<td>Posttest</td>
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<tr>
<td></td>
<td>3.4</td>
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*Figure 1. Academic Performance of high school participants.*
Are students’ changes in mindset related to their academic performance growth?

A Pearson correlation was used to analyze the students’ responses from the pretest and the posttest mindset surveys as well as the academic performance instrument. A Pearson correlation was conducted to analyze students’ change in mindset with the change in the academic performance instrument. I subtracted the scores on the pretest from the posttest to calculate the change in mindset. I subtracted the sum of the pretest from the posttest to calculate the academic growth of the students. The high school participants’ change in mindset has a moderate strong positive correlation, $r = .46$ with the academic growth. The college participants’ change in mindset has a weak correlation, $r = .07$ with the academic growth.

**Interpretation.** The correlation was moderately strong between the academic growth and change in mindset for the high school participants. This means that students who had a stronger growth mindset not only showed higher academic performance, but also their scores increased the most. This shows that the high school students grew and progressed in learning electricity and magnetism.

Unfortunately, the college participants’ correlation showed little to no relationship between academic growth and change in mindset.

Because of the lack of correlation with the college students, it may also be possible that there is no relationship between mindset and academic growth. This, once again however, may be because that half of the college participants had negative academic growth. The students who self-selected to participate may have also played affected this correlation.
Discussion of results

Due to the small sample size and limited amount of time to change long-held beliefs, students in this study did not adopt more growth mindset beliefs. However, it again bears emphasis that students already showed moderately strong growth mindset beliefs before the implementation of the intervention. With a larger sample size and more time to implement the intervention, researchers can more accurately assess the extent to which learning about the brain's changes has any effect on students who hold a fixed mindset belief.

My results are also consistent with Jones et al. (2009) finding that the majority of high school students believe in the growth mindset. All of the students that participated had a growth mindset even though it was not always strong.

Dweck (2008) theorized that people could have a fixed view of math skills but a growth view when it comes to talent or athletic ability. It is similarly possible that even though students hold a growth mindset in general, domain-specific mindsets may be more fixed. For example, most of the students reported having a growth mindset even though in class I overheard discussion of not being able to understand electricity and magnetism.

My intervention, even though founded in multiple studies (Blackwell et al., 2007; Dweck, 2008; Dweck, 2010), was not particularly effective. I was not able to use the Brainology program due to financial limitations. However, I tried my best to recreate the intervention based on the descriptions made in the methods sections of those studies. I think that this may have played a part in the effectiveness of the intervention.

The correlation between both academic performance and mindset, as well as academic growth and mindset with the high school participants supports the work done by Alpay and Ireson (2006), Blackwell et al., (2007), and Dweck (2010). These studies also found a positive relation between growth mindset and academic performance. However, the college participants showed a negative relationship between academic performance and mindset.

Conclusion

The purpose of this research was to determine if encouraging students to see their abilities as malleable improved their performance in physics in an advanced physics classroom. Students with growth mindsets significantly outperform their classmates who hold fixed mindsets (Blackwell et al., 2007; Dweck, 2010). Thus, I hoped to change students' beliefs that their abilities were fixed. I had three different research questions to determine if this change occurred in my sample of high school and college students. Although there was no significant change in the mindset for the high school students, I did find that they had a stronger growth mindset that showed more academic growth compared to the college students who did not show a relationship.

Limitations

The size of my sample is was too small to generalize. Not only did I only have 13 college participants to start, the data set had to be adjusted for absences in the posttest collection. I believe that a sample size of 22 high school and 10 college participants may
have been too small for the quantitative analyses I conducted and may have lead to Type II errors (i.e. false negative whether an effect exists).

Although I employed the intervention with both groups of participants, I only taught the high school students for 7 of the 15 weeks of the semester-long unit. Although this unit took place over a 15-week period of time, much instruction was cut short, or delayed due to field trips, county assessments, and spring break. Two different teachers for the high school and a college professor conducted the instruction for this unit that could also have had adverse effects. I was not there to make sure that the other instructors were promoting a growth mindset.

In the future, I would like to start the intervention on the first day of school, conducting research over both semesters. Fifteen weeks is simply not enough time to change beliefs that have been developed over 15-20 years.

Implications

Practice. I would recommend that teachers who struggle with the fixed mindsets of their students try to establish a growth mindset culture in the classroom. They should make sure that they are addressing students’ responses and answers in terms of effort and not innate ability (Mueller & Dweck, 1998). Teachers should give feedback based on progress instead of whether the answer is just correct or not. Students need to learn how to approach a topic with which they struggle without giving up (Dweck, 2010a). Putting in time and effort to learn something does not mean that a student or person is “stupid.” It means that he or she is dedicated and wants to learn. Students and teachers need to adopt the motto “Practice makes progress”.

Theory. This study supports the theory that academic growth and performance is related to the mindset of the student. More research is needed that explores subject-based mindsets, as a lot of students already over half of high school students hold a growth mindset (Jones et al., 2009) but their mindsets may vary according to academic subject (Dweck, 2008).

Future Research. In the future, I would like to increase my sample size by including other AP Physics C classes in the study from different schools. I would also start my study at the beginning of the school year instead of half way through. This would give me more time to change mindsets if necessary. In addition, I would adapt the mindset survey to be specific to physics mindsets.

In practice, I would add discussion between the students to my intervention. Having students talk about what they struggle with in each unit will help students see that all students struggle with content. In my instruction, I would put more emphasis on learning from mistakes. In the unit, I addressed students’ mistakes if they were shown by chance. In the future, I would like to pick out a mistake from the class to address how students can learn from their mistakes. This would also help students see the benefits to recovery on tests.

I found in my study that my intervention did not change students’ mindsets. I did however find a moderately strong correlation with the high school participants between both change in mindset and academic performance, and change in mindset and growth. Although my intervention may not have changed my small sample sizes’ mindsets, their
intellectual abilities did improve and I believe there is still a need to move toward the
growth mindset movement.

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## Appendix A

### Mindset Test

Please show how much you agree or disagree with each statement by circling the number that corresponds to your opinion.

1. You have a certain amount of intelligence, and you can’t really do much to change it.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

2. Your intelligence is something about you that you can’t change very much.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

3. No matter who you are, you can significantly change your intelligence level.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

4. To be honest, you can’t really change how intelligent you are.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

5. You can always substantially change how intelligent you are.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

6. You can learn new things, but you can’t really change your basic intelligence

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

7. No matter how much intelligence you have, you can always change it quite a bit.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>

8. You can change even your basic intelligence level considerably.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
</table>
9. You have a certain amount of talent, and you can’t really do much to change it.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

10. Your talent in an area is something about you that you can’t change very much.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

11. No matter who you are, you can significantly change your level of talent.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

12. To be honest, you can’t really change how much talent you have.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

13. You can always substantially change how much talent you have.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

14. You can learn new things, but you can’t really change your basic level of talent.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

15. No matter how much talent you have, you can always change it quite a bit.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree

16. You can change even your basic level of talent considerably.

   Strongly Agree    Mostly Agree    Mostly Disagree    Disagree    Strongly Disagree
You Can Grow Your Intelligence

New Research Shows the Brain Can Be Developed Like a Muscle

Many people think of the brain as a mystery. They don't know much about intelligence and how it works. When they do think about what intelligence is, many people believe that a person is born either smart, average, or dumb—and stays that way for life.

But new research shows that the brain is more like a muscle—it changes and gets stronger when you use it. And scientists have been able to show just how the brain grows and gets stronger when you learn.

Everyone knows that when you lift weights, your muscles get bigger and you get stronger. A person who can't lift 20 pounds when they start exercising can get strong enough to lift 100 pounds after working out for a long time. That's because the muscles become larger and stronger with exercise. And when you stop exercising, the muscles shrink and you get weaker. That's why people say "Use it or lose it!"

But most people don't know that when they practice and learn new things, parts of their brain change and get larger a lot like muscles do when they exercise.

Inside the cortex of the brain are billions of tiny nerve cells, called neurons. The nerve cells have branches connecting them to other cells in a complicated network. Communication between these brain cells is what allows us to think and solve problems.
When you learn new things, these tiny connections in the brain actually multiply and get stronger. The more that you challenge your mind to learn, the more your brain cells grow. Then, things that you once found very hard or even impossible to do--like speaking a foreign language or doing algebra--seem to become easy. The result is a stronger, smarter brain.

**A Typical Nerve cell**

**How Do We Know the Brain Can Grow Stronger?**

Scientists started thinking that the human brain could develop and change when they studied animals’ brains. They found out that animals who lived in a challenging environment, with other animals and toys to play with, were different from animals who lived alone in bare cages.

While the animals who lived alone just ate and slept all the time, the ones who lived with different toys and other animals were always active. They spent a lot of time figuring out how to use the toys and how to get along with the other animals.

These animals had more connections between the nerve cells in their brains. The connections were bigger and stronger, too. In fact, their whole brains were about 10% heavier than the brains of the animals who lived alone without toys.

The animals who were exercising their brains by playing with toys and each other were also "smarter"--they were better at solving problems and learning new things.

Even old animals got smarter and developed more connections in their brains when they got the chance to play with new toys and other animals. When scientists put very old animals in the cages with younger animals and new toys to explore, their brains grew by about 10%! 
Children’s Brain Growth

Another thing that got scientists thinking about the brain growing and changing was babies. Everyone knows that babies are born without being able to talk or understand language. But somehow, almost all babies learn to speak their parents’ language in the first few years of life. How do they do this?

The Key to Growing the Brain: Practice!

From the first day they are born, babies are hearing people around them talk—all day, every day, to the baby and to each other. They have to try to make sense of these strange sounds and figure out what they mean. In a way, babies are exercising their brains by listening hard.

Later, when they need to tell their parents what they want, they start practicing talking themselves. At first, they just make goo-goo sounds. Then, words start coming. And by the time they are three years old, most can say whole sentences almost perfectly.

Once children learn a language, they don’t forget it. The child’s brain has changed—it has actually gotten smarter.

This can happen because learning causes permanent changes in the brain. The babies’ brain cells get larger and grow new connections between them. These new, stronger connections make the child’s brain stronger and smarter, just like a weightlifter’s big muscles make them strong.

Newborn 3 months 15 months 2 years
Development of nerve cells in the brain from birth to 2 years old. The nerve cells grow both in size and in number of connections between them.
The Real Truth About "Smart" and "Dumb"

No one thinks babies are stupid because they can't talk. They just haven't learned how to yet. But some people will call a person dumb if they can't solve math problems, or spell a word right, or read fast—even though all these things are learned with practice.

At first, no one can read or solve equations. But with practice, they can learn to do it. And the more a person learns, the easier it gets to learn new things—because their brain "muscles" have gotten stronger!

The students everyone thinks is the "smartest" may not have been born any different from anyone else. But before they started school, they may have started to practice reading. They had already started to build up their "reading muscles." Then, in the classroom, everyone said, "That's the smartest student in the class."

They don't realize that any of the other students could learn to do as well if they exercised and practiced reading as much. Remember, all of those other students learned to speak at least one whole language already—something that grownups find very hard to do. They just need to build up their "reading muscles" too.

What Can You Do to Get Smarter?

Just like a weightlifter or a basketball player, to be a brain athlete you have to exercise and practice. By practicing you make your brain stronger. You also learn skills that let you use your brain in a smarter way—just like a basketball player learns new moves.

But many people miss out on the chance to grow a stronger brain because they think they can't do it, or that it's too hard. It does take work, just like becoming stronger physically or becoming a better ball player does. Sometimes it even hurts! But when you feel yourself get better and stronger, all the work is worth it!

E-mail questions or comments to: Growyourbrain@aol.com