ABSTRACT

SUPPORTING GROWTH MINDSET IN UPPER-LEVEL HIGH SCHOOL STUDENTS: A COMPARISON OF TWO CLASSROOM INTERVENTIONS

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Research has shown that many students harbor the belief that intelligence is an immutable characteristic, incapable of growth via effort. Reasons for such a debilitating self-theory of intelligence include implicit and explicit cues from parents or teachers, experiences in educational settings that emphasize competition or normative comparisons, and the threat of confirming stereotypes about intellectual limitations.

This quasi-experimental study compares two interventions to improve the self-theories of upper-level high school students. Students in both interventions were invited to research mindset, learn facets of neurophysiology, and become familiar with the effects of personal habits on the learning process. One group wrote research term papers on the three topics. A second group addressed the topics to fifth-grade students in pen-pal letters meant to offer informed advice about learning (i.e., the capacity to become “smarter”) to the younger students.

Results showed that although neither was statistically superior in manipulating mindset or teaching neurophysiology, students in both interventions showed significant increases in their belief in the malleability of intelligence, their inclination to adopt mastery
goals, and their ability to suppress test anxiety. The pen-pal intervention generated higher levels of student enthusiasm for the activity and engagement in it. It was noted that the pen-pal intervention offered the additional advantage of conveying the powerful message of internal locus of control inherent to a growth mindset to a broader audience via delivery of the letters to fifth-grade students. Results are discussed in terms of their implications for teaching practices, teacher preparation, and future research.
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SUPPORTING GROWTH MINDSET IN UPPER-LEVEL HIGH SCHOOL STUDENTS:
A COMPARISON OF TWO CLASSROOM INTERVENTIONS

BY
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DEDICATION

First, to my dad. Talk about a scholar—I couldn’t hope to carry his slide rule. And even though he’s been gone eight years now, I know he would be very proud. When I try to do things as he did, they inevitably turn out right.

Second: To all of my students over the last several years.

I want to thank them for being so interested in the work,

for participating in some of it,

and for forgiving my performance as their teacher

when it sagged under the weight of trying to get this work done.
# TABLE OF CONTENTS

| LIST OF TABLES                                      | viii |
| LIST OF FIGURES                                    | ix   |
| LIST OF APPENDICES                                 | x    |

## Chapter

1. INTRODUCTION ................................................................. 1
   Problem Statement ......................................................... 3
   Theoretical/Conceptual Framework ................................. 6
      Mindset ................................................................. 6
      Influence ............................................................... 7
   Research Questions ...................................................... 9
   Significance of/Need for the Study ............................. 11
   Definitions ............................................................... 13
   Methodology .............................................................. 16
   Organization of the Study ............................................. 18

2. LITERATURE REVIEW ........................................................... 19
   Introduction ............................................................... 19
   Goals ........................................................................ 20
   Mindset .................................................................... 26
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mindset, Goal Orientation, Learning Behaviors, and Achievement Outcomes</td>
<td>28</td>
</tr>
<tr>
<td>Mindset and Goal Orientation</td>
<td>29</td>
</tr>
<tr>
<td>Goal Orientation and Learning Behavior</td>
<td>32</td>
</tr>
<tr>
<td>Effort Beliefs</td>
<td>33</td>
</tr>
<tr>
<td>Reaction to Challenge/Setback</td>
<td>35</td>
</tr>
<tr>
<td>Learning Behavior and Achievement Outcomes</td>
<td>36</td>
</tr>
<tr>
<td>How Can Mindset Be Changed?</td>
<td>38</td>
</tr>
<tr>
<td>How to Teach Neurophysiology</td>
<td>43</td>
</tr>
<tr>
<td>3. METHODOLOGY</td>
<td>46</td>
</tr>
<tr>
<td>Research Design</td>
<td>46</td>
</tr>
<tr>
<td>Teacher/Researcher</td>
<td>48</td>
</tr>
<tr>
<td>Participants</td>
<td>49</td>
</tr>
<tr>
<td>Context and High School Setting</td>
<td>49</td>
</tr>
<tr>
<td>Student Participants</td>
<td>53</td>
</tr>
<tr>
<td>Intervention: Two Approaches to Instruction</td>
<td>54</td>
</tr>
<tr>
<td>Intervention Description and Timeline</td>
<td>55</td>
</tr>
<tr>
<td>Data-Collection Procedures</td>
<td>61</td>
</tr>
<tr>
<td>Measures</td>
<td>61</td>
</tr>
<tr>
<td>Achievement</td>
<td>64</td>
</tr>
<tr>
<td>Participant Observation</td>
<td>65</td>
</tr>
<tr>
<td>Term Papers and Pen-Pal Letters</td>
<td>67</td>
</tr>
<tr>
<td>Fifth-Grade Student Feedback</td>
<td>68</td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Parametric Assumptions</td>
<td>69</td>
</tr>
<tr>
<td>Analytic Plan and Preliminary Analysis</td>
<td>70</td>
</tr>
<tr>
<td>Mindset Survey Results</td>
<td>70</td>
</tr>
<tr>
<td>Neurophysiology Test Results</td>
<td>71</td>
</tr>
<tr>
<td>Qualitative Analysis</td>
<td>71</td>
</tr>
<tr>
<td>Field Notes and Research Journal</td>
<td>72</td>
</tr>
<tr>
<td>Student Products</td>
<td>72</td>
</tr>
<tr>
<td>4. RESULTS OF DATA ANALYSIS</td>
<td>73</td>
</tr>
<tr>
<td>Introduction</td>
<td>73</td>
</tr>
<tr>
<td>Endorsement of Mindset</td>
<td>73</td>
</tr>
<tr>
<td>Influencing Mindset by Teaching Neurophysiology</td>
<td>76</td>
</tr>
<tr>
<td>Neurophysiology Comprehension and Retention from Two Different Teaching Interventions</td>
<td>85</td>
</tr>
<tr>
<td>Salient Indicators of Engagement with and Enjoyment of the Intervention</td>
<td>86</td>
</tr>
<tr>
<td>Summary of Quantitative Analysis</td>
<td>93</td>
</tr>
<tr>
<td>Summary of Qualitative Analysis</td>
<td>93</td>
</tr>
<tr>
<td>5. DISCUSSION</td>
<td>95</td>
</tr>
<tr>
<td>Summary</td>
<td>95</td>
</tr>
<tr>
<td>Research Question 1: Prevalence of Mindset</td>
<td>95</td>
</tr>
<tr>
<td>Research Question 2: Susceptibility of Mindset to Influence</td>
<td>106</td>
</tr>
<tr>
<td>Research Question 3: The Teaching of Neurophysiology</td>
<td>116</td>
</tr>
<tr>
<td>Research Question 4: Comparative Levels of Engagement</td>
<td>118</td>
</tr>
<tr>
<td>Summary</td>
<td>119</td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Intervention</td>
<td>120</td>
</tr>
<tr>
<td>Implications</td>
<td>123</td>
</tr>
<tr>
<td>Implications for Teaching Practice</td>
<td>123</td>
</tr>
<tr>
<td>Implications for Teacher Preparation</td>
<td>130</td>
</tr>
<tr>
<td>Implications for Professional Development</td>
<td>131</td>
</tr>
<tr>
<td>Implications for Research</td>
<td>132</td>
</tr>
<tr>
<td>Gender Implications</td>
<td>133</td>
</tr>
<tr>
<td>The Teacher/Researcher’s Preference for the Pen-Pal Intervention</td>
<td>136</td>
</tr>
<tr>
<td>Limitations</td>
<td>137</td>
</tr>
<tr>
<td>Conclusion</td>
<td>139</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>141</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>151</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table | Page
---|---
1. Gender and Ethnic Breakdown of Participants | 54
2. First Two Calendar Months of Interventions | 55
3. Third Calendar Month of Interventions | 56
4. Fourth Calendar Month of Interventions | 59
5. Time 1, Time 2, and Time 3 Neurophysiology Assessment Descriptive Statistics | 65
6. Pre-intervention Mindset Scale Score Descriptive Statistics | 74
7. Independent Samples T-Test Comparing Pre-Intervention Mindset Beliefs by Class Type | 74
8. Independent Samples T-Test Comparing Pre-Intervention Mindset Beliefs by Gender | 75
9. Prevalence of Mindset | 76
10. Mixed Between-Within ANOVA Descriptive Statistics | 77
11. Neurophysiology Test Scores Descriptive Statistics | 84
12. ANCOVA Assumption Correlations | 197
13. Homogeneity of Regression Intervention and Gender Significance Values | 198
14. Tests of Between-Subjects Effects | 199
15. Tests Results for Homogeneity Of Regression Slopes | 201
16. Tests Results of Between-Subjects Effects | 202
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 2 X 2 goal orientation model summary</td>
<td>25</td>
</tr>
<tr>
<td>2. Classroom layout</td>
<td>51</td>
</tr>
<tr>
<td>3. Effort beliefs by intervention</td>
<td>79</td>
</tr>
<tr>
<td>4. Boys’ effort beliefs by intervention</td>
<td>79</td>
</tr>
<tr>
<td>5. Girls’ effort beliefs by intervention</td>
<td>80</td>
</tr>
<tr>
<td>6. Test anxiety by intervention</td>
<td>81</td>
</tr>
<tr>
<td>7. Boys’ test anxiety by intervention</td>
<td>82</td>
</tr>
<tr>
<td>8. Girls’ test anxiety by intervention</td>
<td>83</td>
</tr>
<tr>
<td>9. Term paper grading rubric</td>
<td>174</td>
</tr>
<tr>
<td>10. Field note record</td>
<td>193</td>
</tr>
<tr>
<td>11. Fifth-grade student feedback form</td>
<td>195</td>
</tr>
</tbody>
</table>
# LIST OF APPENDICES

<table>
<thead>
<tr>
<th>APPENDIX</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.  A PILOT STUDY</td>
<td>150</td>
</tr>
<tr>
<td>B.  DISTRICT APPROVAL REQUEST</td>
<td>154</td>
</tr>
<tr>
<td>C.  PARTICIPANT RECRUITMENT SCRIPT</td>
<td>157</td>
</tr>
<tr>
<td>D.  CONSENT FORMS</td>
<td>158</td>
</tr>
<tr>
<td>E.  INTERVENTION EXPLANATION HANDOUT</td>
<td>168</td>
</tr>
<tr>
<td>F.  TERM PAPER RUBRIC</td>
<td>172</td>
</tr>
<tr>
<td>G.  STUDENT MINDSET SURVEY</td>
<td>174</td>
</tr>
<tr>
<td>H.  NEUROPHYSIOLOGY ASSESSMENT</td>
<td>185</td>
</tr>
<tr>
<td>I.  FIELD NOTES FORM</td>
<td>191</td>
</tr>
<tr>
<td>J.  FIFTH-GRADE STUDENT FEEDBACK FORM</td>
<td>193</td>
</tr>
<tr>
<td>K.  ANOCOVA ASSUMPTIONS TESTS</td>
<td>196</td>
</tr>
<tr>
<td>L.  TERM PAPER AND PEN PAL LETTER EXAMPLES</td>
<td>202</td>
</tr>
<tr>
<td>M.  ADDITIONAL PARAMETRIC ASSUMPTIONS NECESSARY FOR 2-WAY ANCOVA</td>
<td>209</td>
</tr>
</tbody>
</table>
Teachers are as willing to label some of their students “smart” almost as much as they are unwilling to label other students “stupid.” Many students, on the other hand, have no qualms about applying the terms to themselves or their peers. Roughly half of all students believe they know where they are on the spectrum from smart to stupid and, additionally, are fairly convinced of the stability of their position on that spectrum (Dweck, 2000). The bright students among this half are inclined to protect their presumed favored status, and struggling students seek only to hide their shortcomings.

By contrast, an equal number of students reject the existence of such an intelligence continuum and dismiss the idea of occupying some permanent position upon it (Dweck, 2000). These students are more likely to acknowledge a real-time level of ignorance, a condition they consider temporary and susceptible to change through effort. Unencumbered by the need to maintain appearances, these students recognize that trying, failing, and trying again (better) is the grist of the intellectual mill, not proof of inadequacy.

These two opposing perspectives of the fluidity of one’s own intelligence have logically come to be known as self-theories of intelligence or mindset. Students steadfast in their beliefs in the immutable nature of (typically) domain-specific ability are said to have a fixed mindset or, alternatively, to maintain an entity theory of intelligence. Conversely,
students who think that they can affect achievement progress or outcome via their own efforts are said to possess a *growth-mindset* or an *incremental* theory of intelligence.

Research by Dweck (2000) demonstrates that perceptions about the malleability of intelligence beget sharply contrasting patterns of learning behavior and that these patterns are determinants of achievement outcomes. The advantages of believing in the efficacy of effort to manifest change in ability should be apparent. Just as apparent is how detrimental it must be to think one’s self both lacking and unable to affect any change. Less apparent are the negative consequences of believing that one’s intelligence is both high and fixed. In the quest to maintain that image, these students are likely to make choices in the classroom that ultimately impede their progress. The susceptibility of student mindset to change, demonstrated in separate studies by Dweck (1986, 2000) and Aronson, Fried, and Good (2002), is cause for optimism for students who hold entity theories of their own intelligence. This study adds to that body of research by comparing two different approaches to influencing students’ theories of their intelligence.

Specifically, this study provides a rich descriptive account of the implementation of two approaches to teach mindset-related brain physiology to upper-level high school students. Both approaches covered the same content but differed in the nature of the students’ role within the instructional practice. One approach involved a novel activity that required more active participation in the learning process, but the second approach was a more traditional activity in which students assumed a more passive role.

Quantitative and qualitative methods were used to examine the effect of each approach on high school student mindset and interest as indicated by surveys, student
reflections, and researcher observations. In addition, pretesting and posttesting facilitated quantitative comparison of cognitive understanding and retention of the lesson’s subject matter, taken here to refer to a modest level of neurophysiology. Surveys, student reflections, and researcher observations were employed as a means of providing a more comprehensive narrative that compared the experiences of students in both interventions.

Problem Statement

Although there exists some ambiguity regarding a correlation between student motivation and achievement, there is less doubt regarding the connection between student motivation and learning behavior. Learning goal structures or mastery goals that emphasize learning focus student attention on the task at hand and, in doing so, tend to elicit higher levels of challenge-seeking, subject-matter interest, and personal satisfaction (Meece, 2003). In contrast, goal structures that emphasize performance are more likely to elicit lower levels of effort, interest, and task enjoyment (Brophy, 2005). And despite higher esteem among teachers for mastery goals, students are more likely to adopt performance goals (Mensah & Atta, 2015).

In addition, although the debate regarding the relative merits of goal orientation continues, research suggests that student motivation at every level of the educational system is in decline and that the problem becomes more acute as students progress through the grades (Anderman & Maehr, 1994; Cordova & Lepper, 1996; Fredricks, Blumenfeld, & Paris, 2004; Fredricks & Eccles, 2002; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Prawat, Grissom, & Parish, 1979; Shean Jen & Yong, 2013; Virtue, 2014; Wigfield,
Eccles, Mac Iver, Reuman, & Midgley, 1991) and might render moot the outcome of the debate. During these formative years, more students come to believe in the (supposedly) fixed nature of their intelligence (Dweck, 2000). This coincidental migration away from wanting to do the work and toward steadfast belief in the work’s futility (with a logical and concomitant drop in motivation) represents a “one-two punch” difficult for many students to overcome.

Additional research shows that the decline in interest in schoolwork is especially precipitous in the areas of math and science (Arambula Greenfield, 1997; George, 2000; Gottfried, Fleming, & Gottfried, 2001; Kahle & Rennie, 1993; Osborne, Simon, & Collins, 2003), a particularly troubling trend in light of the acknowledged importance of these two disciplines to the economic health of any society (Trefil, 2008). Increased societal reliance on technology quite naturally makes such a society more “communally dependent on individuals with a high level of scientific and technological expertise and competence” (Osborne et al., 2003, p. 1052). Should these trends in negative attitudes toward science and math prevail, the demand for these competencies may soon outstrip supply.

Beyond the need to recruit science, technology, engineering, and math (STEM) scholars, the digitization of society raises another pressing issue:

Historically, most educators’ attention has been focused on finding ways to improve the national supply of technically competent men and women—an important goal. Today, however, faced with national issues that are increasingly acquiring scientific and technical dimensions, we are starting to turn to the question of how to go about providing the average citizen with enough scientific knowledge to allow them to participate in public debates in a meaningful way. (Trefil, 2008, p. ix)
Put another way, the challenge before teachers is to reform STEM education at every level in order to increase the number of citizens who can do science as well as increase the number of citizens who know science.

Moreover, the lessons of the past few hundred years and the advancements afforded by them have shown that the scientific way of coming to know something (analysis and interpretation of empirical evidence) is dependable. And by its nature, scientific understanding demands the acceptance of failure as a learning experience. Advancement is the result of observing, experimenting, interpreting, and revising. Experimenting, as the “brutally impartial outside referee” (Trefil, 2008, p. 8), is the single step that most signifies the scientific method and the step that poses the most risk. It is likely no coincidence that these activities are also characteristics of a growth mindset (Shumow & Schmidt, 2013).

To date, the bulk of research into self-theories of intelligence has been performed in grade school classrooms, college classes, and occasionally in the middle grades. Working at the lower end of the age spectrum makes sense from the standpoint of trying to discover how, when, and why either of the two contrary mindsets emerge. The acknowledged difficulty of the transition from grade school to middle school or junior high school, along with the pivotal role mindset plays in that transition, justifies the attention conferred on this particular segment of the student population. Inquiry into longitudinal trends in mindset retention and achievement trajectory justifies work with college students as the last stop in the educational process for most. Attention has been paid to these particular stages of K-8 and college education largely at the expense of high school students.
Theoretical/Conceptual Framework

**Mindset**

During the course of her research into student goal orientations, Dweck (1986) detected patterns of behavior associated with opposing schools of thought regarding the malleability of intelligence. In subsequent research, Dweck and Leggett (1988) and Dweck (2000) linked mindset to patterns of learning behavior demonstrated by students according to their beliefs about intelligence. In particular, Dweck and her colleagues detected differences in the goal orientations of both types of students as well as how they reacted to setbacks, how they reacted to challenging tasks, and what effort meant to them.

Among students, incremental theorists are inclined to adopt *mastery goals* wherein they seek to extend their understanding. Conversely, entity theorist students adopt *performance goals* for which success is defined as either demonstrating superiority or hiding inferiority in normative comparisons with peers. Incrementalists are likely to perceive setbacks as a sign that they do not understand—*yet*. Entityists interpret the same news as a sign that they will *never* understand. Challenge is met by incrementalists as an opportunity and by entityists as a risk. To the incrementalist, effort is an engaging part of the process, but entityists eschew it as either futile or as a sign of weakness.

During the course of their studies, the researchers facilitated comparisons of the two mindsets by observing the *same* students with *different* mindsets (Dweck, 2000; Dweck & Leggett, 1988). To do so, the researchers implemented interventions designed to induce one mindset or the other. And what began as a methodological footnote of much of the
research has now become the focus of many subsequent studies, including this one. If, at
the very least, correlations are accepted between mindset and learning behavior and
between learning behavior and achievement outcome, and, additionally, it is accepted that
mindset is subject to change, then efforts to discover the most efficacious way to do so have
merit.

**Influence**

At the very least, high school science students could benefit from the tutelage of
instructors familiar with mindset and, in particular, its susceptibility to change. It stands to
reason that these benefits could be further leveraged if those instructors employed research-
based instructional practices designed to elicit change. This research compares two
different interventions designed to effect such change.

The two teaching practices that were compared varied significantly with regard to
the roles played by the instructor and students. Attempts to label these approaches have
been somewhat problematic. “Traditional” versus “nontraditional” is perhaps too broad.
“Active” versus “passive” seems close in several aspects but is limited due to the lack of
consensus on definitions of each approach (Michel, Cater, & Varela, 2009).

Of late, a great deal of attention has been paid to instructional strategies termed
“active.” A Boolean search for peer-reviewed articles appearing in journals reveals the
educational and research communities’ growing fascination. A search using “active
learning” as an exact descriptor yields a single article in 1992, two additional articles in
1993, and an average of just over 80 per year during the next decade. If the number of
articles can be taken as reflective of interest in active learning, 2004 was the year that the educational research community really began to take notice. That year, the number of articles jumped by almost 90% from the previous year and increased every year thereafter, peaking at 324 articles in 2012. High regard for the concept, compared to more passive forms of instruction, is exemplified by Bonwell and Eison’s (1991) characterization of active learning as

learning [that] provides the following benefits: students are more involved than in passive listening; students are more engaged in activities such as reading, discussing, and writing; student motivation is increased; students can receive immediate feedback; and students may engage in higher-order thinking, such as analysis, synthesis, and evaluation. (p. 398)

Presumption of the superiority of active learning is perhaps understandable in consideration of the preceding list of virtues. For the purposes of research that, in part, sought to compare instructional practices that might be labeled more active versus more passive, the researcher presumed no such superiority.

Further, the active/passive terminology is often linked with the degree of guidance students receive in the classroom. Consideration of the level of guidance calls into question the merits of all constructivist approaches to learning (Kirschner, Sweller, & Clark, 2006; Sweller, Kirschner, & Clark, 2007), which was decidedly not the focus of this research. Neither were the modest ambitions of this study to help to settle the active-versus-passive debate.

All students in the study were expected to research mindset and a modest level of neurophysiology designed to support the plasticity of intelligence. In both treatments,
whole-class discussions were conducted in order to uncover misconceptions and facilitate a level of consistency of what had been learned during the course of the student research.

The differences in the instructional strategies lie in (a) how the students performed their research and (b) why they performed the research. Students in one treatment group worked in isolation (relative to a second treatment group) to write a research term paper. Students in the second group, utilizing a research format that imposed cooperative strategies (detailed in Chapter 3), were charged with writing a pen-pal letter to a young student in the district to communicate what they (the letter-writers) had learned. Opportunities to work in small and large groups and to use creativity were significantly better for students in the pen-pal treatment than they were for the term-paper writers.

Research Questions

This research study sought answers the following questions:

1. To what degree do students endorse a growth mindset, and are these beliefs about their intelligence related measurably to gender or level of physics class?

   H1: It was hypothesized that descriptive statistics would suggest an overall positive skewness toward the fixed end of the mindset spectrum but that a comparison of endorsement of either mindset according to gender or class would not be statistically significant.

2. How do students who experience different interventions that teach neurophysiology compare with respect to the degree to which they espouse various
mindset-related beliefs, including beliefs about the malleability of intelligence, mastery-goal orientation, effort beliefs, test anxiety, and the use of positive learning strategies?

H2: It was hypothesized that the novelty of the pen-pal intervention and its incorporation of practices designed to elicit stable attitude changes would combine to more effectively result in positive changes in self-theories of intelligence than would the term-paper intervention. Anticipated manifestations of positive changes were an increased recognition of the malleability of intelligence, an orientation toward mastery of course content, higher attributions of the role of effort, lower levels of test anxiety, and greater appreciation of positive (adaptive) learning strategies.

3. How do students in the different instructional approach groups compare with respect to comprehension and retention of course content on neurophysiology?

H3: It was hypothesized that the achievement gains of students exposed to the material within the more student-centered learning environment inherent to the pen-pal intervention would reap greater comprehension and retention gains.

4. How do students in the different instructional approach groups compare with respect to how engaged they are in the activity as manifested in their response to (and enthusiasm for) the activity, their persistence at the task, their apparent enjoyment derived from participation, and any other salient indicators of experiential differences that may have arisen during the course of the study?

H4: It was hypothesized that students exposed to the material within the context of learning it in order to reteach it to younger students (the pen-pal
intervention) would experience greater subject-matter comprehension and retention gains and would exhibit higher levels of lesson engagement.

Significance of/Need for the Study

Accepting that student motivation for school and interest in science is in decline (Anderman & Maehr, 1994; Cordova & Lepper, 1996; Fredricks et al., 2004; Fredricks & Eccles, 2002; Hulleman, Godes, et al., 2010; Wigfield et al., 1991), classroom teachers face an increasingly uphill battle to engage their students in the study of a discipline identified as both critical for national prosperity and rife with career opportunities (George, 2000; Gottfried et al., 2001; Kahle & Rennie, 1993; Osborne et al., 2003; Trefil, 2008). Research into motivation has uncovered connections between self-theories of intelligence and learning behaviors that bear on academic outcomes (Dweck, 1986, 2000; Dweck & Leggett, 1988). Other research has suggested that self-theories are subject to modification and, further, that an effective means of doing so is to teach aspects of neurophysiology that demystify the physical learning process (Aronson et al., 2002; Bergen, 1991; Dweck & Leggett, 1988).

Coincidental to the evolution of thought that characterizes theories of intelligence as a dependable predictor of goal orientations, learning behaviors, and achievement outcomes has been the explosion of articles, books, and conferences dedicated to neurophysiology and its application to education. The concurrence of these developments is suggestive of a perfect storm in which educators are aware of debilitating student mindsets and efficacious
methods for influencing mindset and have increasingly easy access to the exact resources (neurophysiology) necessary to intervene.

Among the implications of summative consideration of these various research findings is that teachers might wield more influence than previously thought regarding students’ beliefs in their ability to learn—beliefs shown to be correlated with a broad, critical range of behaviors. It makes sense that researchers would shift their focus from the diagnosis of mindset to how best to change or manipulate it. To date, limited resources have been allocated to research application of these principles to upper-level high school students. For that matter, little of the extant research has been “shovel-ready” in terms of facilitating immediate teacher use. It would appear that the next piece of the puzzle would be to know how best to use the summative conclusions of this research in combination with the burgeoning neurophysiology resources.

Research is often proposed as necessary to fill a gap. The need identified here is less of a hindsight perspective of a gap and more of a forward-looking recognition of what the next step should be. The difference is significant because it explains the shortage of research in practical classroom application of the insight afforded by earlier studies. Among the more recent studies suggestive of a shift in emphasis from theory to practice is research performed by Schmidt, Shumow, and Kackar-Cam (in press), wherein the researchers focus on teacher behavior believed to promote growth mindset. The current research sought to contribute to the body of existing research on this evolution of thought by studying a relatively under-researched segment of the student population with a focus on specific interventions accessible to most high school science teachers.
Teachers stand to benefit from this research. It seeks to shed more light on the concept of the malleability of student intelligence. In parlance common within the educational community, plasticity of intelligence supports the idea that all students can learn, and heightened (or renewed) cognizance of the potential for all students to learn is, undoubtedly, a better disposition from which to teach. Such a philosophy shifts the teacher’s role from triage to healing.

Students stand to benefit by being taught by teachers who can either adjust their instructional practices to accommodate mindset (triage) and/or use the ability to shepherd students from a fixed mindset toward the more personally beneficial growth mindset (healing). Additionally, it is likely that no student wants to be bored. It logically follows that working with a teacher skilled at heightening interest would restore some of the joy to the learning process that has steadily eroded for most students since the early grades.

Definitions

The following terminology was used in this study:

**Achievement**: Performance on summative and formative assessments of cognitive and rote proficiency compared to baseline measures in the domain of knowledge of neurophysiology deemed appropriate for the purposes of conveying the plasticity of intelligence.

**Active learning**: Learning encompassing strategies that invite increased levels of student-initiated activity. For the purposes of this study, a classroom activity in which students met in groups to perform research, discuss findings, and share letter passages was
presumed to represent active learning—terminology originally included only as a descriptor for one of the two interventions.

**Effort beliefs**: Concepts that indicate how students perceive effort according to what it connotes. Growth-mindset students embrace effort as an integral part of the learning process wherein strategies are added or revised and the knowledge base is broadened. Fixed-mindset students trying to maintain the perception of high ability are likely to regard effort as indicative of deficiencies, and those students convinced of their low status eschew effort as a futile endeavor (Dweck, 1986 & 2010a)

**Engagement**: A qualitative description that signifies a level of personal interest and/or enthusiasm. Among the symptoms of engagement are student reactions during the course of performance of the required activities, student inquiries into the process (“What’s next?” “When do we…?” “Have you…?”), and informal student comments regarding placement in one treatment or the other (“It’s not fair…”).

**Entity theory of intelligence**: A slightly more sophisticated incarnation of fixed mindset, suggesting, as it does, that one’s intelligence is an immutable entity.

**Entityist**: A term coined for the current study as a convenient way to refer to students who maintain an entity theory of intelligence.

**Goal orientation**: What students desire to get out of a particular activity or situation.

  - **Mastery-goal orientation**: Student motivation for learning that is less achievement-based and more progress-based.
  - **Performance-goal orientation**: Student motivation for learning that is more achievement-based and less progress-based, aligning students toward
demonstrations of superiority relative to peers. For the purposes of this study, no distinction was made between performance-approach and performance-avoidance goal orientations.

**Incremental theory of intelligence:** A slightly more sophisticated incarnation of growth mindset, suggesting, as it does, that one’s intelligence can be increased in increments.

**Incrementalist:** A term coined for the current study as a convenient way to refer to students who maintain an incremental theory of intelligence.

**Mindset:** The personal theory of intelligence held by each student. More specifically, it is a measure of student belief in the degree of malleability of intelligence.

  - **Fixed mindset:** The belief that intelligence is a fixed quantity established at birth and resistant to change.
  - **Growth mindset:** Belief in the ability to manage domain-specific aptitude through effort and strategy use.
  - **Effort:** The level of persistence at a task.

**Neurophysiology:** For the purposes of this research, those aspects of brain function that have only to do with learning, e.g., working (short-term) memory, long-term memory, and synaptogenesis.

**Passive learning:** Learning that requires less initiative by placing students in a situation in which learning occurs in isolation or within a teacher-centered environment. Just as with active learning, use of this terminology in this study is no more than a relic of how the two different interventions were originally identified.
Pen-pal exercise: Phrase used throughout the study in order to dissuade readers desirous of locating this study somewhere in the active/passive learning debate. Those wishing to characterize the instructional strategies as one type of learning or the other do so at their own discretion. Instead, “pen-pal exercise” avoids the debate and is consistent with how the author refers consistently to the exercise conversationally. Rather than refer specifically to instructional methodology, this nomenclature focuses instead on student product. In addition to circumventing the active/passive debate, this terminology is consistent with the supposition that the student product was a determinant of student reaction to the intervention.

Resilience: Within the milieu of education, a students’ ability to recover from a setback.

Term-paper exercise: The term of preference for the author during and after the course of the study.

Methodology

The framework of the study called for a mixed-method design that utilized quantitative data-collection techniques to facilitate comparison between the two treatment groups. The study’s target population was a convenience sample of 11th- and 12th-grade high school physics students assigned to the teacher/researcher’s classes. Students were, de facto, randomly assigned to one of two intervention groups by virtue of the physics class they were taking. Both groups were exposed to the same information regarding brain physiology but in quite different ways and for quite different purposes.
Both groups were introduced to the concept of self-theories of intelligence and some neurophysiology basics during the course of a class lecture. Subsequent to that introduction, one group was asked to perform additional research in small groups in order that they could write an accurate, inclusive, age-appropriate letter to a fifth-grade student in the district intended to communicate the merits of a growth mindset, including rudimentary brain functioning as it pertains to learning, the vital role of effort, and the power of believing that anatomy is not destiny. The second group learned brain physiology via more traditional means. Subsequent to their classroom lecture, these students performed independent research and participated in a class discussion as preparation for writing a research term paper.

Administration of a mindset survey before and after the interventions was used to detect shifts in mindset. Throughout the interventions, participant observations facilitated by field notes captured behavior indicative of engagement with the material as a means of comparing one treatment against the other. Additionally, it was hoped that these observations might help to establish evidence of changing mindset. A longitudinal aspect was added by surveying available student participants one year after the initial study. Answers to questions about their recollections of the mindset lesson and their feelings regarding the utility of the lesson added depth to the study’s results.

In order to assess the relative efficacy of the neurophysiology lesson, students took a test of student knowledge and understanding of the prescribed aspects of brain functioning. Administration of the test three times (once prior to intervention, once immediately following the intervention, and once more several weeks after the intervention) facilitated
comparison of the teaching approaches via mixed between-within subjects analysis of variance (ANOVA) wherein individual student scores were compared across all three assessments and group scores (by intervention) were compared. Additionally, an independent samples t test was used to determine if differences existed in mindset by gender or class prior to the intervention.

Organization of the Study

The study consists of five chapters. Chapter 1 introduces the study, outlines the theoretical framework through which the study’s results were analyzed, enumerates the questions the study sought to answer, and offers a brief outline of the study’s methodology.

Chapter 2 is a review of the literature on student self-theories of intelligence, achievement-goal theory, active versus passive learning, and the specific benefits afforded student tutors. Chapter 3 details the study’s methodology as well as the data collection and analysis techniques. Chapter 4 presents the study’s results. Chapter 5 offers discussion of the study’s results, including recommendations and implications for instructional practices, and makes suggestions for future research.
CHAPTER 2
LITERATURE REVIEW

Introduction

The idea that student motivation is a critical aspect of achievement is both commonsensical and the conclusion of an enormous amount of research. Achievement Goal Theory (AGT) (Ames, 1992; Barron & Harackiewicz, 2001; Dweck & Leggett, 1988) is among the theories posited to explain student motivation and, by extension, achievement outcomes. As a theory, AGT suggests that orientation toward a particular type of goal manifests itself in a predictable array of learning behaviors and that the adaptive (or maladaptive) nature of these behaviors is a strong determinant of achievement outcomes (Dweck, 1986, 2000).

Parallel to and actually springing from this line of research into goal-driven motivation has been the study of why students adopt a particular goal orientation. Known as mindset or self-theory of intelligence, this line of research suggests that the degree of a student’s belief in the malleability of intelligence determines goal orientation (Dweck, 1986, 2000; Dweck & Leggett, 1988). Additionally, it has been suggested that student mindset is subject to influence and possibly manipulation (Aronson et al., 2002; Dweck, 1986; Dweck & Leggett, 1988). Following this line of logic, there is merit to investigating how to influence student mindset in order to elicit goal orientations that generate more
adaptive learning behaviors, including higher levels of task persistence, less concern with public errors, greater esteem for incremental increases in competence, and less regard for current skill levels (Elliott & Dweck, 1988).

The review of applicable literature follows this same history of development by starting with an explication of goals, followed by discussion of mindset. Next, the causal relationships between mindset and goal orientations, between goal orientations and learning behavior, and finally, between learning behavior and achievement outcomes are treated in sequence. The review concludes with a look at how mindset might be influenced through classroom activities and practices.

Goals

Over the past 25 years, an average of one paper or dissertation related to AGT has been published about every eight days (Hulleman, Schrager, Bodmann, & Harackiewicz, 2010). Since the mid-20th century, “the concept of goal pursuit has been central to the study of achievement motivation and performance outcomes” (Wentzel, 1989, p. 131). There is ample justification for the close association between motivation and goals. The origin of the word “motivate”—to move—demands some rationale or impetus for the movement. In many motivational theories, goals provide that impetus (Schunk, Pintrich, & Meece, 2008).

The intention of this study to focus on student theories of intelligence (and goal orientations as manifestations of those theories) necessitates a discussion of goals. In view of the pervasiveness of discrepant operational versus conceptual definitions, a review of the terminology associated with goals and goal orientations is an appropriate place to begin. A
meta-analysis performed by Hulleman, Godes et al. (2010) represents a credible arbiter of the terminology and thus comprises the framework for terminology used in this study.

Hulleman, Schrager et al. (2010) establish a working definition of an achievement goal as a “future-focused cognitive representation that guides behavior to a competence-related end state” (p. 423; italics in original). Goal orientation is not an accidental term, suggesting as it does an integration of what must be accomplished (the goal) with what must be done (how to approach and engage the task) to accomplish the goal (Schunk et al., 2008).

During the formative days of AGT, a variety of characterizations of opposing goal orientations appeared. Dweck and others (Dweck, 1986; Dweck & Leggett, 1988; Elliott & Dweck, 1988) suggest that students routinely valued either “performance (to seem competent) or . . . learning (to increase competence)” goals (Elliott & Dweck, 1988, p. 6, italics added). Nicholls (1984) distinguishes two forms of achievement goals according to the two ways that students “construe competence or ability” (p. 328). “Task involvement goals” refers to self-referenced judgments of ability wherein higher degrees of task mastery indicate competence. In contrast, “ego involvement goals” refers to judgments of ability made on the basis of comparison with others. Ames (1984) describes the two goal orientations as noncompetitive (individualistic or cooperative) and competitive, but by 1988, she had adopted the terms mastery and performance (Ames & Archer, 1988).

Pintrich (2003) offers succinct definitions of mastery and performance-goal orientations, now widely accepted as labels for the two primary classifications of achievement-goal orientation:
Mastery goals orient the student toward learning and understanding, developing new skills and a focus on self-improvement using self-referenced standards. In contrast, performance goals represent a concern with demonstrating ability, obtaining recognition of high ability, protecting self-worth, and a focus on comparative standards relative to other students and attempting to best or surpass others. (p. 676)

AGT has undergone a great deal of change during the course of its years of scrutiny, primarily in terms of the emergence of additional dimensions to the original construct.

Prior to the advent of performance avoidance goals, prevailing wisdom held that “performance goals are . . . less adaptive [than mastery goals] in terms of subsequent motivation, affect, strategy use, and performance” (Pintrich, 2000, p. 544). Goal theory experienced a revision during the last half of the 1990s based on research spearheaded by Harackiewicz and Elliot (Elliot & Church, 1997; Elliot & Harackiewicz, 1996; Harackiewicz, Barron, Carter, Lehto, & Elliot, 1997) that refuted the blanket presumption of “mastery good, performance bad,” as espoused by normalized goal theory (Pintrich & Schunk, 2002). Instead, studies showed that there were situations in which performance goals were responsible for enhanced achievement and performance. The determinant was whether students were concerned with demonstrating competence relative to peers or trying to hide inferiority from them. Mastery goals, it was concluded, were more likely to generate personal interest that might not necessarily translate to better achievement. The achievement-goal model was thus expanded to accommodate “clear empirical support for distinguishing between approach and avoidance performance goals” (Schunk et al., 2008, p. 206).

More recently, significant changes to the theory include a call to recognize a mastery-avoidance goal orientation (Elliot, Murayama, & Pekrun, 2011; Pintrich, 2003),
thus expanding AGT to a 2 X 2 model along dimensions of mastery/performance and approach/avoid. Some within the field remain unconvinced of the need, suggesting that although “there may be occasions when students are focused on avoiding . . . mastering the task, . . . mastery goals have been discussed and researched primarily in terms of an approach orientation” (Schunk et al., 2008, p. 188). In addition, the detractors cite the counterintuitive nature of the construct as well as a relative absence of empirical research data to support bifurcation of mastery-goal orientations. Having noted their dissent, review of extant literature and conduct of the current research proceeded under the framework of the 2 X 2 model:

The goals of the trichotomous and 2 X 2 achievement-goal models are conceptualized on this basis: a mastery-approach goal focused on the attainment of task-based or self-based competence, a mastery-avoidance goal focused on the avoidance of task-based or self-based incompetence, a performance-approach goal focused on the attainment of other-based competence, and a performance-avoidance goal focused on the avoidance of other-based incompetence. (Elliot et al., 2011, p. 2)

One implication of adopting the 2 X 2 model has been the exoneration of performance goals as a result of linking negative behavior that had previously been associated with performance goals to performance-avoidance goal orientations (Senko, Hulleman, & Harackiewicz, 2011).

AGT seems destined for additional changes. Delineation of goals along the lines of task-based and self-based standards has raised concerns among some researchers (most notably Elliot) about “whether these two standards are similar enough to belong in a single goal construct or are different enough to warrant separate goal constructs” (Elliot et al., 2011, p. 2). In essence, these researchers have divided the self-referenced goal orientation
according to concerns for either absolute task demands or intrapersonal concepts of one’s own trajectory. In so doing, these researchers have created the need for a 3 X 2 model.

Another significant change taking place over roughly the same time period as the evolution of the 3 X 2 model was in response to normative goal theory’s inability to fully explain why mastery goals were not always superior to performance goals in their service to students. One possible explanation offered for the gray area was the suggestion that “individuals might sequentially or simultaneously integrate and pursue mastery and performance goals” (Harackiewicz et al., 1997; italics added). Pintrich (2000) synthesizes the various goal perspectives, reasoning that students might simultaneously adopt some combination of performance and mastery-goal orientations that would address a personal set of goals by eliciting an equally personal pattern of behavior. The combination called for a multiple goal theory, or at least a change of AGT to accommodate multiple goals.

The motivation goal community welcomed the debate that followed Pintrich’s suggestion. Owing to the divergent concerns of social change versus theory-building, consensus has yet to be reached. The ensuing research agenda concentrated less on a black-and-white perspective of performance versus mastery goals and more on “multiple goals, multiple outcomes, and multiple pathways to learning and achievement” (Pintrich, 2003, p. 676) to the benefit of the educational community.

Elliot et al.’s (2011) call for an additional dimension to the 2 X 2 model and Pintrich’s (2000) call for consideration of contextual factors that would be best described by a multiple-goal model have ignited debate that continues to the present. Until the debate is resolved, and for the purposes of this study, the trichotomous model (the 2 X 2 model
absent mastery avoidance) can suffice. Based largely on the work of Hulleman, Schrager et al. (2010), Figure 1 summarizes each goal orientation within this model.

<table>
<thead>
<tr>
<th>Performance Approach (PAp): a helpful definition takes into account three types of PAp goals, namely appearance (demonstrating worth or ability to an audience), normative (competitive), and evaluative (the hybrid of the first two)</th>
<th>Performance Avoidance (PAv): negative mirror images of PAp goal orientations</th>
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<tr>
<td>Mastery Approach (MAp): commonly summed up as learning “that focuses on learning and skill development” (p. 425), Hulleman, Schrager et al. (2010) suggest that this orientation actually assumes many forms including interest, curiosity, increased competence, fulfilling potential, and the desire for challenge</td>
<td>Mastery Avoidance (MAv): relatively few examples of students intentionally sabotaging efforts to master a skill or subject—so few in fact, that the construct has been dismissed by many Hulleman, Schrager et al. (2010)</td>
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No matter how many rows and columns ultimately comprise the achievement-goal matrix, reflection on the extant body of research concludes that consideration of culture and context prevents researchers and practitioners from relying on any “one size fits all” theory. It was during the course of further research on student motivation and its relationship with adaptive and maladaptive patterns of behavior that the idea of mindset came into being.

Alone and in collaboration with Diener (Diener & Dweck, 1978, 1980; Dweck, 1986), Dweck’s study of student attributions for failure led her to conclude that there were two attributional patterns exhibited by students: mastery-oriented and learned helplessness. Of the two patterns, she hinted at the direction that her future research would take when she offered that “there may well be important differences in other achievement-related beliefs and behaviors” (Diener & Dweck, 1978, p. 452). By the end of the 1980s, Dweck had
uncovered a highly important difference in ability beliefs that offered promise for explaining the opposing response to failure patterns “in terms of underlying psychological processes” (Dweck & Leggett, 1988, p. 256).

**Mindset**

As a formal construct, mindset originated with Dweck and Leggett’s (1988) “general conceptualization of individual’s implicit [self] theories” (p. 256). The suggestion that students adopt a pattern of learning behaviors consistent with their perspectives on their ability to learn is the precept upon which this study is based. During the course of research into student motivation, Dweck (2000) noticed a pattern of student behavior associated with either of two diametrically opposed perspectives (self-theories) of intelligence. One of these divergent theories holds that domain-specific intelligence or aptitude can be modified through effort. In view of their belief in “ability as an acquirable skill that can be increased by gaining knowledge and competencies” (Bandura, 1993, p. 120), students so inclined are said to hold a *growth* or *incremental mindset*. Conversely, other students fail to acknowledge a link between the input of work and a corresponding achievement output, opting instead to “view ability as an inherent capacity” (p. 120). Convinced as they are of the immutable nature of their intelligence, these students are said to hold a *fixed* or *entity mindset*.

As 20th-century theorists and researchers transitioned from the behaviorist perspective to a volitional point of view that accommodates free will, educational psychologists led a similar transition away from belief in the rigidity of domain-specific
intelligence. Vestiges of implicit belief in IQ scores as an unassailable gauge of intelligence remain, but the enlightened position accommodates intelligence as a fluid construct capable of being managed (Dweck & Leggett, 1988; Nicholls, 1984; Wellman, 1990). Dweck (2010a) quite effectively summarizes the burgeoning belief in the plasticity of competencies:

Experts talk about talent less as a pure gift and more as something that develops and reaches fruition through dedication and learning. They highlight the many, many hours of engagement that typically go into developing an exceptionally high level of ability and tell us that even in prodigies, ability is accompanied by constant engagement with it. Thus much of the “gift” may be a passion for an area and the desire to engage with it vigorously over long periods of time. (p. 59)

Gladwell (2008) supports this position, going so far as to assign a number of hours (10,000) of engagement in an activity that results in a level of expertise well beyond that achieved by more modest levels of commitment.

It is important to note that this accommodation is not a suggestion that all students share a common domain-specific potential or that each will experience the same or similar levels of challenge during the course of learning. Instead, the implication is that “for any given individual, intellectual ability can always be further developed” (Blackwell, Trzesniewski, & Dweck, 2007, p. 247).

The recurrence of identifiable self-theories demands the attention of the educational community. The preponderance of each theory of intelligence is the subject of some debate. Dweck’s (2000) own estimates place the split at roughly 40% growth, 40% fixed, and 20% undefined, whereas other research efforts suggest less balance (Leondari & Gialamas, 2002). Whatever the proportions, the ominous trend upon which researchers
tend to agree is the tendency for students to transition from a growth to a fixed mindset as they progress through the educational system.

Mindset, Goal Orientation, Learning Behaviors, and Achievement Outcomes

Dweck’s work presumes goal orientation as a product of mindset, a position not necessarily held by all. For instance, consider Nicholl’s (1984) perspective: he suggests that learning behaviors resulted from conceptions of competence. When students referenced competence to personal levels of understanding, they were likely to exhibit learning behaviors associated with mastery-goal orientations. In contrast, when students referenced their competence to “the ability of members of a normative reference group” (p. 329), they likely behaved in a manner consistent with a performance-goal orientation.

For the purposes of this research, achievement-goal orientations have been limited to the trichotomous model, reflecting the study’s alignment with Dweck (1986). Within this framework, beliefs in the malleability of intelligence manifest themselves in learning behaviors including reaction to setbacks or challenge, perceptions of the role of effort in achievement, and test anxiety, constructs that have been shown as closely related to goal orientations.

Another alignment between this research and the work of Dweck (1986) is the presumed linear relationship among mindset, goal orientation, behavioral patterns, and, ultimately, achievement outcomes. A review of literature from the first half of the 1980s indicates that self-theories of intelligence were taking root but had yet to be formally named as fixed or growth mindset. The common parlance at the time equated a fixed mindset with
helplessness in view of the strong associations these students had between ability beliefs (inherently outside their control) and performance. Conversely, growth-mindset students were known as mastery-oriented for their association of (internally controlled) effort and performance. In these early cases, mastery orientation had yet to become identified as a particular goal orientation. This understanding is critical to recognizing how Dweck (1986, 2000) and her colleagues conceptualized the relationship among mindset, goal orientation, and behavioral patterns.

**Mindset and Goal Orientation**

The goal of this study was to add to the body of research upon which educators may rely to improve instructional practice. Cast in that light, the critical link between mindset and the goal orientations it elicits makes the study of the link consequential. Within the trichotomous model, student learning goals manifest themselves as one of three different orientations according to mindset (Blackwell et al., 2007; Dweck, 1986; Elliott & Dweck, 1988; Mangels, Butterfield, Lamb, Good, & Dweck, 2006; Schunk et al., 2008; Smiley & Dweck, 1994).

The case of growth-mindset (mastery-approach) students is relatively simple: a priority for learning inclines them to adopt mastery goals “in which individuals are concerned with increasing their competence” (Dweck & Leggett, 1998, p. 256). The individual nature of the pursuit of personal improvement predisposes these students toward mastery goals (Bandura, 1993). In sum, “the acquirable skill view fosters a task-diagnostic focus aimed at expanding one’s competence and mastering challenges” (p. 121).
The bifurcation of performance goals into approach and avoidance makes the case of fixed-mindset students slightly more complex but no less logical. In the case of students with high estimations of their abilities, early constructs of performance-approach goals suggest that these students “are concerned with gaining favorable judgments of their competence” (Dweck & Leggett, 1988, p. 256). Since this early iteration, the perspective of performance-approach goals has expanded to address demonstrations of competence relative to others. Although high-ability students value normative assessments as proof of their status, low-ability students fear the capacity of these same assessments to confirm their low status wherein “the successes of others belittle their own perceived ability” (Bandura, 1993, p. 121).

Although a preponderance of research and theory posits a relationship between goal orientation and academic outcomes, less research has been done on the origins of goal orientations. Dweck and Leggett (1988) make their lead/lag hypothesis clear, suggesting that “a consistent predictor of children’s goal orientation is their ‘theory of intelligence’” (p. 262). Senko et al. (2011) support this causality perspective, suggesting that goal orientations “derive in part from different views of ability. Students pursuing mastery goals tend to consider ability a malleable attribute . . . [but] students pursuing performance goals tend instead to consider ability a fixed attribute” (p. 27). Sternberg, Conway, Ketron, and Bernstein (1981) reached a similar conclusion by studying the implicit theories of intelligence of survey volunteers among persons waiting on the arrival of trains, in supermarkets, or studying in college libraries. Church, Elliott, and Gable (2001) conclude
that “mastery-goal adoption was predicted by need for . . . high competence expectancies” but “performance-approach goal adoption was predicted by need for achievement” (p. 43).

During the course of Dweck’s unpublished research with Mary Bandura in 1981 and then with Leggett in 1985, Dweck and her colleagues confirmed their hypothesized connection:

We found a clear and significant relation between students’ theories of intelligence and their goal choices: The more students held an entity theory of intelligence, the more likely they were to choose a performance goal, whereas the more they held an incremental theory, the more likely they were to choose the learning [mastery] goal. (Dweck, 2000, p. 21)

Dweck can hardly be more emphatic about her opinion than by naming a book chapter in part, “Students’ Theories about Their Intelligence Foster Their Achievement Goals” (p. 20).

As noted earlier, a close reading of Nicholls (1984) and Duda and Nicholls (1992) offers a contrasting position: “beliefs about the causes of success in school . . . of 207 high school students were found to be related in a logical fashion to their personal goals” (p. 290) as evidence that goal orientation begets mindset. This presumed causal directionality can be teased out of Duda and Nicholls’s conclusions regarding student definitions of success. When the immediate goals are task-oriented, success entails hard work, the antecedent of which must be the mindset that ability is malleable. On the other hand, when the immediate goal is ego-oriented, success “is defined by the goal of establishing one’s superiority over others” (p. 290).

Despite the contrary nature of these cause-effect perspectives, their overlapping belief in the link between goal orientation and mindset is of much greater significance. The current study was undertaken with the presumption that mindset precedes goal orientation.
Goal Orientation and Learning Behavior

Far from being merely a transition between the previous and current topics, the previous paragraph’s suggestion that mindset and goal orientation are inextricably linked is essential for interpreting literature concerned with learning behaviors. The previous section stated that the goal of this study was improved instructional practice, but to what end? The answer to that question is the presumptive link between teaching practices and learning behavior. Accepting the primacy of mindset, associations between mindset and learning behavior are assumed to be mediated via goal orientation from this point.

Contemporary cognitive views of motivation stress the critical role of beliefs, goals, and other mental processes as determinants of learning behavior (Ames, 1992; Ames & Archer, 1988; Dweck, 2010a; Elliot & Harackiewicz, 1996; Elliott & Dweck, 1988; Middleton & Midgley, 1997). Study results are rather unambiguous in support of this position, particularly with regard to correlating goal orientation with a variety of profoundly important learning behaviors: “Students’ perceptions of mastery and performance goals showed different patterns of relation with learning strategies, preference for challenging tasks, attitude toward the class, and beliefs about the causes of success and failure” (Ames & Archer, 1988, p. 264). Additional manifestations of goal orientation include the degree of the use of self-instructional strategies and even a student’s decision to exercise the opportunity for improvement (Ames, 1984). A common thread in much of the extant research is the espousal of some basic beliefs summarized by Blackwell et al. (2007) during the course of the researchers’ comparison of affective behavior:

Relative to entity theorists, incremental theorists have been found (a) to focus more on *learning goals* (goals aimed at increasing their ability) versus *performance goals*
(goals aimed at documenting their ability); (b) to believe in the utility of effort versus the futility of effort given difficulty or low ability; (c) to make low-effort, mastery-oriented versus low-ability, helpless attributions for failure; and (d) to display mastery-oriented strategies (effort escalation or strategy change) versus helpless strategies (effort withdrawal or strategy perseveration) in the face of setbacks. (p. 247)

The learning behaviors most often cited are student opinions of effort and their reaction to challenge or setback. The prominence of these citations has to do with the fundamental role each plays in student motivation.

**Effort Beliefs**

“Effort is what leads to success. Putting effort into your work is what will get you far in life,” as noted in written student feedback during the 2012 pilot study for this research into teaching of self-theories of intelligence. An early indication of the inextricable link between self-theories of intelligence and opinions of effort was Diener and Dweck’s (1978) use of student self-report measures on the causal relationship between effort and failure as an unsophisticated but prophetic indicator of mindset. In the time since, there has been abundant research to support the claim that mindset strongly predicts students’ opinions of effort (Ames, 1984; Ames & Archer, 1988; Blackwell et al., 2007; Diener & Dweck, 1978; Dweck, 1986; Dweck & Molden, 2005; Nicholls, 1984; Yeager & Dweck, 2012).

Attribution Theory (AT) offers a parallel to entity and incremental theories of intelligence that helps explain opinions of effort. According to AT, competence derives from either an uncontrollable and stable aptitude or is a by-product of effort exertion (Weiner, 1985, 2005), constructs that reflect fixed and growth mindsets, respectively. Based on the assumptions that “individuals are motivated by a goal of understanding and
mastering their environment and themselves [and] trying to understand the causal determinants of their own behaviors” (Schunk et al., 2008, p. 81), AT posits that the value in knowing why events transpire as they do (or did) offers the opportunity to more effectively manage outcomes (Weiner, 1985).

Incremental theorists (incrementalists) tend to orient toward mastery. They construe their intelligence as a sort of “intellectual muscle” that can be strengthened by continually challenging and stretching it (Dweck, 2000, 2010b). They attribute their successes or failures to controllable causes. These students reject an association between effort and any presumed level of intelligence, reasoning that “even geniuses . . . had to work hard for their successes” (Dweck, 2007, p. 8).

Entity theorists (entityists) are likely to attribute aptitude or lack thereof to uncontrollable causes. In their view, having to work hard suggests an intellectual deficit. Among these students, those with presumed high levels of intelligence disdain effort, and those with low levels discredit it. Until one understands the pathology of the fixed mindset, the debilitating effect of effort exertion on “gifted” or “bright” students may seem counterintuitive. The requisite belief in intelligence as a stable, valuable commodity worthy of protection necessarily casts effort in the role of the enemy at the gate: “having to exert high effort is . . . threatening because it presumably reveals one is not smart” (Bandura, 1993, pp. 120-121). Having to work hard to understand something presents the gifted student with a choice: “work hard and feel dumb . . . or don’t work and act smart” (Dweck, 2007, p. 8).
Reaction to Challenge/Setback

Simply put, “implicit theories of intelligence . . . appear to create different psychological worlds for students: one that promotes resilience and one that does not” (Yeager & Dweck, 2012, p. 304). Reaction to setbacks or challenge according to the trichotomous model, not surprisingly, bears striking resemblance to opinions of effort. Explanations for how students respond to academic adversity involve the concept of risk: “the tasks that are the best for learning are often challenging ones that involve displaying ignorance and risking periods of confusion and errors” (Dweck, 2000, p. 16). Blackwell et al. (2007) summarize the connection to goal orientation:

Research has shown that . . . theories of intelligence shape [student] responses to academic challenge. For those endorsing more of an entity theory, the belief in a fixed, uncontrollable intelligence—a “thing” they have a lot or a little of— orients them toward measuring that ability and giving up or withdrawing effort if the verdict seems negative. (p. 247)

Incrementalists’ responses are characterized by an absence of personal disillusion. Instead, these students redouble their effort to correct strategic or procedural errors, recognizing that such mistakes and ensuing efforts at corrective action are the essence of learning (Ames, 1984; Ames & Archer, 1988; Blackwell et al., 2007; Diener & Dweck, 1978; Dweck, 2000). Bandura (1993) summarizes the process and its rationale, stating that “such children . . . seek challenges that provide opportunities to expand their knowledge and competencies. They regard errors as a natural part of an acquisition process. One learns from mistakes. Therefore, they are not easily rattled by difficulties” (p. 120).

Without controllable causal attributions or conditions that foster risk-taking, entity theorists respond in predictable ways: “setbacks indicate a lack of ability and, in the fixed
mindset, that lack of ability is permanent” (Dweck, 2007, p. 8). The response of low-status students is fairly stable. These students perceive setbacks as evidence of their intellectual inadequacy.

As with opinions of effort, there is a tendency to believe that a presumption of high (fixed) ability would serve students well in the classroom. Although there are some situations for which this is true, challenge or reactions to setback are not among them. The normative comparison of superiority must be protected, a belief that explains why these particular students gravitate toward activities and assessments of only moderate challenge, eschewing the risk of exposure that higher challenge represents. For the sake of maintaining the appearance of proficiency, these students are willing to forfeit the academic benefits gained through adaptive behaviors such as mistake repair, revision of ineffective strategies, enhanced self-regulation, and an expansion of competencies (Bandura, 1993; Blackwell et al., 2007; Dweck, 2007).

If the percentage of students afflicted by a fixed mindset was small, addressing the harmful attendant learning behaviors might be relegated to a page in a school’s Response to Intervention manual. However, Dweck (1986, 2000) and her colleagues found evidence of mindset in locales as diverse as seventh-grade math classes and college classrooms in both Hong Kong and at Columbia University (Blackwell et al., 2007; Dweck, 2007).

**Learning Behavior and Achievement Outcomes**

There is abundant literature linking goal orientation to academic outcomes via the learning behaviors associated with mastery or performance orientations. Definitions of
success for each theory further distinguish them and help to explain behavior. Performance goals necessitate a normative comparison among students that guarantees winners and losers. On the other hand, achievement metrics for mastery approach goal orientation lack an absolute frame of reference. Instead, success is determined against “either task-based criteria . . . or . . . self-defined criteria” (Senko et al., 2011, p. 27). Goals that are personal (e.g., exceeding a previous term paper grade) or intangible (e.g., a feeling of improvement) are more accessible to those who hold them, which may explain why mastery-goal orientation elicits stronger affect than performance-goal orientations (Ames, 1992, 1984; Ames & Archer, 1988; Elliott & Dweck, 1988; Middleton & Midgley, 1997; Senko et al., 2011; Smiley & Dweck, 1994).

Senko et al. (2011) submit that “the findings for mastery goals have been consistent and mostly favorable” (p. 27), credited as they are with eliciting a variety of adaptive learning and motivational behaviors, including enhanced levels of interest, persistence, self-efficacy, help-seeking, more effective self-regulation, and higher task valuations. Among the field’s preeminent researchers is ample support for this conclusion (Ames, 1992; Church et al., 2001; Elliot & McGregor, 2001; Elliot et al., 2011; Elliott & Dweck, 1988; Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Henderson & Dweck, 1990; Hulleman et al., 2008; Middleton & Midgley, 1997; Murayama, Elliot, & Yamagata, 2011; Pekrun, Elliot, & Maier, 2009; Pintrich, 2000).

Specific predictive relationships among goal orientation, learning behavior, and achievement outcome include mastery with the use of more positive, effort-based strategies
(Blackwell et al., 2007), adolescents’ help-seeking behaviors (Ryan & Pintrich, 1997), performance on exams (Church et al., 2001; Daron, Butera, Mugny, Quiamzade, & Hulleman, 2009; Pekrun et al., 2009), and levels of interest (Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000). Another line of research investigated the predictive power of mindset, learning behaviors, and achievement outcomes. Results from these studies include links between growth mindset and higher grades (Henderson & Dweck, 1990; Stipek & Gralinski, 1996), as well as growth mindset and higher level of enjoyment/valuation of subject matter (Aronson et al., 2002). Collectively, these studies cover a broad range of student ages from middle school through college undergraduates. Besides legitimizing the trichotomous goal-orientation model (at the very least), the results of these studies confirm a relationship between mindset/goal orientation and academic outcomes and justify the increased attention paid to classroom applications.

**How Can Mindset Be Changed?**

Accepting the superiority of a growth mindset as an asset to academic achievement, the question remains how best to use this insight to leverage achievement gains. One could argue that familiarity with the deleterious learning behaviors associated with a fixed mindset might enable teaching professionals to suppress them. Another more holistic approach might be to seek to manipulate student mindset—an idea more akin to treating the disease rather than the symptoms.

In 2000, Dweck posed the rhetorical question, “what if students' implicit theories were manipulated in real life?” (p. 36). The answer to the question was that struggling
learners and those suffering negative stereotypes could “focus on getting smarter through learning” (Dweck, 2010a, p. 60), and it signaled the research community’s transition from confirming mindset to determining the means to influence it.

During the course of studying the effects of mindset on goal orientation, learning behaviors, and achievement outcomes, Dweck and others (Dweck, 1986; Dweck & Leggett, 1988) established mindset’s susceptibility to short-term change: “although implicit theories can be influenced when we manipulate them directly in our experiments, they tend to be rather stable” (Dweck, 2000, p. 36).

In sum, extant research supports several conclusions. To begin, self-theories of intelligence have been shown to play an integral role in student motivation via the goal orientations they elicit. Next, the particular goal orientations children adopt have been correlated with a variety of adaptive or maladaptive behavioral patterns. Finally, more recent research indicates that the theories of intelligence that foster goal orientation and determine learning behavior are subject to change in the short term and, depending on the sophistication of the intervention, subject to lasting change.

At first, Dweck (2000) and others identified common instructional practices for the capacity to promote or suppress growth mindset. For years, teachers and parents have made it a practice to offer praise for intelligence in the belief that doing so insulates children from the consequences of failure in a manner consistent with the nurture perspective. Researchers found that far from fortifying students against negative outcomes, this common practice has the potential to inhibit adaptive patterns and, in fact, has been shown to

Quite logically, these same researchers surmise that praise focused on effort and strategy would suppress a fixed mindset and promote a growth mindset (Dweck, 2000, 2007, 2010a, 2010b; Kamins & Dweck, 1999; Yeager & Dweck, 2012). The positive results that confirmed their suppositions have more recently been built upon by the work of Schmidt et al. (in press). In a study that compares the teaching styles of two teachers who ostensibly implemented identical mindset interventions in their seventh-grade science classes, these researchers found that teacher emphasis on growth mindset, including cognizance of mastery-goal orientation and learning strategies, correlated positively with higher student achievement.

Dweck (2010a) identifies a second common practice long held to promote student resilience. Intuitively, it makes sense that allowing students to string together several correctly answered questions or solved problems would instill in them a belief in their own competence. Such practice wastes the time of students seeking mastery and poses the risk of discovery of shortcomings for students seeking (or fearing) comparison to their peers. Instead, teachers ought to maintain just the right amount of rigor. Dweck (2010a) suggests incorporating tasks that stretch students by requiring them to synthesize exercises that “train students’ attention, . . . memory, . . . and cognitive flexibility” (p. 61). Indeed, early childhood programs have been designed just for this purpose (e.g., *Tools of the Mind*, 1993).
Were the profound conclusions of the vast amount of research into mindset and motivation simply distilled into such nuanced teaching habits as the two mentioned above, an enormous opportunity to introduce transformative teaching practices that can better serve diverse student populations will have been missed. A much more explicit and promising means by which students might be convinced of the capacity they have to change their levels of intelligence is to teach them exactly how those changes occur. Interventions used by Dweck (2007) and Aronson et al. (2002) ultimately originated from the same idea: that there is content about the brain that can be provided that has been shown to be effective at manipulating mindset. The overlap between Dweck (2007) and Aronson et al. (2002) is belief in a strategy that is startlingly logical, astonishingly simple, and profoundly effective: they teach students that they can be taught (Aronson et al., 2002; Dweck, 2007).

Discovery of the efficacy of the approach was a byproduct of research efforts designed to assess the impact of a changed mindset. Dweck (2007) briefly describes how, during the course of a study that attributed higher achievement scores, increased motivation, and improved grades to students’ newfound growth mindset as the result of an intervention, researchers successfully manipulated mindset by teaching students “that their brains form new connections every time they learn, and that over time, they can become smarter” (p. 8). Aronson et al. (2002) reasoned that students facing stereotype threat were likely to adopt the same (performance) goal orientations as fixed-mindset students. It logically followed that “one way to help students resist . . . stereotype threat in a maladaptive fashion . . . would be to convince them that their abilities are expandable” (p. 116). Bergen (1991) found that he could successfully change student theories of mindset
when he exposed an intervention group of college students to information suggesting that exceptionalism in any domain is a product of controllable factors.

These effective manipulations share a reliance on teaching students aspects of neurophysiology (in particular, the brain processes specific to learning) in order to convey the message that intelligence is not an immutable entity. In studies involving samples as diverse as junior high school and elite college students, Dweck (2007) observed an increased valuation of learning at the expense of looking smart as well as a palpable change in students’ desire to work earnestly at challenging material.

Despite the elegant simplicity and proven effectiveness of this approach, the fact that it has yet to gain widespread support within the educational community stands as another example of “prescriptions for supporting student motivation based on theory or experimental research . . . [that] have negligible impact in classrooms” (Turner, Warzon, & Christensen, 2011, p. 719). One notable exception to this disconnect is the assortment of student and teacher resources available through Mindset Works® (2008), developed by Dweck and Blackwell. Mindset Works® is an “online program . . . available to students, educators, administrators, parents, and anyone interested in learning how to improve their intelligence” (About Us page).

Among the tools available through Mindset Works® are the Brainology® (Mindset Works®, 2008) program and the EducatorKit® (Mindset Works®, 2008.). The former is an “online program that teaches brain science and study skills to middle school and high school students” (About Us page). The latter is a suite of “resources to support [educators’] own process of adopting and implementing a growth mindset over time in their classroom
and school” (The Offerings tab, Learn More page). In addition, Mindset Works® offers access to an online user community as well as a kit designed to help schools implement the various strategies. Mindset Works® notwithstanding—this research aspires to bridge the gap that remains between mindset research and educational practice.

**How to Teach Neurophysiology**

Reasoning that a rudimentary understanding of neurophysiology might facilitate adoption of a growth mindset, this study seeks to compare the efficacy of two different instructional practices. The study pursued data enabling the researcher to compare the effectiveness of the two methods to teach students neurophysiology and, in so doing, facilitate a comparison in the ability of each intervention to influence self-theories of intelligence. One particular intervention was chosen for its ubiquity, and the other for its novelty.

The term-paper intervention was selected for its commonplace use in traditional educational settings. Teachers of high school juniors and seniors are likely to have at least passing familiarity with them, and few students are likely to have reached those grades without having had to author at least one.

Whereas the term-paper intervention was traditional, the pen-pal intervention was novel. In fact, its selection had very much to do with the fact that few students were likely to have experienced a similar assignment during the course of their schooling, and research suggests that stimuli such as *novelty* and *surprise* are effective during the “catch” phase of catching and holding students’ attention (Mitchell, 1993). The letter-writing assignment
relied on “social psychological tactics shown not only to change attitudes, but also make them persevere.” (Aronson et al., 2002, p. 116). Beyond novelty, authorship of a pen-pal letter offered other possible benefits that might lead to higher levels of cognition.

In a 1984 study, Benware and Deci compared the efficacy of instructional strategies that differed in the expectations students had for what they were to learn. One group of students understood that they were learning the material in order to be tested on it, but a second group believed they were learning the same material in order to teach it to someone else. In Deci’s own words, “the simple idea is to have students learn something that they will then put to use. It requires activity—use your learning for something other than just taking a test” (personal communication, February 2, 2013). Benware and Deci observed heightened attention to the material by the students who expected to teach it, consistent with prior studies documenting the benefits of being a tutor (Allen & Feldman, 1973; Cloward, 1966; Goldschmid & Goldschmid, 1976).

When Aronson et al. (2002) employed the pen-pal exercise, they were counting on additional psychological constructs to enhance the learning experience. Specifically, the researchers anticipated comprehension gains based on the teaching effect. Whether the gains were the result of higher levels of exposure to the material or the creation of higher order cognitive structures, Bargh and Schul (1980) confirmed that in anticipation of tutoring others, students exhibited higher levels of cognition. Aronson et al.’s design also predicted retention gains based on public advocacy. Earlier, Higgins and Rholes (1978) had shown that when students were asked to advocate publicly for a position in their own words, there was an attendant deepening of the students’ commitment to that position.
Though Benware and Deci (1984) failed to raise the issue, another reason that learning to teach might inspire more active student participation is the opportunity for connectedness afforded by the activity. Discussions of this aspect of student behavior are more often associated with counseling programs; however, Karcher’s (2009) research suggests that “there is evidence that cross-age peer mentoring can have beneficial effects for both the mentees as well as the mentors who provide it” (p. 293).

Additional justification for the pen-pal approach was experience. In the course of a performing a small-scale pilot study of the intervention during the previous school year (details can be found in Appendix A), a variety of student feedback indicated an evolution of attitudes toward intelligence and personal habits that might affect learning.

The methodological strategies selected for use in the current study were chosen for their suitability according to anticipation of the data required to answer the research questions. They represent practice-based methods applied according to the best traditions of qualitative, quantitative, and mixed-method research and have been outlined in Chapter 3.
CHAPTER 3

METHODOLOGY

This chapter begins by providing a rationale for many of the research decisions. An overview of the research design is offered, followed by a detailed description of the methodology.

Research Design

In order to test the two interventions’ relationship to students’ self-theories, content comprehension and retention, and enthusiasm for and enjoyment of the lessons, a quasi-experimental design was used and data were collected using a multi-method approach that included administration of opinion surveys and content assessments along with participant/observer field notes. As a quasi-experimental study, intervention groups were assigned randomly to existing sections of the researcher’s physics classes. The nature of the interventions and the classes to which they were assigned is described shortly.

Question 1 sought to determine if there are variations in self-theories of intelligence and, if so, whether gender was related to which theory any student was likely to hold. The survey tool was designed to measure five dimensions of student beliefs that are theoretically indicative of mindset: opinion of the malleability of intelligence, mastery-goal orientation, effort beliefs, test anxiety, and use of positive strategies. Question 2 sought to
detect significant changes in self-theories of intelligence after students had experienced either of two different interventions.

Estimating student mindset for the purposes of answering the first and second research questions was accomplished by using student responses to Likert-type scale questions from a survey used in research by Blackwell et al. (2007) as a tool “to assess students’ initial motivational profiles, including theories of intelligence, learning and performance goals, beliefs about effort, and attributions and strategies in response to failure” (p. 254).

Question 3 sought to determine whether there were differences in cognitive and rote retention gains made by participants in each treatment group. The efficacy of the interventions at teaching neurophysiology was measured via student scores on an assessment designed for the purposes of this study.

Question 4 sought to compare the interventions by gauging levels of student enjoyment, enthusiasm for the exercise, engagement and interest in the exercise, and ultimately student willingness to persist with the exercise. The purity of the descriptions necessary to answer this question is determined ultimately by the researcher/observer’s decisions about what is and what is not meaningful (Wolcott, 1994). Hindsight suggests that a more comprehensive approach to qualitative data-gathering that would have included direct inquiry may have yielded more and different types of data from which to reach conclusions.

Instead, the teacher/researcher anticipated qualitative assessment of student response to the interventions to be the most transparent aspect of the study, and as a result,
the research design called for near complete reliance on participant observation (specifically field notes) and the inspection of student artifacts. Closer reading of Wolcott (1994) may have prompted inclusion of direct questioning of the students regarding their enthusiasm and engagement. Failure to do so resulted in a higher than ideal degree of dependence on estimates of student enthusiasm and engagement based on the teacher/researcher’s professional opinion and assessment.

Quantitative data were analyzed utilizing appropriate parametric tests. Qualitative data-collection techniques were employed that were consistent with established advantages of this type of research wherein the aim of the researcher was to gain “understanding from the informants’ point of view, . . . letting them teach [the researcher] what is important” (Bogdan & Biklen, 2007, p. 35). Among the strategies used to gather qualitative data were participant observation field notes, document collection (in the form of samples of student work), and optional self-reports of reaction to the interventions.

Teacher/Researcher

The teacher/researcher hoped to capitalize on the merits of intensive, long-term participant observation best summarized by Maxwell (2005):

Long-term participant observation provides more complete data about specific situations and events than any other method. Not only does it provide more, and more different kinds of, data, but also, the data are more direct and less dependent on inference. Repeated observations and interviews, as well as the sustained presence of the researcher in the setting studied, can help to rule out spurious associations and premature theories. (p. 110)
From the outset, the teacher/researcher’s belief that the percentage of students who maintain domain-specific entity theories of intelligence was significantly greater than Dweck’s (2000) 40% estimate threatened the ability to “rule out spurious associations and premature theories.” (Maxwell, 2005, p. 110). The potential for the research to conclude that one or both of the proposed teaching approaches could influence mindset, in combination with the attendant implications for teachers and their students, represented a threat to the fidelity of the study that was mitigated through member checks and careful journaling.

Participants

Context and High School Setting

The research took place at a large urban/suburban high school located in the Great Lakes region of the United States. The surrounding community population was large and diverse, supporting another public high school and portions of four private high schools. The most significant trends in terms of populace had been a migration into the area by families seeking refuge from the not-too-distant large city as well as recognition of the area as a destination for Hispanic families.

At the high school, the result was the emergence of Hispanic students as the predominant student ethnicity. School administrators had detected an increased gang presence, a higher percentage of at-risk students, an increased dropout rate, lower reading
proficiency scores, and an overall devaluation of education coincidental but not necessarily correlated to this demographic shift.

Currently, the student population at the high school level was approximately 44% Hispanic, 38% Caucasian, and 13% African American. The remaining portion was comprised primarily of Asian students along with a small sample of international students due to a locally strong World Relief organization. Approximately 50% of the student population received free or reduced lunch service. The graduation rate was just over 73% based on those who graduated within four years of entering high school. This rate does not include those who completed their degree requirements during the summer after their senior year or during a fifth year of high school. The average ACT score was 17.4 during the 2011-2012 academic year and 19 for the 2012-2013 academic year. The percent of students who enrolled in four-year colleges after graduation was approximately 43%, with another 41% enrolling in community colleges, 4% enlisting in the military, 5% entering the labor force directly, 2% attending some sort of trade school, and 5% listing their post-graduation plans as “other.”

Upon approach, the building was notable for its size. Hemmed in by the local neighborhood and surrounded on three sides by athletics fields, the school took up several city blocks. The seven-lane track that encircled the football field nearly touched one side of the building, and the football field stadium lights confirmed the proximity of a school, especially on Friday nights of home football games. The building projected a working-class image; although there were no overt signs of luxury such as a planetarium dome or swimming pool facade, the contemporary brick design was well-maintained. The building
had undergone several expansions over the years, resulting in classrooms that varied from cramped and steamy (or frigid depending on the time of year) to modern, well-equipped, and ideally temperature-maintained learning environments.

The classroom occupied by the teacher-researcher was one of the latter. As part of an addition built in 2004, the room was designed expressly for teaching physics. As such, it had copious whiteboard space, wireless access, moveable two-person lab benches that doubled as desks, and counters on three walls that featured access to running water and natural gas. Cabinets lined the three walls of the room not covered by whiteboard, interrupted by only two smallish windows.

The setting for the start of the interventions was exactly the same in each of the three classes. All were conducted in the very same classroom, which was wide and deep from the instructor’s perspective. Students sat in pairs at lab tables that were arranged in three rows, with four tables in the front row and five tables in each of the other two rows. The gap in the front row was located front/center to facilitate closer students/instructor proximity whenever desired. Figure 2 diagrams the classroom as it was arranged during the course of the interventions.

Figure 2. Classroom layout.
The high school teaching staff numbered 191, 144 of whom had advanced degrees. The average level of teaching experience was 12 years. Four years ago, the school implemented Positive Behavioral Intervention and Support (PBIS) to address the growing need to make students more aware of behavioral expectations. At about the same time, the school transitioned to an eight-period day. At the time of the study, the school was in the second year of the implementation of both a house system of deans and counselors as well as a weekly late start to accommodate Professional Learning Communities (PLCs).

Two years of science credits were required for graduation. Ninth-grade students were placed in integrated science, biology, or honors biology, according to reading level, middle school academic history, teacher recommendation, and their performance on a standardized test. Performance in these ninth-grade offerings subsequently determined student placement in biology or one of three levels of chemistry. Approximately 86% enrolled in a third year of science, currently an elective for the vast majority. The most popular options were “regular” physics or AP physics-1, as dictated by their science performance to that date. Roughly 87% of these junior science students (approximately 75% of the entire class) elected to pursue a fourth year of science, entering one of the AP classes offered (biology, chemistry, or physics-2), one of the two-semester lab contact classes (anatomy and physiology or earth science), or some combination of two one-semester electives.

Prior to undertaking the research, a complete description was provided to district administrators, along with a request for their approval to conduct the research. A copy of the request letter is in Appendix B.
Student Participants

In the case of the current study, the random selection of study participants compulsory to accepted research methodology must be qualified. The school’s procedure that called for assigning teachers to class sections after students had been randomly placed by guidance counselors precluded any prestudy designation of students to either intervention. However, it must be noted that students in either of these two levels of physics class most likely came from the roughly 40% of the student body who eventually pursued four-year college degrees. Compared to the balance of the student population at this school, students recruited for the study were less likely to rely on free or reduced lunches, less likely to present classroom management issues, and more likely to attend to their studies.

One honors section was designated for the pen-pal intervention, a second honors section designated for the term-paper intervention, and the regular physics class designated for the pen-pal intervention. A copy of the recruitment script that was read to these students can be found in Appendix C. After each class section was informed of the teacher/researcher’s intentions to conduct a research study coincident to teaching a unit on neurophysiology, students and parents were provided with a description of the study, including the voluntary nature of use of data gathered from the variety of research tools utilized. Consent was sought for use of data collected during the course of the unit’s implementation, including survey responses, aggregated performance on neurophysiology pretests and posttests, digital audio recordings of class discussion, and recorded field notes.
Copies of the various consent forms are in Appendix D. The participation rate across all classrooms was 100%.

The imbalance of enrollment by ethnicity (relative to the district profile) (see Table 1) was likely indicative of a relationship between enrollment decisions and college ambitions. That fewer minority students applied to study at the university level is well-documented (Cross & Slater, 2000; Fletcher & Cox, 2012; Heinrich & Holzer, 2011). The discrepancy between the ethnic profile of the school and that of the physics classes could logically be inferred from the link between elective study of physics and a desire to pursue a four-year college degree.

### Table 1

<table>
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<th>Characteristic</th>
<th>1st Period Reg. Physics, Pen Pals (n = 21)</th>
<th>5th Period Honors Physics, Pen Pals (n = 23)</th>
<th>6th Period Honors Physics, Term Papers (n = 24)</th>
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<tr>
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<td>2</td>
<td>4.0</td>
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Intervention: Two Approaches to Instruction

Previous studies have concluded that students’ theories of intelligence are subject to manipulation (Aronson et al., 2002; Bergen 1991; Blackwell et al., 2007; Dweck, 2007).
This research sought to compare two interventions designed to modify student theories of intelligence by alerting them to the concept of mindset and by teaching them rudimentary neurophysiology as it pertains to the learning process.

**Intervention Description and Timeline**

The description of the interventions has been broken roughly into calendar month segments, including a table of that month’s activities and followed by an account of what took place on each day.

Day 1 of the intervention occurred on September 19th (see Table 2) when the preintervention mindset survey was administered to each class. The longest it took any single student to complete the survey was 15 minutes, the shortest was 5 minutes, and a rough average was between 10 and 15 minutes.

<table>
<thead>
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<th>Month</th>
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<th>Term-Paper Intervention</th>
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<td>1</td>
<td>Administer preintervention mindset survey</td>
<td>Administer preintervention mindset survey</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Administer preintervention neurophysiology assessment</td>
<td>Administer preintervention neurophysiology assessment</td>
</tr>
<tr>
<td>October</td>
<td>3</td>
<td>Brief explanation of project (recruitment script read); initiated consent/assent process</td>
<td>Brief explanation of project (recruitment script read); initiated consent/assent process</td>
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</tbody>
</table>

On Day 2 of the intervention (September 24th in regular physics and September 30th in honors physics), the neurophysiology preintervention assessment was administered.

Again, there were no significant differences in how long it took the average student in any
of the three classes to finish the assessment. The soonest anyone finished was 15 minutes and the longest was just under 30 minutes.

On Day 3 (October 21st), the introduction script was read, and consent/assent forms were distributed, followed by a short question and answer period. Basic teacher/researcher expectations were explained to each intervention group. The entire process took about 30 minutes of class time.

Details of the interventions were revealed to students in all three classes on Day 4 (November 11th) during a shortened (40-minute) period (see Table 3). Teacher/researcher expectations for each intervention were detailed in handouts (see Appendix E), and questions were addressed in the discussions that followed in each class on Day 5. The explanation and handout emphasized that student participation was voluntary and could not negatively affect their grades in the class.

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Pen-Pal Intervention</th>
<th>Term-Paper Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>November</td>
<td>4</td>
<td>Intervention explained orally and in writing in class; small groups assembled to select areas of expertise for Jigsaw activity</td>
<td>Intervention explained orally and in writing in class</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Prepared for library research day by going over teacher expectations.</td>
<td>Prepared for library research day by going over teacher expectations.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>In library in small group research (jigsaw-fashion); summary due</td>
<td>In library in individual research; rough outline due</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Small-group expert presentations; class discussion based on letter feedback</td>
<td>Class discussion based on outline feedback</td>
</tr>
</tbody>
</table>

Expectations of the term-paper writers included independent research into mindset, neurophysiology, and personal habits and behavior for the purpose of authoring a three-to-
five page term paper. Students were asked to write their papers using 12-point Times New Roman font doubled-spaced with standard margins. Students were expected to include references, though no minimum number was specified and MLA or APA formatting of references were equally acceptable. A rubric detailing teacher/researcher expectations for the term paper can be found in Appendix F.

Students in the second intervention were instructed to research the same scope of material for the purpose of appropriately communicating the information to fifth-grade students via pen-pal letters. These latter students met briefly in small groups of three or four to select from among the three facets of the unit’s subject matter in preparation to share their expertise within their small groups “Jigsaw-style.” Format instructions for the letters were issued and included suggestions to use a font and font size easy to read, include some personal background information in order to establish a link, and limit the letter’s length to two pages.

On Day 6, students proceeded directly to the library where they experienced a brief tutorial from the library staff on the basics of Internet research. Students in the term-paper class were seated at large four-person library tables, each with a laptop computer that they had checked out of a cart as directed upon entering the space. Students in the pen-pal classes were likewise instructed to check out laptops, but they proceeded to larger work stations that had been created prior to their arrival by pushing tables together. These larger tables accommodated all eight or nine members of each expert group.

After a short lesson by the librarian in how to research books and peer-reviewed articles on the internet, students in both interventions initiated research into mindset,
neurophysiology, and behavior that affects learning. Term-paper students performed their research in relative isolation, consistent with the teacher/researcher expectation of originality.

Students in the pen-pal intervention performed their research within a format that promoted cooperative strategies and intraclass communication. The common practice across all six expert groups (three in each pen-pal class) was to assign Internet research to about half of the group and book research to the other half.

On Day 7 (November 20), pen-pal letter writers started class by meeting for a short period to allow the small group experts to share a summary of the results of their research. That same allotment of time was used in the term-paper intervention class to address questions regarding details of the structure of the term paper. These disparate activities were followed by class discussions in each based on teacher/researcher review of student submissions. The discussion prompts were the same in each class: Why were students asked to do what they were doing? What had they learned that surprised or intrigued them? And what questions had arisen during the course of their research? The rationale for asking these particular questions, besides maintaining consistency over both interventions, was to (a) sustain student attention on the intent of the exercise; (b) build on student curiosity that surprise or intrigue may have initiated; and (c) assure that student attention remained focused on the salient aspects of mindset and neurophysiology.

On Day 8 of the interventions (December 3rd) (see Table 4), another class discussion was held, this one after submission and subsequent teacher review of the term-paper and
second pen-pal letter drafts. During the course of the roughly 20-minute dialogue, issues of subject-matter misconceptions and writing mechanics were raised in all three classes.

Table 4
Fourth Calendar Month of Interventions

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Pen-Pal Intervention</th>
<th>Term Paper Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>December</td>
<td>8</td>
<td>Class discussion to address misconceptions and questions of mechanics</td>
<td>Class discussion to address misconceptions and questions of mechanics</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Final letter drafts due/address and decorate envelopes</td>
<td>Term papers submitted</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Administer postintervention neurophysiology assessment and mindset survey</td>
<td>Administer postintervention neurophysiology assessment and mindset survey</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Administer neurophysiology posttest</td>
<td>Administer neurophysiology posttest</td>
</tr>
</tbody>
</table>

Pen-pal letters and term papers were due on Day 9 (December 16\textsuperscript{th}). Only a single pen-pal letter exceeded two pages in length. Most were in the one-and-a-half-page range, plus or minus a half page. In response to the teacher/researcher’s earlier encouragement to personalize their letters with drawings, pictures, or small, flat tokens that could fit into an envelope, many enthusiastically accepted the offer, resulting in the insertion of a variety of flourishes, including class photos, string bracelets, free-hand and computer drawing, and stickers.

On the same day, the term-paper writers merely submitted the final copies of their work. With few exceptions, the submitted papers were three to five pages in length. The number of references varied from one (a notable and exceptionally low number) to seven (an overwhelmingly popular number of references).
Although it did not count as an intervention activity date in the strictest sense, activities undertaken by the teacher/researcher on the following day (December 17th) did have a bearing on the implications of the study. On this day, the letters were delivered to the fifth-grade classes. Over the course of approximately 45 minutes in each class, an explanation of what the high school students were trying to accomplish was offered to the elementary school students. Specifically, they were informed that the high schoolers wanted to help their younger peers develop a successful recipe for learning upon which they could rely on for the rest of their lives.

After this preface, the letters were distributed and the recipients were invited to use a highlighter to highlight the points they believed their pen pals were trying to make regarding a recipe for learning. From the perspective of the teacher/researcher, the sessions with the fifth-graders were energizing and fun.

The penultimate official day of the interventions (Day 10) was held on December 20th. Students took roughly three-quarters of an hour to complete a postintervention mindset survey and neurophysiology assessment. Day 11 (January 31st) was devoted to a third administration of the neurophysiology assessment in order to discern varying levels of content retention.

Using 50 minutes as one day, the design of the term paper intervention entailed about four days of in-class work and three more out of class. The pen-pal intervention consumed five days in-class with the expectation that students would spend another two days out of class. This slight imbalance between in-class and out-of-class was unavoidable owing to the more time-intensive nature of authoring a paper. Careful observations of the
time spent on each intervention failed to provide sufficient data from which to reach an ironclad conclusion as to which intervention demanded more student effort in terms of time.

Data-Collection Procedures

*Pre- and postsurveys.* Participants completed surveys in which they reported their beliefs regarding the malleability of intelligence, goal orientations, the efficacy of effort, levels of test anxiety, and learning strategies before and after the interventions (see Appendix G; Blackwell et al., 2007).

*Neurophysiology assessment:* Participants took a neurophysiology assessment (developed by the teacher/researcher in cooperation with the school’s AP psychology teacher) three times: once prior to the intervention, once immediately after the intervention, and one additional time approximately five weeks after the intervention (see Appendix H).

*Field notes.* During the approximate seven days of the study (spread over 10 weeks of the fall semester), the researcher took field notes (assisted by digital audio recordings of class sessions) and collected samples of student work (e.g., sample letters or term-paper excerpts).

Measures

*Theories of intelligence:* A survey instrument with five separate scales was used to measure the extent of each student’s theory of intelligence. All survey items were taken from Blackwell et al.’s (2007) survey designed to measure explicitly and implicitly mindset beliefs using a 6-point Likert-type scale (1 = “disagree a lot” to 6 = “agree a lot”).
Agreement with some of the survey items reflected belief in an incremental theory of intelligence and were positively scored (higher scores associated with an incremental theory). Agreement with some of the survey items was suggestive of an entity theory of intelligence and these items were reverse scored.

Measures were constructed to be consistent in their measuring and maximize the internal consistency of the measure. The internal consistency of the items in the survey was tested by calculating Cronbach’s alpha coefficients within each subsection as well as for the overall survey. Inter-item correlations were also checked because several of the scales had fewer than 10 items (Pallant, 2013). In cases in which Cronbach’s alphas fell below desired thresholds, inter-item consistency was used to identify and delete scale items inconsistent in their measurement of the underlying (mindset) construct. In some cases, items were consistent for one of the surveys (pre- or post-) but not the other. When this happened, the decision was made to delete such items from both preintervention survey data and postintervention survey data in order to maintain consistency. Internal consistency was given higher priority than balancing the number of positively- and reverse-scored items per scale, resulting in an apparent imbalance on several of the scales between incremental and entity theory statements.

Aggregate (mean) scores were calculated for each student for each scale. These scores were presumed to provide an idea of where students stood on the spectrum of strong entity theory belief (1) to strong incremental theory belief (6). In the case of test-anxiety scores, the aggregate scores were reversed in order that higher scores were more reflective of anxiety levels more consistent with an incremental theory, but lower scale scores were
more suggestive of an entity theory. This convention was implemented so that subsequent inspection of scale scores would reflect the intuition that higher scores would coincide with higher test anxiety. The five scales along which student beliefs were measured are described as follows.

**Malleability of Intelligence.** A measure of student beliefs about the malleability of intelligence was constructed by taking the mean of five items: three incremental items (e.g., “No matter who you are, you can change your intelligence a lot”); and two entity-theory items (e.g., “You can learn new things, but you can't really change your basic intelligence”; Blackwell et al., 2007).

**Mastery-Goal Orientation.** A measure of student goal orientation was constructed by taking the mean of 13 items: five incremental items (e.g., “An important reason why I do my school work is because I like to learn new things”); and eight entity-theory items (e.g., “It’s very important to me that I don't look stupid in class”; Blackwell et al., 2007).

**Effort Beliefs.** A measure of student beliefs about the efficacy of effort in changing intelligence was constructed by taking the mean of 10 items: two incremental items (e.g., “The harder you work at something, the better you will be at it”); and eight entity-theory items (e.g., “If you're not doing well at something, it's better to try something easier”; Blackwell et al., 2007).

**Test Anxiety.** A measure of student test anxiety was constructed by taking the mean of five entity theory items (e.g., “I usually have an upset feeling when I take a test”; Blackwell et al., 2007).
Use of Positive Strategies. A measure of student utilization of strategies associated with an incremental theory was constructed by taking the mean of nine incremental items (e.g., “When I study, I put important ideas in my own words”; Blackwell et al., 2007).

Achievement

A neurophysiology assessment was designed to determine levels of cognitive understanding and rote learning of the aspects identified as pertinent to the interventions’ ability to manipulate mindset. Assessment items covered parts of the brain, including the structure of neurons and the processes of integration, adaptation, and sophistication; basic mechanics of how the brain changes when it “learns;” and the effects that behavioral and environmental factors, such as sleep, nutrition, emotion, and drug use, can have on learning. Some of the test questions were culled from retired college board advanced placement (AP) psychology tests as well as test bank items furnished by Worth Publishers for use with Myers Psychology for AP (Myers, 2010) and some were created specifically for the purposes of this research.

Upon grading the assessments, the determination was made that several of the items did not accurately reflect aspects of neurophysiology deemed relevant to the purposes of the intervention. A second neurophysiology score (referred to as the “Selected Items Score”) was calculated based on a revised set of test items. The possible score range for the complete test was from 0 to 26 and 0 to 15 for the selected items score. The observed scores for the complete test ranged from 0 to 19, and scores for the selected items test
ranged from 0 to 12. Mean values, standard deviations, and skewness and kurtosis for both versions of each of the three times the assessment was given are shown in Table 5.

Table 5
Time 1, Time 2, and Time 3 Neurophysiology Assessment Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Skewness Statistic</th>
<th>Std. Error</th>
<th>Kurtosis Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preintervention complete test score</td>
<td>68</td>
<td>3</td>
<td>15</td>
<td>8.84</td>
<td>2.832</td>
<td>.397</td>
<td>.291</td>
<td>-.490</td>
<td>.574</td>
</tr>
<tr>
<td>Preintervention selected items test score</td>
<td>68</td>
<td>1</td>
<td>9</td>
<td>4.72</td>
<td>2.212</td>
<td>-.001</td>
<td>.291</td>
<td>-.979</td>
<td>.574</td>
</tr>
<tr>
<td>Postintervention complete test score</td>
<td>66</td>
<td>5</td>
<td>18</td>
<td>11.53</td>
<td>3.287</td>
<td>.064</td>
<td>.295</td>
<td>-.842</td>
<td>.582</td>
</tr>
<tr>
<td>Postintervention selected items test score</td>
<td>66</td>
<td>2</td>
<td>12</td>
<td>6.45</td>
<td>2.213</td>
<td>.322</td>
<td>.295</td>
<td>-.171</td>
<td>.582</td>
</tr>
<tr>
<td>Delayed complete test score</td>
<td>58</td>
<td>4</td>
<td>19</td>
<td>11.22</td>
<td>3.857</td>
<td>-.129</td>
<td>.314</td>
<td>-.729</td>
<td>.618</td>
</tr>
<tr>
<td>Delayed selected items test score</td>
<td>58</td>
<td>0</td>
<td>12</td>
<td>6.07</td>
<td>2.714</td>
<td>-.015</td>
<td>.314</td>
<td>-.389</td>
<td>.618</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Participant Observation**

Assuming the role of teacher/researcher carries the risk of loss of objectivity but rewards the researcher with an unparalleled view of how the student participants respond to the interventions. Arguably, there is no better way to gauge student response to each phase of the interventions than as the teacher/researcher (Gay, Mills, & Airasian, 2012). Kemmis and McTaggart’s (2000) portrayal of classroom action research as inclusive of “research that typically involves the use of qualitative, interpretive models of inquiry and data
collection by teachers with a view to teachers making judgments about how to improve their own practice” (p. 569) suggests that this particular methodology is uniquely suited to roles of both teacher and researcher.

Experience gained in the pilot test of the pen-pal intervention suggested that there would be several specific student actions and reactions worth noticing. Among them were levels of involvement in class discussions, inquiries (about the intervention) outside of class time, and the quality of the artifacts produced by study participants, e.g., their letters and the term papers.

Once removed from the field (by as little time and space as possible), it was incumbent upon the researcher to flesh out the skeleton provided by field observations. Immediate transcription into a word-processing program accomplished several important goals. It increased the accuracy of direct quotations, allowing the observer to more faithfully capture the emic perspective (Patton, 1990). It reduced reliance on recall. It provided for inserting information recalled out of order. It served to coalesce main ideas or themes discovered during the time in the field (Bogdan & Biklen, 2007; Creswell, 2008; Patton, 1990). And it provided an opportunity to insert “hunches, questions, and insights” (Gay, Mills, & Airasian, 2012) that facilitated subsequent analysis.

Synthesis of the suggestions offered in the variety of resources (Bogdan & Biklen, 2007; Marshall & Rossman 2011; Patton, 1990) resulted in the custom-made field-note protocol found in Appendix I. Experience gained during the course of the pilot pen-pal project led the researcher to believe that the independent, small-group and large-group work inherent in the intervention would provide time to make notes of observations. A single
mounted video camera with the lens cap left on was used during the course of whole-class discussions to capture relevant occurrences (audio only) and serve as a memory aid for subsequent analysis of field observations.

**Term Papers and Pen-Pal Letters**

Students were instructed to submit their term papers and letters electronically, providing the teacher/researcher with a repository for the products of their work. No special organization, aside from files saved according to the author’s last name, was used.

An additional source of data came in the form of written reflection by several of the term-paper writers. The fact that the pen-pal letter writers had no such opportunity was due purely to the researcher’s inexperience. Term-paper reflections came about as a means of giving the students in this intervention the same opportunity to earn class points that the letter writers had by virtue of writing a second letter to the fifth-graders. In hindsight, students in each treatment should have been given the same opportunity for reflection because of the value typically associated with such an exercise and for the additional insight it would have provided the researcher.

Despite this shortcoming, a description of the reflections and analysis and interpretation of the term-paper authors has been included. It can be weakly argued that pen-pal letter writers offered reflective feedback during the course of the intervention in view of the relatively transparent nature of the exercise compared to writing a term paper, typically performed in relative isolation.
Fifth-Grade Student Feedback

The fifth-grade pen-pal letter recipients were asked by their teachers to reflect on what they learned from exchanging pen-pal letters with high school students. It should be noted that in addition to the letters, these students were visited by the teacher/researcher, during which time they were given their letters, were given time to open and read them, and then were led by the teacher/researcher in a discussion designed to elicit their thoughts on what was of most importance in the letters. The specific format used to capture their thoughts was a half-page sheet of paper with four writing prompts asking them to list something they learned, something else they learned, a lifestyle change they applied, and if they had any other comments. Forty-four students responded (see Appendix J for a copy of the form used to collect this feedback).

Considered in isolation, the feedback from the pen-pal letter recipients cannot qualify as data helpful in answering any of the research questions. In the strictest sense, not one of the questions addresses collateral change manifested in the habits or beliefs of the fifth-grade students. If, however, one considers the broader educational concerns that directly led the teacher/researcher to undertake the study (specifically the potential of the adoption of favorable mindsets and healthier personal habits to stimulate adaptive learning strategies among students), collection, analysis, and interpretation of these data helped in the process of identifying implications of the study.
Parametric Assumptions

In view of the exclusive use of parametric tests for the study’s quantitative analysis, the resulting data sets were checked to make sure the necessary assumptions requisite for these particular tests had been met. The small sample sizes made the assumption of normality more than just a formality.

Using the revised scope of survey items, only a single z-score (1.96) suggested a violation of normality at $p < .05$. There were, however, several large kurtosis values that suggested that further assessment of the data’s normality was warranted. Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) tests yielded ambiguous results. In particular, some items passed K-S but failed S-W and vice versa.

Using this ambiguity as a means of identifying possible violations of normality, histograms and normal Q-Q plots were generated and consulted. With one exception, visual inspection of the histograms and accompanying Q-Q plots suggested normal distribution. The lone exception was the histogram for post-intervention mindset mean. Its normality suffered from a noticeable negative skewness that might be explained ultimately by a migration of thought by participants toward a growth mindset.

Performance of analysis of covariance (ANCOVA, described below) required confirmation that several additional assumptions were met. These assumptions, and the results of the tests used to verify that they had indeed been met, can be found in Appendix K. Additionally, Appendix K provides evidence confirming the data’s fulfillment of the assumptions necessary to perform the 2x2 ANCOVA. A single additional test for
homogeneity of intercorrelations as an assumption was required for the split-plot ANOVA, described following.

Analytic Plan and Preliminary Analysis

Mindset Survey Results

The first research question sought to discern the degree to which students adhered to either of the self-theories of intelligence. The extent to which students embraced a growth or fixed mindset, along each of the five scales (and comparisons between males and females as well as between honors and regular physics students), was determined by performing independent-samples t tests.

The second research question sought to discern differences in student response to the interventions. In view of the ubiquitous nature of significant differences between the response of males and females to instructional practices, t tests were performed in order to check for any such differences. Statistically significant differences in two of the scales suggest higher levels of test anxiety for girls ($p = .01$) as well as their greater likelihood to employ positive strategies ($p < .001$).

A mixed between-within ANOVA was used to examine mindset beliefs across the five scales. Early results of some of the tests suggested that any analysis that failed to control for gender would have been incomplete. Gender was added as an independent variable to the previous mixed between-within ANOVA to determine if there was a statistically significant interaction between gender and intervention type.
Neurophysiology Test Results

Research Question 3 asked how students in the different instructional approach groups compared with respect to their comprehension and retention of course content on neurophysiology. A mixed between-within subjects ANOVA was performed to check for any statistically significant difference in performance on the neuro assessments over time (from Trial 1 to Trial 3) using scores for the complete test. Two additional mixed between-within ANOVAs were performed to compare time-1 test scores (prior to the intervention) directly with time-2 (immediately after the intervention) and to compare time-1 scores directly with time-3 scores (given six weeks after the end of the intervention). As with the analysis of possible changes in mindset, gender was added to these analyses as an independent variable.

Qualitative Analysis

Qualitative analysis was based primarily on data collected during the course of the study, including researcher field notes, entries in a research journal, and student products, namely the term papers and pen-pal letters. Field notes were comprised primarily of written reflections made in situ or as near to real time as possible. The real-time notes were handwritten on a participant observation form (see Appendix I) and were transcribed subsequently into a research journal stored and updated as a Word document. When necessary, audio recordings of the intervention sessions were consulted in order to enhance memory. All student products were submitted electronically, a format that facilitated their
collection, storage, and analysis. In total, this body of qualitative data lent itself best to a search for patterns and significant events, the results of which follow.

Field Notes and Research Journal

As mentioned above, field notes were routinely transcribed into the researcher’s journal. By design, the resulting document was meant to provide the bulk of data with which to make a comparison of the experiential differences of participants in the interventions by capturing anecdotal evidence.

Student Products

Each type of artifact served to present the researched material (neurophysiology, explication of mindset, and personal habits that might affect learning) in a manner befitting the instructional directions given within a particular intervention. Each student submission was assessed for aspects judged as indicative of relative levels of engagement or enthusiasm for the intervention. One example of each type (term paper and pen-pal letter) can be found in Appendix L.
CHAPTER 4
RESULTS OF DATA ANALYSIS

Introduction

This chapter provides the results of a mixed method quasi-experimental study of two different interventions designed to raise student awareness of the susceptibility of intelligence to growth. The chapter includes discussion of parametric test results for each of the first three (quantitative) research questions as well as an analysis of data associated with qualitative assessment of student response to the interventions.

Endorsement of Mindset

Results presented in this section address Research Question 1, which asked, “To what degree do students endorse a growth mindset, and are these beliefs about their intelligence related measurably to gender or level of physics class?”

Mean scores for each scale suggest that student self-theories of intelligence most often reflect a growth perspective with regard to their ability to change their level of intelligence ($M = 4.86$, $SD = .64$) through effort ($M = 4.41$, $SD = .71$). Middling mean values for mastery-goal orientation ($M = 3.58$, $SD = .70$), use of positive strategies ($M = 3.73$, $SD = .79$), and test anxiety ($M = 3.31$, $SD = .123$), in combination with a broad range of scores along these scales, suggest the absence of consistent mindset beliefs that could be
characterized as either growth or fixed. Descriptive statistics for the calculated means are in Table 6.

Table 6
Preintervention Mindset Scale Score Descriptive Statistics

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malleability of intelligence</td>
<td>4.86</td>
<td>.64</td>
<td>3.17</td>
<td>6.00</td>
<td>0.77</td>
</tr>
<tr>
<td>Mastery-goal orientation</td>
<td>3.58</td>
<td>.70</td>
<td>2.00</td>
<td>5.50</td>
<td>0.82</td>
</tr>
<tr>
<td>Effort beliefs</td>
<td>4.41</td>
<td>.71</td>
<td>2.67</td>
<td>6.00</td>
<td>0.62</td>
</tr>
<tr>
<td>Test anxiety*</td>
<td>2.69</td>
<td>1.23</td>
<td>1.00</td>
<td>6.00</td>
<td>0.90</td>
</tr>
<tr>
<td>Positive strategies</td>
<td>3.73</td>
<td>.79</td>
<td>1.38</td>
<td>5.50</td>
<td>0.72</td>
</tr>
</tbody>
</table>

*Lower scale scores coincide with lower levels of test anxiety

Two-tailed t tests’ results, summarized in Table 7, indicate that there were no significant differences by class type (regular physics versus honors physics) in any of the mindset scales. T tests comparing males to females (see Table 8) suggested a statistical difference between males and females prior to the intervention for test anxiety and positive strategies. Prior to the intervention, females reported significantly higher test anxiety relative to males. An eta-squared value of .09 signifies a moderate to large effect size. Prior to the intervention, females reported significantly higher likelihood to employ positive strategies (associated with a growth mindset) relative to males. An eta-squared value of .19 signifies a large effect size.
Table 7
Independent Samples \(t\) Test Comparing Preintervention Mindset Beliefs by Class Type

<table>
<thead>
<tr>
<th>Scale</th>
<th>Regular Physics (n = 21)</th>
<th>Honors Physics (n = 47)</th>
<th>(t)</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malleability of intelligence</td>
<td>4.67</td>
<td>4.83</td>
<td>.86</td>
<td>.39</td>
</tr>
<tr>
<td>Mastery-goal orientation</td>
<td>3.60</td>
<td>3.66</td>
<td>.30</td>
<td>.77</td>
</tr>
<tr>
<td>Effort beliefs</td>
<td>4.25</td>
<td>4.26</td>
<td>.02</td>
<td>.99</td>
</tr>
<tr>
<td>Test anxiety*</td>
<td>2.78</td>
<td>2.65</td>
<td>.47</td>
<td>.68</td>
</tr>
<tr>
<td>Positive strategies</td>
<td>3.52</td>
<td>3.67</td>
<td>.77</td>
<td>.44</td>
</tr>
</tbody>
</table>

*Lower scale scores coincide with lower levels of test anxiety

Table 8
Independent Samples \(t\) Test Comparing Preintervention Mindset Beliefs by Gender

<table>
<thead>
<tr>
<th>Scale</th>
<th>Males (n = 33)</th>
<th>Females (n = 35)</th>
<th>(t)</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malleability of intelligence</td>
<td>4.70</td>
<td>4.85</td>
<td>-.84</td>
<td>.40</td>
</tr>
<tr>
<td>Mastery-goal orientation</td>
<td>3.72</td>
<td>3.57</td>
<td>.93</td>
<td>.30</td>
</tr>
<tr>
<td>Effort beliefs</td>
<td>4.25</td>
<td>4.26</td>
<td>-.12</td>
<td>.91</td>
</tr>
<tr>
<td>Test anxiety*</td>
<td>2.30</td>
<td>3.05</td>
<td>2.62</td>
<td>.01</td>
</tr>
<tr>
<td>Positive strategies</td>
<td>3.28</td>
<td>3.95</td>
<td>-.97</td>
<td>.00</td>
</tr>
</tbody>
</table>

*Lower scale scores coincide with lower levels of test anxiety

With regard to the purported balance between entityists and incrementalists (Dweck, 2000), such an equal bifurcation of students, according to self-theories of intelligence, would have manifested itself as a strongly bimodal histogram of mindset scale scores. None of the five histograms of mean scale scores suggested such bimodalism.

According to a rubric established by Hong, Chiu, Dweck, Lin, and Wan (1999), the percentages of students in the current study characterized as entity theorists, incremental theorists, or neither varies widely across the five scales. Hong et al., used a three-item survey instrument developed by Dweck and Henderson for a 1988 study (and modified with
the addition of a fourth question in 1997) to classify students’ theories of intelligence. In that study, as in this, student responses along a 6-point Likert scale facilitated calculation of mean scores per student per scale. The researchers classified scale scores of less than 3.0 as indicative of a fixed mindset, scores greater than 4.0 as indicative of a growth mindset, and scores between 3.0 and 4.0 as indicative of an ambiguous mindset. Table 9 displays the variety of mindset classifications along the five scales.

Table 9
Prevalence of Mindset

<table>
<thead>
<tr>
<th>Mindset Scale</th>
<th>Fixed Mindset (&lt; 3.0)</th>
<th>Ambiguous Mindset (3.0-4.0)</th>
<th>Growth Mindset (&gt; 4.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Malleability of intelligence</td>
<td>0</td>
<td>0.0</td>
<td>12</td>
</tr>
<tr>
<td>Mastery-goal orientation</td>
<td>10</td>
<td>15.0</td>
<td>39</td>
</tr>
<tr>
<td>Effort beliefs</td>
<td>0</td>
<td>0.0</td>
<td>29</td>
</tr>
<tr>
<td>Test anxiety</td>
<td>28</td>
<td>41.0</td>
<td>21</td>
</tr>
<tr>
<td>Positive strategies</td>
<td>12</td>
<td>18.0</td>
<td>35</td>
</tr>
</tbody>
</table>

Note. n = 68

Influencing Mindset by Teaching Neurophysiology

Results presented in this section address the second research question, which asked, “How do students who experience different interventions that teach neurophysiology compare with respect to the degree to which they espouse various mindset-related beliefs, including beliefs about the malleability of intelligence, mastery-goal orientation, effort beliefs, test anxiety, and the use of positive learning strategies?”

The survey instrument was administered to the students once prior to the intervention and once again just after the intervention. In view of the ubiquity of how
males and females often respond differently to classroom interventions, the analysis additionally sought to detect if gender was a mitigating factor in how students responded to the intervention. After confirming that the additional assumptions of lack of correlation among covariates, linearity, and homogeneity of regression slopes had been met (see Appendix M), a mixed between-within ANOVA was performed to examine the effectiveness of the interventions at promoting a growth mindset across each of the five scales, simultaneously assessing the extent of a possible interaction between intervention and gender. Table 10 presents the preintervention and postintervention scores and Wilks’ Lambda test scores and effect size statistics for main effect.

Table 10
Mixed Between-Within ANOVA Descriptive Statistics

<table>
<thead>
<tr>
<th>Scale</th>
<th>Pen-Pal Letter Writers (n = 44)</th>
<th>Term Paper Writers (n = 24)</th>
<th>Wilks’ Lambda</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Malleability of intelligence</td>
<td>4.70</td>
<td>.76</td>
<td>5.04</td>
<td>.68</td>
</tr>
<tr>
<td>Mastery-goal orientation</td>
<td>3.57</td>
<td>.62</td>
<td>3.29</td>
<td>.54</td>
</tr>
<tr>
<td>Effort beliefs</td>
<td>4.16</td>
<td>.58</td>
<td>4.37</td>
<td>.54</td>
</tr>
<tr>
<td>Test anxiety*</td>
<td>2.56</td>
<td>1.25</td>
<td>2.15</td>
<td>1.34</td>
</tr>
<tr>
<td>Positive strategies</td>
<td>3.46</td>
<td>.75</td>
<td>3.42</td>
<td>.81</td>
</tr>
</tbody>
</table>

Note. n = 68
*Lower scale scores coincide with lower levels of test anxiety
Malleability of Intelligence. In the analysis of the malleability of intelligence, there was no significant interaction between intervention type and time, Wilks’ Lambda = .98, $F(2, 63) = 1.60, p = .210$. However, the low power of the test (.24), owing to the small sample size, restricts the ability to detect the existence of a statistical difference between intervention type and time. There was a statistically significant main effect for the interventions between Time 1 and Time 2, Wilks’ Lambda = .94, $F(2, 63) = 4.14, p = .046$. The partial eta squared value (.061) suggests a moderate effect size. No differences according to gender were detected.

Mastery-Goal Orientation. In the analysis of mastery-goal orientations, there was no significant interaction between intervention type and time, Wilks’ Lambda = .99, $F(2, 63) = .33, p = .57$. This test had very low power (.09) to detect a difference between the intervention groups over time. There was a statistically significant main effect for the interventions between Time 1 and Time 2, Wilks’ Lambda = .74, $F(2, 63) = 22.96, p = .000$. The partial eta squared value (.264) suggests a large effect size.

Effort Beliefs. In the analysis of effort beliefs, there was a significant interaction between intervention type and time, Wilks’ Lambda = .90, $F(2, 63) = 6.83, p = .011$. A partial eta squared value of .096 suggests the interventions had a moderate effect. There was no statistically significant main effect for the interventions between Time 1 and Time 2, Wilks’ Lambda = .99, $F(2, 63) = .465, p = .498$.

Review of the plots in Figure 3 derived from the mixed between-within ANOVA reveals relevant trends. The higher starting scale scores of students in the term-paper intervention are associated with greater belief in effort although lower scale scores indicate
less confidence in the power of effort. The graph indicates two quite different experiences according to intervention. Over time, the term-paper writers became less convinced of the ability of effort to impact their academic performance, but the pen-pal writers became more convinced. Ultimately, students from each intervention held roughly the same belief about effort.

![Estimated Marginal Means of Effort](image)

**Figure 3:** Effort beliefs by intervention (higher scores indicate greater belief in the efficacy of effort).

Consideration of gender (see Figure 4) reveals that this erosion is especially precipitous among boys.
Figure 4. Males’ effort beliefs by intervention (higher scores indicate greater belief in the efficacy of effort).

Results for tests to reveal differences in belief in the efficacy of effort according to gender were nonsignificant, Wilks’ Lambda = .99, $F(2, 63) = .87, p = .354$). Effect size (partial eta squared = .013) and test power (.15) were ambiguous in their ability to support rejection of the null hypothesis. Figure 5 suggests that either intervention is likely to increase girls’ beliefs in the efficacy of effort, but more so if they experience the pen-pal intervention.
Figure 5. Females’ effort beliefs by intervention (higher scores indicate greater belief in the efficacy of effort).

*Test Anxiety.* In the analysis of test anxiety, there was a significant interaction between intervention type and time, Wilks’ Lambda = .93, $F(2, 63) = 4.92, p = .030$. There was a statistically significant main effect for the interventions between Time 1 and Time 2, Wilks’ Lambda = .92, $F(2, 63) = 5.35, p = .024$. The partial eta squared value (.077) suggests a moderate effect size. There was a small between-subjects effect (partial eta squared = .064; test power = .541). Table 10 presents the preintervention and postintervention scores and Wilks’ Lambda test scores and effect size statistics for main effect.

Review of the plots from the ANOVA reveals relevant trends. Despite the inexplicably higher (healthier) initial perspective of test anxiety by students in the pen-pal
intervention, these students experienced a reduction in test anxiety compared to the relatively stable perspective of test anxiety demonstrated by students in the term-paper intervention (see Figure 6). As with test anxiety, effect size (partial eta squared = .005) and test power (.08) were ambiguous in their ability to support rejection of the null hypothesis regarding the interventions’ capacity to assuage test anxiety by gender.

Figure 6. Test anxiety by intervention (lower indicate lower levels of test anxiety).

Figure 7 suggests that boys responded negatively to the term-paper intervention, growing in test anxiety between the beginning and end of the intervention.
Figure 7. Males’ test anxiety by intervention (lower scores indicate lower levels of test anxiety).

A notable change over the course of the intervention is indicated in Figure 8. Girls in the pen-pal intervention began with higher levels of test anxiety than did those in the term-paper intervention. By the end of the intervention, these girls (in the pen-pal intervention) had more successfully embraced a growth-mindset perspective of tests—one that reduces fear of them.
Figure 8. Females’ test anxiety by intervention (lower scores indicate lower levels of test anxiety)

**Positive Strategies.** With regard to positive strategies, there was no significant interaction between intervention type and time, Wilks’ Lambda = .99, $F(2, 63) = .049, p = .825$. The very low power of the test (.06) is ample cause for speculation that the test was unable to discern a significant result. There was no statistically significant main effect for the interventions between Time 1 and Time 2, Wilks’ Lambda = .999, $F(2, 63) = .070, p = .792$. There was a significant between subjects effect (partial eta squared = .171; test power = .948). Table 11 presents the preintervention and postintervention scores and Wilks’ Lambda test scores and effect size statistics for main effect.
Table 1

Neurophysiology Test Scores Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Pen-Pal Letter Writers (n = 19)</th>
<th>Term-Paper Writers (n = 19)</th>
<th>Wilks’ Lambda</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Delayed</td>
<td>Pre</td>
</tr>
<tr>
<td>Neuro Test M</td>
<td>5.32</td>
<td>7.32</td>
<td>7.32</td>
<td>5.16</td>
</tr>
<tr>
<td>Neuro Test SD</td>
<td>2.36</td>
<td>2.00</td>
<td>2.00</td>
<td>2.17</td>
</tr>
</tbody>
</table>

Neurophysiology Comprehension and Retention from Two Different Teaching Interventions

Results presented in this section address the third research question, which asked, “How do students in the different instructional approach groups compare with respect to comprehension and retention of course content on neurophysiology?”

A mixed between-within ANOVA was conducted to determine whether there was a difference in neurophysiology conceptual understanding and retention according to intervention type. Descriptive statistics for student performance on the neurophysiology test are shown in Table 11.

Results of the ANOVA suggest that there was no significant interaction between intervention type and time, Wilks’ Lambda = .96, $F(2, 34) = .70$, $p = .50$. The low power of the test (.16) to detect a difference suggests caution in total faith in the null hypothesis.

There was no statistically significant main effect for the interventions over Time 1, Time 2, and Time 3, Wilks’ Lambda = .97, $F(2, 34) = .427$, $p = .66$. Again, a low power statistic (.11) suggests restraint in total acceptance of the null hypothesis.
Two additional ANOVA tests were conducted to guard against significant results that may have been obscured by considering all three times in the analysis. Specifically, one ANOVA was performed for differences between Time 1 and Time 2, and another was performed for differences between Time 1 and Time 3.

The ANOVA comparison between Time 1 and Time 2 suggests no significant difference between the interventions, Wilks’ Lambda = .96, $F(2, 42) = 1.72$, and $p = .196$. The power of the test (.25) to determine a significant difference is reason for using care in concluding no difference. The ANOVA comparison between Time 1 and Time 3 suggests no significant difference between the interventions, Wilks’ Lambda = .96, $F(2, 35) = 1.60$, and $p = .215$, but reliance on such a conclusion is again tempered by the test’s suppressed capacity to reveal a difference (power = .23).

Salient Indicators of Engagement with and Enjoyment of the Intervention

Results presented in this section address the fourth research question, which asked, “How do students in the different instructional approach groups compare with respect to how engaged they are in the activity as manifested in their response to (and enthusiasm for) the activity, their persistence at the task, their apparent enjoyment derived from participation, and any other salient indicators of experiential differences that may have arisen during the course of the study?”

This research question sought to assess levels of student engagement, enjoyment, and enthusiasm. As factors less susceptible to metrics of comparison, qualitative methods associated with action research were used without illusions of generalizability of the results.
The interventions were “a curricular idea [brought] to life in . . . concrete interaction with specific students under local circumstances” (Altrichter & Posch, 2009, p. 222). In the case of this research, the plan (the “curricular idea”) was to engage students in an activity (the “concrete interaction”) that sought to manipulate the mindset of students who were in the teacher/researcher’s high school physics classes (the “local circumstances”) and were constrained by entity theories of intelligence (the “specific students”). The study’s axiology derives from recognizing contextual similarities rather than focusing on the undeniable differences that exist between the research environment and one’s own particular, and presumably unique, teaching environment (McAteer, 2013).

The research journal maintained by the teacher/researcher during the course of the study, comprised of 11 pages and over 4,400 words, provided most of the data from which to draw conclusions regarding relative levels of student engagement and enthusiasm. However, the clarity of hindsight reveals profound shortcomings in the ability of this data to inform definitive conclusions. Field notes and journal entries did not contain a sufficient number of pertinent observations that could be coded in quest of a means of comparison. Instead, it is left to the teacher/researcher to draw on significant experience as a practitioner to relate impressions of student engagement and enthusiasm, abetted when possible by field notes and journal entries.

Expressed Levels of Satisfaction. A poignant contrast between the experiences of students in the two interventions was the mild level of dissatisfaction expressed at the outset of the interventions by the term-paper writers. As word spread regarding the contrast between the interventions, the term-paper writers voiced their dissatisfaction at the apparent
disparity between how much enjoyment they would have writing a term paper (none) versus the enjoyment that their pen-pal peers were going to have. They also believed that they were going to have to work harder to produce a paper. During the later stages of the intervention, confirmation of the mild animus term-paper writers had for pen-pal letter writers was confirmed by the chorus of affirmation offered by pen-pal letters in response to the open query: “Are your friends who are writing term papers jealous of you?”

**Research Atmosphere.** Day 6 of the intervention was spent performing research in the school library. Field-note records and entries in the research journal provide accounts of the activity. Students in the term-paper class were either seated at large four-person library tables, each with a laptop computer that they had checked out of a cart as directed upon entering the space, or they had migrated to individual study carrels spread around the perimeter of the library space. The mood was subdued as students pursued their research in relative isolation (as compared to the pen-pal letter writers). In contrast, students in the pen-pal classes gathered to work at larger stations that had been created prior to their arrival by pushing two tables together. During the first few moments, these students cooperatively selected group leaders and recorders within each of the three areas of expertise. Additional time was spent further breaking down their assigned topic by subtopics (e.g., drug abuse or “brain foods”) or by reference type (e.g., Internet research or reference books). By so doing, these students appeared to make much better use of the available resources.

In contrast to the more restrained atmosphere of the term-paper researchers, the pen-pal students consulted one another frequently or announced lines of inquiry or breakthroughs. In contrast to the term-paper writers, the first few moments of their research
session was marked by animated moments of cooperation and collaboration as they selected group leaders and recorders. An example was Cassie broadly proclaiming that she would thoroughly read passages in Dweck’s (2000) *Self-Theories* associated with the origin of mindset. Moments later, Erik told the group that he was on a website that had lots of information on how drugs and alcohol “messed up learning.”

Very few pen-pal students failed to play an obvious role in the research effort. and the few students who did seem to shrink from the task had by then demonstrated an aversion for any such interaction in class. Maddie was an example of this detachment—I watched as she stared at a frozen computer screen for at least 10 minutes, failing to call attention to her apparent inability to make contact with the virtual world through an Internet connection. By comparison, the independent work performed by term-paper writers made teacher assessment of levels of engagement much more difficult. By working independently at remote work stations scattered throughout the library, these students had latitude to be off-task not afforded to the pen-pal letter writers.

*Final Day of Intervention.* Day 9 activities by intervention were radically different. Term-paper writers merely handed the final draft of their papers. On the same day, letter authors addressed the envelopes under starkly different conditions. Earlier in the intervention, the question had been posed regarding latitude for decorating the envelopes as well as what could be included in them. From that moment on, many made rather elaborate plans. The colored pencils and markers provided for addressing the envelopes were often supplemented with stickers, photos, drawing, and personal artifacts such as string bracelets. The atmosphere was reminiscent of the teacher/researcher’s recall of class sessions held on
the eve of holiday breaks wherein students engaged in purely recreational pursuits. “Festive” would be an apt description of the mood in the pen-pal classes this day.

*Pen-Pal Letters and Term Papers.* Restriction of description, analysis, and interpretation of the products of each intervention to points salient to the comparison of the two yielded little more than nuance. Students in both interventions showed quite similar foci. The pen-pal letters dwelt upon the brain’s weight gain during learning, what constitutes a “good night’s sleep,” what processes occur in the brain during sleep, the deleterious effects of drugs and alcohol, the importance of eating a healthy breakfast, differences in how people learn, and descriptions of mindset.

Whereas the letters addressed each of the items tersely and in isolation, the term-papers were routinely constructed along a three-part outline. Each of the three seminal aspects of the research was introduced, defined, and then explicated (typically) via personal experience.

Perhaps the greatest differences between the products of each intervention were in the depth of treatment of the research topics and in how personal connection to the material manifested itself. The trend among term-paper writers was to provide deeper descriptions and definitions of the topics and then expand on these descriptions and definitions by making specific, personal connections with each topic. In contrast, the pen-pal letter writers tended to provide a more superficial treatment of the material (as might be expected owing to consideration of their audience), and rather than personalizing the information, these particular authors sought more often to give their younger peers advice based on the new information they were conveying. Whether these differences translate to varying
levels of engagement and enthusiasm (in an attempt to answer the research question) is difficult to assert.

An additional difference worthy of report due to its inclusion in the implications and discussion of the study was the teacher/researcher’s interaction with the fifth-grade letter recipients. These students had been briefed prior to the teacher/researcher’s visit. During a brief question-and-answer session prior to the dissemination of the letters, questions posed by these young students were interpreted by the teacher/researcher as indicative of a high level of interest in a novel activity. When asked to open and read their letters and use a highlighter to mark passages that resonated with them, many students were observed to highlight nearly the entire letter. Although some students sat quietly, reading their letters intently and highlighting passages, others in the room spontaneously read passages aloud, straining for teacher attention to some aspect that held some personal meaning. Still others took their letters to share with friends across the room.

This flurry of activity was followed by a teacher/researcher-moderated session in which the students had a chance to vocalize their thoughts in a more managed discussion. Strategic placement of student revelations on a blackboard enabled the teacher/researcher and the classroom teachers to help the elementary school students better assimilate much of what the high school students were trying to communicate. Field notes written immediately following the classroom sessions indicated that the items most commonly mentioned by the fifth-graders were changes to the brain during the course of learning something new, the need for adequate sleep, the need to eat a healthy breakfast, and what it means to have either of the two mindsets.
As a follow-up exercise, the fifth-grade teachers solicited feedback from their student participants about the exercise. Each student was asked to submit written answers to four questions on a half-page survey instrument (see Appendix J). In response to the questions about what they had learned, 25 of the 45 students who responded recalled that the brain changes upon learning something new (“When you get borned (sic) and get older, your brain changes”), 20 mentioned the need for adequate sleep (“When you’re sleeping, the brain does not rest. It’s working and storing information”), 20 recognized the need to eat a healthy breakfast (“That you need to breakfast because it stays in your body all day and your brain uses it.”), and 15 said that they had learned what it means to have either of the two mindsets (“If you believe that you can do something you can do it.”).

In response to the query into lifestyle changes, each student offered specifics about how they had applied what they learned in the letters from their high school pen pals, ranging from new bedtime routines (“I started to go to sleep at 8:00 and getting 10 hours of sleep and I started to get better grades”) to new breakfast routines (“now I am eating breakfast every morning”). The opportunity the survey gave to express anything notable elicited comments suggestive of their appreciation for having had the chance to learn what they had and how they had learned it: “I love pen pals, and next time maybe we should take a field trip to [the high school] and see our pen pals and do a project on the brain with them,” “It was a good idea to teach us about the brain,” and “I think the project is wonderful.”
Summary of Quantitative Analysis

The research study utilized a quasi-experimental design to generate sufficient data to answer three quantitative questions regarding comparison between two different instructional strategies ultimately designed to manipulate mindset. Results of those analyses suggest that although each intervention successfully taught neurophysiology and was able to manifest change in how students perceived their own intelligence, neither intervention offered a statistically significant superiority over the other at doing so.

Summary of Qualitative Analysis

Patton (1990) warns that “the human factor is the great strength and the fundamental weakness of qualitative inquiry and analysis” (p. 372). In the case of this research, the “human factor weakness” manifested itself as a limited body of qualitative data from which to draw dependable conclusions. Of the available data, it was hoped that quality of the products generated by students in each intervention could be compared in order to provide additional data from which to draw conclusions; however, the large disparity in assignments made it unlikely that any sort of metric comparison could be applied reasonably and confidently. It fell then to the teacher/researcher to be especially diligent in the making of scrupulous observations and conduct a meticulously fair and inclusive analysis of the qualitative data.

Under these conditions and from the perspective of an experienced practitioner, it can be reasonably argued that students in the term-paper intervention were not nearly as engaged and enthused about their classroom experiences as were students in the pen-pal
intervention. On almost any scale of overt indicators of enjoyment (e.g., prolonged discussions prior to and after class time, inquiries during classwork not associated with the interventions, or gleeful exclamations), the pen-pal letter writers displayed reactions associated with higher levels of commitment to the exercise and enjoyment in performing it. Caution is urged in concluding that these disparate levels of overt enjoyment are manifestations of mindset, and the intent of their monitoring was not meant to show as much. Instead, the utility in asking Research Question 3 was to help make decisions regarding instructional practices based on the level of interest teachers could anticipate.
CHAPTER 5
DISCUSSION

This chapter discusses the findings of this study. Details of the statistical analyses have been reported in Chapter 4. Findings are summarized and discussed in light of prior literature by research question as preface to discussion of their implications to teacher practice, teacher preparation, professional development, and future research. Additionally, gender implications are addressed to the extent allowable by the study’s data, the teacher/researcher’s preference for one of the interventions is briefly explained, limitations of the study are outlined, and a concluding statement is offered.

Summary

Research Question 1: Prevalence of Mindset

Calculations of mindset scale scores and subsequent classification of students in the current study according to a taxonomy established by Hong et al., (1999) failed to yield a pattern that would support Dweck’s (2000) “soft” suggestion that most students display one mindset or the other. In two of the scales (belief in the malleability of intelligence and belief in the efficacy of effort), zero students in the current study held theories consistent with a fixed mindset (scale scores below 3.0). In four scales (all except belief in the
malleability of intelligence), the percentage of students deemed to have ambiguous theories (scale scores between 3.0 and 4.0) ranged from 31% of to 51%. Complete details of the breakdown within each of the five scales may be found in Table 10 in Chapter 4.

One possible explanation for the indistinct mindset profile of the current study’s participants was the use of data generated from a self-report instrument. Concern for the fidelity of mindset analyses and interpretations based on data gathered via self-report tools can be traced to Dweck’s earliest attempts to determine what students thought about intelligence. The initial instrument developed by Dweck and Henderson for a 1988 study was a three-item survey that asked respondents for their degree of agreement with three entity-theory “I” statements. Statements reflective of incremental-theory belief were omitted because the researchers believed that the opportunity for participants to select these more compelling, more socially desirable responses would compromise the candor of their answers. A single item aligned with incremental-theory belief was added in 1997 after passing validity analyses, and more recent studies (Blackwell et al., 2007) have relied on a survey that contains over 50 mixed items. The mix in the particular instrument used in the current study was roughly 60% entity statements and 40% incremental statements.

A second possible explanation for the indistinct mindset profile is application of a taxonomy that lacks the finesse required to accommodate shades of mindset. Blunt classification of mindset as fixed, ambiguous, or growth according to Likert-scale scores (Hong et al., 1999) fails to recognize the nuanced roles played by extenuating circumstances on how students characterize their intelligence. The nature of praise conferred at home and in the classroom (Kamins & Dweck, 1999), stereotype threat
(Aronson et al., 2002), and classroom environment (Dweck, 2000) are but three factors that influence student perceptions of intelligence. Neither does the classification system take into account domain specificity. Ubiquitous student expressions of strengths for some subjects or interests and weaknesses in others may not qualify as evidence of fixed mindset, but they are at least indicative of tepid belief in an internal locus of control across a variety of student pursuits.

The closest that Dweck (2000) comes to asserting that the majority of students have one mindset or the other (and that the split between mindsets is roughly uniform) is her suggestion that “about half of [students] select performance goals as their preferred goal and half select learning goals” (p. 16). Even in this instance, the reader must infer that goal orientation alone equates to mindset.

Studies where Dweck and her research partners collected data on pretreatment mindset are the exception. In a 1999 study, Hong et al., used the three-item survey to ascribe an entity theory to 38% of the participants, an incremental theory to 33%, and an ambiguous theory to the remaining 29%—numbers that are much more in line with the current study. The screening process for the Mangels et al. (2006) study of the influence that beliefs about intelligence have on learning success classified 13% of the participants as holding ambiguous beliefs about intelligence. No information was provided on the split of the remaining 87% classified as having strong beliefs one way or the other.

Caution should be exercised in interpreting the limited number of studies that include methodological steps to determine pre-existing theories of intelligence as a de facto admission that the prevalence of fixed mindset has been overstated. In many of these
studies, researchers sought first to manipulate mindset and then measure manifestations that correlated with important learning behaviors such as response to setback (Yeager & Dweck, 2012), selection of challenging tasks (Dweck, 2010b), attributions for failure (Diener & Dweck, 1978; Hong et al., 1999), teacher expectancies (Dweck, 1986), response to various types of praise or criticism (Dweck, 2007, 2010a; Kamins & Dweck, 1999), measures of self-esteem (Dweck, 2000), goal orientation (Dweck & Leggett, 1988; Elliott & Dweck, 1988), expectations of future performance (Diener & Dweck, 1980), and error correction tendencies and strategies (Mangels et al., 2006). As such, participants’ preconceptions of intelligence (taken to mean prior to treatment) were less important in most of these studies than were real-time estimations of the ability to change intelligence.

Part of the impetus for initiating the current study was to determine the prevalence of fixed mindset among students who populated the teacher/researcher’s classes and to report that information for others to use to make estimates (to the degree possible) of the prevalence within their own student populations. Attempts to fashion an overall mindset score have yielded ambiguous results (Shumow & Schmidt, 2013). As an alternative to a single overall score for each student, student patterns of thought in the current study were determined by assessing student responses along five discrete fixed- to growth-mindset scales.

**Malleability of Intelligence**

In nearly every study on the effects of mindset on academic performance, researchers started from the premise that students’ theories of intelligence were the most
cogent factor driving learning behavior (Blackwell et al., 2007; Diener & Dweck, 1978, 1980; Dweck, 2010b, Dweck & Leggett, 1988; Hong et al., 1999; Mangels et al., 2006; Yeager & Dweck, 2012). The good news for participants in the current study was that not a single student believed unambiguously in the immutable nature of intelligence prior to the interventions. The better news was that roughly four of five students believed they exercised control of their intelligence.

The student response pattern that suggested that not a single student endorsed an entity theory of intelligence could have been anticipated. The five statements used to calculate an overall opinion of the malleability of intelligence were relatively transparent in terms of whether they advocated a fixed or growth mindset (e.g., “you can always change how intelligent you are,” or “you can’t really change your basic intelligence”) and lent credence to Dweck and Henderson’s (1988) apprehension to use any incremental theory statements on the earliest versions of this instrument. It is likely that most students know that they are supposed to endorse the idea that you can change your intelligence and that succumbing to the socially desirable responses was likely more responsible for the apparent absence of fixed mindsets than any actual absence.

Goal Orientation

In contrast to the malleability of intelligence, survey items having to do with goal orientation were a little more opaque and, as such, less susceptible to mitigation along social acceptability lines: “I like schoolwork best when I can do it really well without too much trouble” or “The main thing I want when I do my schoolwork is to show how good I
am at it.” Regardless of whether goal orientation is the antecedent of mindset or a product of it, greater confidence in the results arouses greater concern: fewer than 3 students in 10 held goal orientations consistent with an incremental theory of intelligence.

If belief in the malleability of intelligence is the basic premise, scale measurement of student goal orientations (closely linked to motivation) might be considered “second among equals” because of how deeply the two constructs intertwine. As the progeny of research into student motivation, much of the extant mindset research dwells on the relationship between the two. Any limitations of the survey instrument to accurately peg student goal orientation should not be construed as a weakness of the current study but rather as acknowledgment of the fickle nature of student goal orientation. Subsequent discussion within this chapter that characterizes student mindset as fickle suggests that practitioner decisions should rely less on establishing unassailable real-time estimates of goal orientation and more on the recognition that all students are likely to manifest each goal orientation at some point.

**Effort Beliefs**

The fact that not a single student held beliefs about effort consistent with a fixed mindset is thought to result from the confluence of two mitigating factors. The first had to do with a degree of skepticism in the ability of the self-report instrument to accurately and honestly assess student beliefs. Nearly every positively scored item invoked some combination of “hard” and “work” (e.g., “the harder you work at something, the better you will be at it”), and the reverse-scored items focused on the “ease” of a task, (e.g., “if you’re
not doing well at something, it’s better to try something easier”). Just as it is reasonable to conclude that most students know they should endorse the idea that they can change their intelligence, it can reasonably be concluded that students have been conditioned to embrace hard work—at least outwardly.

The second factor affecting student scores along this scale had to do with the population of students from which the study’s sample was drawn. As third-year science students, participants voluntarily enrolled in these particular physics classes. Most, if not all, anticipated enrolling in college after high school and were aware (to varying degrees) of the expectation of heavier workloads in college as well as the seminal role effort would play in better positioning them for acceptance to the college of their choice. Anecdotal evidence gathered in the building’s science office (as various teachers related exasperation at the low percentage of students in certain classes who submit homework assignments or even stories of overt hostility toward teachers regarding the expectation to do so) strongly suggests that student appreciation for effort is not universal.

**Test Anxiety**

Assessments can be used to indicate progress or provide a basis of normative comparison to peers, depending on student mindset. The stark ability tests have to do one or the other makes anxiety toward them a relatively reliable indicator of mindset. Scale scores along this dimension indicated a higher level of fixed mindset than any other scale. According to \( t \) tests, 4 in 10 students identified with behavior consistent with entity theories of intelligence, and 3 in 10 could be considered to have an incremental theory. The surprise
result along this scale was the significant percentage of students (3 in 10) whose ambiguous test anxiety scale score suggested “test insouciance.” Professional judgment based on classroom experience inclines the teacher/researcher to believe that the accuracy of admissions of test anxiety via the survey suffered from the social undesirability of making such an admission and that more students live in fear of tests than the survey results would seem to indicate.

\[ T \]-test results suggest that girls experienced higher levels of test anxiety prior to the interventions. This finding was consistent with Mallow’s (1986) and Aronson et al.’s (2002) supposition that fear of perpetuating negative stereotypes regarding acuity for science necessarily raises the stakes for test-takers. How this gender difference arose and what sustains it has implications for instructional practice. Research suggests that a possible explanation has to do with the differential feedback offered to young boys and girls during their formative school years.

Dweck et al. (1978) found that teachers were more likely to attribute the failure of boys in classroom situations to lack of motivation and that nearly half of the negative feedback given to boys focused on issues of compliance. Together, these tendencies facilitated boys’ conclusions that negative feedback had no bearing on their intellectual abilities and that perceived shortcomings could be attributed to lack of effort rather than an immutable lack of intelligence. Combined, these perceptions would serve to reinforce the virtues of effort without transmitting any messages that imply intelligence as a fixed quantity.
Conversely, teacher feedback to girls was largely positive, relatively free of attributions for failure to motivation or effort, and on the occasions when it was negative, targeted intellectual failures (Dweck, Davidson, Nelson, & Enna, 1978). These patterns suggest that teachers respond differently to the same behavior and the same to differentiated behavior according to gender. Consequently, the message conveyed to young girls is that their “smartness” is an admirable, stable trait. Girls’ greater tendency for compliance and concomitant lower frequency of negative feedback is thought to make girls more likely to associate adult or teacher feedback with ability. The conformance that girls demonstrate through use of teacher-prescribed learning behavior may be interpreted as a defensive strategy designed to limit teacher criticism.

Regardless of the origin of the stereotype or the conditions that sustain it, neurophysiology does not favor students additionally burdened with the belief that their test performance might serve to reinforce a negative stereotype. Aronson (2004) acknowledges his epiphany that “human intellectual performance is far more fragile than we customarily think; it can rise and fall depending on the social context” (p. 16). And though the capacity of social context to influence student performance might seem like a fundamental truth, results of neurophysiology research confirm the mechanism by which it occurs.

Specifically, a positive learning environment (as perceived by the student) initiates a release of endorphins that stimulate frontal-lobe activity conducive to learning. Stressed students, in contrast, experience the release of cortisol, which stimulates the body’s “fight-or-flight” defense, a condition that encumbers logic processes such as recall and pattern recognition. Impediments to the hippocampus’ ability to attend to intellectual tasks is
exacerbated by the fact of its underdevelopment at this age. However, the susceptibility of mindset to change suggested by this study and others (Good, Aronson, & Harder, 2008) is cause for optimism.

Positive Strategy Use

The fact that 31% of study participants aligned themselves with adaptive learning behaviors associated with a growth mindset can be interpreted in a variety of ways. One interpretation is that the figure is quite consistent with the proportion of students (28%) who identified with a mastery-goal orientation, and, as previously noted, the goal orientation scale was perhaps the most resistant to the influence of social acceptability. Ames’s (1984) suggestion that differences in goal orientation determine “the relative tendency to use strategies for modifying one’s effort and task performance” (p. 478) suggests that figures from these two scales should indeed be consistent with one another.

*T* tests detected a statistically significant pre-existing difference along this scale according to gender. Girls exhibited a greater propensity to use learning strategies normally associated with a growth mindset.

Differences According to Physics Class

The *t* tests that were performed to detect pre-existing differences indicated that there was no statistically significant difference with respect to any of the outcome indicators between students based on the physics class in which they were enrolled. This result was only mildly surprising. The relative homogeneity of the segment of the student body from
which students in these two particular physics classes come from supports the consistency in mindset demonstrated by the statistical tests. The results arouse minor surprise when a finer distinction between the two classes is drawn. Why might students so clearly identified according to their physics class enrollment as superior or average yield statistical tests results suggestive of no real difference in mindset?

One tangible but unsophisticated explanation might be that students in either an honors or regular physics class could be expected to be equally adept at offering socially acceptable answers to the survey questions by the time they reach the 11th grade. Another hypothesis that explains the apparent uniformity of student responses has to do with goal orientation.

Specifically, it is the teacher/researcher’s professional opinion that the main reason why 11th-grade students find themselves either in or out of an honors track is the nature of self-expectations. On its surface, the level of student self-expectations seems a likely predictor of mindset and, hence, could be expected to extrapolate to at least a statistically significant differentiation in self-theories of intelligence by physics class. However, the performance-goal orientations elicited by expectancies may trump the differences in the specific nature of those expectations.

It appears that by the time the students have reached 11th or 12th grade, their academic identity has been established by virtue of the unofficial cohort of students with which they are associated. Statistical differences between students in both levels of physics class might be mediated by the preponderance of students who could arguably be enrolled in either level of class. Students struggling to keep up in honors classes are likely to
manifest the signs of frustration predicted by Csikszentmihalyi (1990) to occur when challenge exceeds skill. Yet the possibility of relocation into a lower-level class underpins a powerful performance avoidance goal orientation.

In a like manner, more highly skilled students who languish in classes that fail to challenge them become bored. The relative ease with which these particular students succeed in the lower-level class could logically be inferred to support these students’ performance approach goals. In either case, potent performance-goal orientations can be expected to elicit similar responses to survey items.

**Research Question 2: Susceptibility of Mindset to Influence**

Following the intervention, students in both intervention groups were more likely to believe in the malleability of intelligence, more likely to adopt mastery goals, and less likely to experience test anxiety relative to their reports prior to the intervention. Students who experienced the pen-pal intervention also reported greater gains regarding their beliefs in the efficacy of effort in changing intelligence compared to term-paper writers. Additionally, pen-pal letter writers manifested lower levels of postintervention test anxiety when compared with term-paper writers.

**Malleability of Intelligence**

A significant main effect for time suggests that the interventions successfully manipulated students’ belief in their ability to change their intelligence. There was no significant interaction effect suggesting that there was no difference in the extent to which
the interventions manipulated students’ belief in the malleability of intelligence successfully.

The successful influence of student opinions of intelligence was consistent with results of similar efforts at manipulating student mindset in previous seminal studies (Aronson et al., 2002; Dweck, 1986; Dweck & Leggett, 1988). The importance of this result along this “scale” is difficult to overstate. It is reasonable to characterize malleability of intelligence as the progenitor of each of the other four scales measured in the current study as well as a variety of adaptive learning behavior previously connected with academic gains.

Belief in the malleability of one’s own intelligence has been shown to be a determinant of goal orientation (Dweck, 1986, 2000; Dweck & Leggett, 1988) and has been recognized as an antecedent of greater task persistence and healthier attributions for failure (Diener & Dweck, 1978). Students who espouse growth mindsets are more likely to acknowledge the value of effort (Ames, 1984; Ames & Archer, 1988; Blackwell et al., 2007; Diener & Dweck, 1978; Dweck, 1986; Dweck & Molden, 2005; Nicholls, 1984; Yeager & Dweck, 2012), and in so doing, are more likely to accept challenge or take risks (Ames, 1984; Ames & Archer, 1988; Blackwell et al., 2007; Diener & Dweck, 1978; Dweck, 2000). Previous studies have linked mindset with the use of more positive, effort-based strategies (Blackwell et al., 2007), the help-seeking behaviors of adolescents (Ryan & Pintrich, 1997), their levels of interest (Harackiewicz et al., 2000), and, in cases where academic achievement might be the standard of measurement, performance on exams (Church et al., 2001; Darnon et al., 2009; Pekrun et al., 2009). Apparent changes made by
participants in the current study consistent with those observed by previous researchers included heightened awareness of the effects of personal habits on learning (e.g., diet, exercise, and sleep regimens), recognition of how a grade indicates a real-time assessment of progress rather than an absolute assessment of ability, and a greater willingness to take risks in class.

The fact that two so different-looking interventions succeeded in changing student mindset to an extent that was statistically identical was mildly surprising. But closer inspection of the salient aspects of each intervention reveals them to be more alike than they are different. Mindset, as a social-cognitive construct, is notorious in its resistance to change, but it is susceptible to change. In fact, the most profound implication may well be that as long as these common, essential aspects of the interventions are addressed, teachers anywhere should be optimistic about their ability to fashion successful interventions that suit the particular students who populate their classrooms.

The key aspects that were common to both interventions were (a) teaching mindset explicitly, (b) teaching cogent aspects of neurophysiology, (c) providing the opportunity for students to advocate publicly, and (d) inviting students to make personal connections with the benefits of practice and perseverance. In both intervention groups in the current study, students were taught about mindset. Students were also taught requisite aspects of neurophysiology and, most especially, about the brain’s ability to change in response to stimuli. Accepting the premise that neuroscientific information facilitates a growth mindset by offering an authoritative psychological argument, experiments have shown these arguments “are more compelling when they are accompanied by neuroscientific data”
(Yeager & Dweck, 2012, pp. 311-312). Although the breadth of that corpus of knowledge should be dictated by the sophistication of the audience, the depth must include an emphasis on the brain’s potential for change as the most salient aspect of the science.

What is left to the practitioner is to design interventions that combine these seminal aspects in a manner most appropriate for the given situation. Results of the current study suggest that practitioners could reasonably expect results by designing interventions that compel students to learn about and publicly advocate for belief in the brain’s capacity for change (Aronson et al., 2002; Higgins & Rholes, 1978), e.g., poster-making, video lesson-making, extolling the virtues of a growth mindset to a younger student, or making and maintaining a web page.

Results of this study further support the efficacy of intervention designs that invite students to learn about mindset and neurophysiology for purposes other than to be tested (Bargh & Schul, 1980; Karcher, 2009), e.g., teaching another (younger or struggling) student. Interventions that facilitate connections among students may well stimulate emotional investment—a condition under which “students are much more likely to remember curriculum content” (Sousa, 2011, p. 90). Interventions that invite students to associate personal experiences that link effort and improvement within any domain (Halverson & Pallak, 1978; Regan & Fazio, 1977), e.g., asking students to recall experience with mastering a skill or establishing plans to acquire and master a skill, would also be supported by the results of this study.

Whereas teaching mindset and neurophysiology could be considered the message, the medium is left to individual practitioners. The pen-pal intervention was thought to offer
students advantages not available to students who wrote term papers. In addition to anticipated gains in catching and holding student attention due to the novelty of the teaching approach (Mitchell, 1993), the suggestions offered in the previous paragraph have been linked by the associated researchers to attitude changes that are (a) readily accessible to the students, (b) more likely to influence their decisions, and (c) more resistant to change over time.

The inability to declare one intervention better than the other in terms of changing student beliefs regarding intelligence along any of these three psychological dimensions can be attributed to the design of the current study, which did not accommodate measurement of accessibility, likelihood to influence decisions, or resistance to change. Future research efforts that include a formal longitudinal component could help gauge resistance to change. Accessibility and the likelihood to influence decisions might be measured by adding think-aloud and strategy-tracking components that would provide researchers insight into students’ thoughts, emotions, and strategy use during the course of contemplating challenging classwork. In addition to student responses to postexercise interview questions, data gathered by these means have been used successfully in previous studies to uncover attributions for failure or success, assessments of prior work, estimates of the chance of future success, espousal of interest in schoolwork, and even mood or levels of anxiety (Diener & Dweck, 1978).
Mastery-Goal Orientation

A significant main effect for time suggests that the interventions fostered mastery-goal orientation successfully. There was no significant interaction effect, suggesting that the interventions did not differ in the extent to which they manipulated students’ goal orientation toward mastery successfully.

The equal ability of the interventions to influence opinions of the malleability of intelligence and to manipulate student goal orientations was consistent with the foundational psychological constructs common to both manifestations of mindset. The fact that mindset theory originated from research on goal orientation inexorably links the two constructs (Dweck & Leggett, 1988; Nicholls, 1984) and could rightfully justify anticipation of equal measures of success in managing the malleability and goal-orientation facets of student theories of intelligence.

In terms of communicating information essential to foment attitude change regarding the worthiness of a particular goal, the differences between the interventions could be characterized as superficial. Neither emphasized the value of growth mindset more than the other, nor did either require students to probe neurophysiology to a greater depth. As the foundational tenets of instructional practices that aspire to change students’ attitudes regarding the desirability of pursuing subject-matter mastery versus demonstrating superiority or hiding inferiority, the interventions addressed these components in nearly equal measure. In addition, constant, overt messaging of these tenets has become an integral part of the environment established by the teacher/researcher and might have
served to wash out differences that otherwise may have been detected in the statistical analyses.

Effort Beliefs

A significant interaction effect suggests that there was a differentiated effect of the interventions on students’ beliefs about effort. A detectable difference between the two groups of students in the intervention that failed to rise to the level of statistical significance was the fact that prior to the intervention, students in the term-paper intervention were statistically more likely to believe in the efficacy of effort than were students in the pen-pal intervention, yet by the end of the intervention, these beliefs had been modified to the point that all students (statistically) held effort in the same regard. Plots (see Figures 2-4 in Chapter 4) were consulted in order to guide interpretation of these main effect results.

The absence of a main effect for time may be explained by interpreting belief in the plasticity of intelligence as an antecedent to belief in the capacity of effort to change intelligence. As has been suggested in the discussion of belief in the malleability of intelligence, student acceptance of the susceptibility of intelligence to change could logically be considered the cause and each of the other four scales as effects. Students with an incremental theory of intelligence are more likely to adopt mastery-goal orientations. They are more likely to recognize effort as the internally controllable foundation of intelligence, and to then equate positive learning strategies as leverage with which to make gains. And they are less likely to see tests and other normative comparisons as measurements of some immutable level of intelligence.
The lead-lag nature of these cause-and-effect relationships and the absence of a longitudinal aspect of the current study’s design could explain the absence of measurable improvement in belief in effort as well as the inclination to use more positive learning strategies. Research designs that provide for longer term assessment of effort beliefs and the employment of positive learning strategies (reasonably based on belief in effort) would help to determine if the foundational aspects of the interventions changed student attitudes successfully and set the stage for additional research into the efficacy of specific instructional strategies.

The plot of means for effort revealed that prior to the intervention, students in the term-paper treatment were more likely to believe in the efficacy of effort to change intelligence than were students in the pen-pal treatment group. After the intervention, these opinions had been reversed.

The inability to elicit statistically significant changes in student recognition of the merits of effort that would have been consistent with significant increases in mastery-goal orientation may have more to do with where students started than how much they changed. Survey instrument results for effort beliefs were questioned earlier in this chapter, and it was hypothesized that the social desirability of endorsing hard work was responsible for the total preintervention absence of a fixed mindset along this scale. It may well be that students had nowhere to go. Their initial scores were high enough that there was no room for statistically significant improvement. Otherwise, it is difficult to reconcile the strength of postintervention reductions in test anxiety.
Test Anxiety

A significant interaction effect suggests that there was a differentiated effect of the interventions on students’ test anxiety. Students in the pen-pal intervention reported a decrease in test anxiety after participating in the intervention, whereas term-paper student reports of test anxiety remained stable.

Significant changes in goal orientation and test anxiety can be logically paired via the overall message: intelligence is pliable. Within the teacher/researcher’s classroom during the course of the interventions (and as a habit of practice), grades were stridently characterized as a means of establishing where students were in their personal journeys from “more ignorant” to “less ignorant” about a lesson topic. By continually characterizing grades as where students were instead of who they were made tests less frightening.

Positive Strategy Use

No significant interaction effect for students’ reports of positive strategy use suggests that the students did not differ by intervention groups. No main effect for time suggests that students’ inclination for positive strategy use was resistant to change because neither intervention promoted change successfully (or substantially) in the extent to which students used positive strategies to learn.

As has been suggested in the previous discussion of the lack of a main effect for time on student perspectives of effort, the absence of a main effect for time on valuations of positive strategies might have to do with degrees of separation. If it is true that adopting an incremental theory of intelligence is a necessary condition of manipulating beliefs
regarding the primacy of mastery goals and the value of effort, it seems reasonable to speculate that these realizations are necessary conditions for students to embrace specific learning behaviors associated with a growth mindset. As such, manifestations of mindset according to learning behavior would be the most distal to the interventions and the least likely to show up within the time frame of the current study. Cast in this light, the absence of statistical evidence of changes in student attitude regarding positive strategy use are speculated to result from the current study’s lack of a longitudinal component.

A point that might make the lack of main effect moot is the teacher/researcher’s skepticism of the survey instrument’s capacity to reflect accurately student mindset on the basis of the survey instrument’s probes regarding positive learning behavior. Each item retained on the survey in order to meet nominal internal consistency standards was positively scored and referred to some very specific study technique. Of the nine scored items, few are emphasized on a regular basis in any class, in the professional opinion of the teacher/researcher. The appearance of a surfeit of them on any one student’s list of “go-to” strategies would come as a surprise, considering the sheer magnitude of variety of learning and study strategies currently available to students.

The difficulty in using a discrete list of learning behaviors as a barometer of mindset might serve as a basis for implications for both research and teaching. Research-wise, it might be prudent to add valid, negatively-scored items to the survey that are less susceptible to social acceptability in order to more accurately gauge students’ mindset on the basis of their responses. Teaching-wise, an implication is the suggestion that students would be better served by teachers conversant in mindset. Changing the goal orientation of
the classroom to align more with an emphasis on mastery would necessitate promotion of learning behaviors less focused on the “getting” of knowledge and more focused on the creation of knowledge.

**Research Question 3: The Teaching of Neurophysiology**

The final statistical analysis compared neurophysiology knowledge gains between both interventions. Although each intervention resulted in statistically significant gains in content comprehension and retention, differences between the two interventions never rose to significant levels.

It was conjectured that the combination of the pen-pal intervention’s novelty with its decidedly more active teacher and student roles would yield greater student gains. In the earliest stages of contemplation of the current study, the teacher/researcher considered using the terms “active learning” and “passive learning” to distinguish one intervention from the other. However, to do so would have meant risking a common misinterpretation of exactly what active learning and passive learning entail. Although the educational community has struggled to reach consensus on definitions of each, it is decidedly not the case that active learning equates to active students and passive learning equates to sedentary students. Challenging tasks that require students to create more complex cognitive structures may well be completed in isolation or apparent inactivity.

Among the arguments that predict superiority of the pen pal intervention is how the novelty of the student product might affect student interest. Teachers asking students in either intervention to learn material for reasons other than to be tested on it should
reasonably anticipate higher levels of interest and hence, intrinsic motivation. Going further, the less traditional reason to learn the material inherent in the pen pal intervention, i.e., learning it to teach it to others, could well stimulate the construction of more complex neural structures with multiple pathways of recall (Bargh & Schul, 1980) as well as increased attention to the material in terms of awareness (Allen & Feldman, 1973; Cloward, 1966; Goldschmid & Goldschmid, 1976) and longer periods of contact.

On the other hand, it could be argued that the novelty of the pen-pal intervention might actually *detract* from its effectiveness. Teachers and students are likely more familiar with the basics of producing a research term paper, especially considering the ubiquity of easy-to-follow rubrics that typically accompany their assignment. It is logical to expect that this level of familiarity would result in clearer instructions issued by teachers and higher levels of clarity of purpose for students.

In addition to salient differences that might have cancelled out one another, profound similarities between the interventions and the environment in which they were administered might have rendered them statistically indistinguishable. Class discussions held to assure correct and complete understanding of the requisite level of neurophysiology were common to both interventions. It could also be reasonably speculated that the decision to limit the scope of the neurophysiology content provided students with a relatively narrow focus, meaning that assessments of knowledge structures and declarative knowledge (Michel et al., 2009) would be restricted in their ability to tease out differences by intervention.
Research Question 4: Comparative Levels of Engagement

“Oh yeah—I’m still jealous about that.” (Bill, a term-paper participant, well after the intervention, to his cousin Andy, a pen-pal participant)

The apparent level of student enthusiasm for and interest in the intervention is less ambiguous. Based on the teacher/researcher’s professional assessment and observations, students engaged to a markedly higher level in the pen-pal intervention. Explanation for the disparity is thought to be a combination of the novelty of the exercise, the opportunity students had to mentor a young student, the creative freedom to generate a document expected to grab and hold the attention of another student, the more collaborative research environment, and the anticipation of interaction with another student.

By comparison, field notes taken during the course of the interventions are bereft of any mention of enthusiasm for the exercise by term-paper writers. An excerpt from the research journal dated November 17th lends perspective to the contrast in experiences: “when sixth hour learned that they would be writing term papers and that fifth was writing pen-pal letters, an outcry arose, insisting that sixth was having to work harder and would have less fun.”

Letter writers demonstrated higher levels of engagement in and enthusiasm for the intervention along any indicative scale familiar to practitioners: they interacted with and consulted one another; they laughed frequently; they engaged with one another, they ignored the teacher’s presence (in a positive way); they asked questions; they gave thoughtful consideration to their audience; they persisted at the exercise well after the bell rang; they made inquiries about their progress outside time set aside for the unit; and they
remained interested long after their letters had been sent. Unanticipated anecdotal evidence in the form of positive, offhand comments made by returning students the year after the intervention offer additional support for this conclusion.

Summary

The purpose of this study was to compare the effectiveness of two interventions designed to influence the self-theories of intelligence of upper-level high school students, in part by teaching neurophysiology, and in part by teaching students explicit theories of intelligence and how they influence student learning behavior. The interventions were shown to manipulate student mindset to a level of statistical significance that merits consideration by practitioners. The paucity of statistical differences between the two interventions combined with accommodation of the surfeit of individual learning styles presented by students on a daily basis is consistent with an understanding held by most practitioners—namely, that there is no one-size-fits-all instructional panacea. That realization should not be grounds for dismissal of either intervention; rather, it should empower classroom teachers with the capacity to design and implement instructional strategies specific to their situations.

Research Question 1 asked, “To what degree do students endorse a growth mindset, and are these beliefs about their intelligence related measurably to gender or level of physics class?” The results of the current study suggest that the answers to these questions are moot. In light of how academically debilitating a fixed mindset has been found to be, it is frightening to contemplate the suggestion that close to half of students espouse an entity
theory of intelligence (Dweck, 2000). In seeking answers to the questions, the teacher/researcher sought to gauge the prevalence of fixed mindset in order to justify the use of class time to intervene. Ultimately, it matters less exactly what the proportion of fixed to growth mindsets is in any single classroom because belief in such stark delineations presumes stability and interdomain consistency of mindset on a per-student basis.

Teachers notoriously (and properly) rely on sound rationale prior to making changes—even minor ones—in their practice. In the case of implementation of instructional strategies thought to modify student theories of intelligence (as an antecedent to more positive learning behavior), teachers might logically wonder about the pervasiveness of fixed mindset in their classes. Such a global perspective ignores the tendency of students to “think more in terms of specific domains of performance, at least for understanding their own and classmates’ performance in school contexts in which intellectual work is divided into subject areas” (Stipek & Gralinski, 1996: p. 397).

Intervention

The last three research questions reflect the teacher/researcher’s anticipation of an answer to the first question that would justify mindset interventions or, at the very least, integration of strategies judged to be effective at combating fixed mindsets. The inability of the current study to answer questions about the superiority of an intervention to manipulate mindset may well be due to the primacy of the message over the medium. The absence of a control group of students limits the generalizability of the results and, more importantly, precludes any consideration of the influence of “mindset-mindful” teaching
practices routinely employed in the teacher/researcher’s classroom. These practices are
discussed below as implications for teacher practice.

The inability of statistical tests to distinguish between the interventions is not to say
that relevant points of comparison between the two interventions were absent. Together,
the interventions were successful at (a) changing student opinions of the malleability of
intelligence, (b) eliciting greater valuation of mastery goals, and (c) suppressing test
anxiety.

Speculation as to why students in the interventions differed in their opinion of effort
centered on the nature of the interventions themselves. Students greeted the pen-pal
exercise as an interruption in the course of traditional classroom instruction. That novelty
may have liberated them from focusing on the effort they are routinely asked to exert and,
instead, enabled them to acknowledge a cause-effect relationship between effort and
success. Meanwhile, term-paper writers may have been less willing or able to move
beyond cognizance of the fact that they were, yet again, being asked to put forth effort into
an undertaking with neither a clear understanding of the reasons for doing so nor with an
idea of the eventual results of participation.

The interventions did not differ in whether participants became interested in
personal eating and sleeping habits as a result of their research into obstacles and
enhancements to learning. Revelations of the potential of diet and sleep to affect academics
prompted a quite popular activity wherein the students kept a series of four week-long logs
of how much sleep they received in a 24-hour period, what they ate for breakfast each day
for the week, and how their perceptions in school with regard to their academic
achievement and levels of alertness. Each class period started with a short (five-minute) discussion/voluntary show of hands of how much sleep each student had received the previous night and what sorts of breakfasts, if any, had been eaten. There was evidence in some of the term papers and pen-pal letters that this heightened awareness might have modified some personal habits in these two areas. There was a groundswell of interest in continuing the sleep log/five-minute discussion the following semester.

Student treatment of neurophysiology and mindset was more technical in the term papers, as one might expect of writers considering a more sophisticated audience (teacher/researcher instead of a fifth-grade student). The products of this intervention suggested that these students were more introspective in carrying out their assignment. The typical term-paper approach was to address each of the three aspects of the unit (mindset, neurophysiology, and habits and behaviors that affect learning) one at a time. It was quite common for the writers to introduce the subtopic by defining it and then following up the definition by linking what they learned to their personal situations. It is conceivable that what the term-paper intervention lacked in novelty, it made up for in its ability to trigger recognition of the utility value of the exercise among its participants. As has been alluded to, these students fall under the random sample caveat of likely being more oriented toward college preparation.

Among the activities experienced by the pen-pal letter writers but not afforded to term-paper writers was the opportunity to perform research collaboratively by working in a large group and then in small groups. They became experts within a small group for one aspect of the unit content. They may have had the opportunity to act as the manager or
recorder of a large expert group. They established relationships with young students to whom they could offer advice. The novelty of the experience intrigued them and served as respite from the monotony of repetitive, traditional instructional strategies typical of many of their school days.

Implications

Implications for Teaching Practice

Intrigued by the potential of mindset to explain the patterns of learning behavior frequently demonstrated by students, the teacher/researcher’s own practice has been heavily influenced in recent years by the infusion of efforts to promote incremental theories of intelligence. Evolution of the instructional culture of the classroom has been informed by personal research into mindset, the neurophysiology of learning, and, most recently, performance of the current study.

The confluence of these efforts has led to the implementation of a variety of instructional practices believed to leverage this insight. Several implications for teaching have already been mentioned in the course of interpretations of the data analyses for each of the four research questions. Some are revisited here (along with additional implications linked to results of the study) in varying levels of detail.

Feedback and praise. Feedback and praise should be consistent with an emphasis on process, effort, and progress. If unlearning is accepted as something that is often the antecedent of learning something, it may well be that teachers must unlearn what they know
about feedback and praise. It is difficult to imagine negative student response to praise for intelligence, just as it is difficult to imagine teachers not experiencing satisfaction about having given their students something so valuable. Additionally, teachers may be disinclined to emphasize effort, strategies, or persistence, fearing that students might perceive such emphasis as faint praise offered as a consolation prize. Extant research suggests that effort-focused feedback correlates with mastery goal orientation but personal praise often correlates with learned helplessness (Dweck, 2007; Dweck et al., 1978; Kamins & Dweck, 1999). Examples of modifications made by the teacher/researcher to his own practice included a concerted effort to replace the banalities of general, “feel good” praise with focused process and/or effort praise, along with specific, achievable suggestions for improvement. The teacher/researcher’s goal was to consider locus of control in the feedback and praise offered to students, thereby conveying the message that their progress was within their control.

**Autonomy.** Offering students a choice of interventions is supported by remarks made by some of the study participants one year after the intervention. The teacher/researcher had access to these students during the course of the following school year, and a chance discussion of their participation in the interventions served to repudiate the blanket assumption of student preference for the pen-pal intervention. Several term-paper students suggested that their learning styles were better suited to benefitting from having written a paper. Additionally, a pen-pal letter writer expressed regret that she had not been allowed to write a term paper. Consideration of the lack of statistical difference between the interventions, in combination with the recognized benefits of adjusting
teaching practices to accommodate the variety of student learning styles, suggests that more students could profit from either intervention if allowed to name and pursue a preference.

*Classroom goal emphasis.* Many common instructional strategies, including traditional grading systems, are often perceived by students as the means by which teachers distinguish the “smartness” of students. Competitive situations tend to focus student attention on abilities rather than effort and have been positively related to self-handicapping strategies (Friedel, Cortina, Turner, & Midgley, 2010). In contrast, when students perceive teacher emphasis on learning, improvement, and mastery, these students are more likely to employ more effective strategies, prefer greater challenge, have a more positive attitude about class, and make stronger associations between effort and success—all hallmarks of an incremental theory of intelligence.

The argument being made in the current study is that there is no reliable profile predictive of fixed or growth mindset. Instead, several factors, including context, academic discipline, minority membership, and/or past experience, conspire to elicit, at the very least, a domain-specific mindset. Quite often, students are handicapped (and teachers are frustrated) by the emergence of fixed mindset when an entity theory of intelligence conveniently explains student performance. In the experience of the teacher/researcher, the likelihood of students to harbor domain-specific fixed mindsets defies the experience many have had in pursuits outside the classroom. An example would be the physics student who has honed her percussion skills over the course of years of lessons and hours of practice, ultimately being rewarded by earning the coveted title of section leader. Yet this same student may confide in her physics teacher that she anticipates struggling in class because
she has “never been very good at science.” The typical response to the question, “If effort and perseverance work in the music room/in the weight room/on the balance beam, why won’t they work in the classroom?” has been silence. This passing moment has been interpreted by the teacher/researcher as that “aha” moment when students draw the parallel between what it takes to improve outside the classroom with what it takes to improve inside it.

Additional steps taken in the teacher/researcher’s classroom to foster growth mindsets included the cessation of posting grades (even by supposedly anonymous student identification numbers), offering exercises aimed at mastery by name, and the addition of a graphical component to student progress reports that provided students with stark visual evidence of their progress. For more specific suggestions, see Ames (1984, 1992), Ames and Archer (1988), Nicholls (1984), or Urdan, Midgley, and Anderman (1998).

**Challenge.** “The challenge for educators is to create environments that foster the development of talent over time, . . . that teach them to love challenges, to enjoy effort, and to be resilient in the face of setbacks” (Dweck, 2010b, p. 60). Dweck’s (2010b) research suggests that when teachers give precedence to challenging, meaningful tasks over simple tasks (long thought to enhance self-esteem), students are more likely to associate improvement or progress with effort. This approach dictates accommodation of students who may take longer to assimilate content.

In the experience of the teacher/researcher, this aspect of growth-mindset promotion can be problematic because the students most in need of recognizing the virtue of challenge are the same students most likely to perceive it as threatening. Teacher cognizance of what
is at stake for the students helps mitigate the threat by presenting challenge initially in nonevaluative situations in which students have been more comfortable taking risks.

Grading system. The premise of an incremental self-theory of intelligence is that intelligence is subject to growth. Students can be better positioned for academic success through the use of adaptive learning behaviors associated with belief in the ability to change—to become “smarter.” An essential aspect of support for this mindset is students’ capacity to measure their own progress. Teachers who elect to implement instructional practices to promote growth mindsets may want to consider the use of grading systems that convey the importance of student progress.

Grading systems that rely on averaged assessment scores (e.g., quizzes and unit tests) to measure student understanding at the end of a grading period are antithetical to any degree of belief in “the learning curve”—a graphical expression of the idea that “a student might start a grading period with little or no knowledge regarding a topic but end the grading period with a great deal of knowledge” (Marzano, 2006, p. 97). Within these typical grading systems, low grades early in a grading period doom students to end-of-period grades that do not accurately reflect progress. And rather than revealing a real-time level of ability, such grading policy disincentivizes efforts to achieve mastery, undermines belief in the value of challenge, and reinforces the high-stakes nature of any assessment.

Among the language changes made by teacher and students in class was the expunging of all references to “tests” or even “quizzes.” Instead, students were given regular “assessments” that were distinguished from one another by their number. Students were assured that as long as they worked to earn additional attempts, the series of numbered
assessments was theoretically unlimited. The message was transmitted to students early in the class and often thereafter that their school cared more about students achieving their desired level of mastery than about how long it took them to do so. Some assessments were formal and many were not, but by assigning them all the same ability to serve the same purpose, they became unofficially known as a student's “academic GPS.”

By suppressing the traditionally overt linkage among assessments, grades, and student identification, tests came to pose less of a threat to esteem (performance avoidance) and instead enabled students to use their scores to chart their progress toward mastery. At the same time, the assessment system, implemented because of its consistency with instructional practices that accommodate mindset, enabled students to pursue mastery at an individual pace that could ultimately be reflected in measures associated with performance-approach goals.

The method of mounting evidence (Marzano, 2006) represents a grading system more closely matched to the philosophy and implementation of classroom practices consistent with growth mindset. Within it, students remain apprised of the status of their progress, they have multiple opportunities to demonstrate what they know, and their past performance is used to mediate current assessment scores that might otherwise indicate lapses in understanding. Anecdotal evidence that suggests at least a cursory level of integration of growth mindset is the evolution of a student chorused refrain: in response to the teacher/researcher’s prompt, “What does a grade tell us?”, students would respond in unison, “It tells us where we are, not who we are!”
Corpus of neurophysiology knowledge. Although Yeager and Dweck (2012) suggest “collaborative partnerships between researchers, practitioners, and students . . . to engineer interventions that will work at scale” (p. 312), interventions designed to work at a particular place and time need not raise the specter of complexity and oversight that such a suggestion introduces. However, implementation of an intervention on a smaller scale does not absolve teachers from a healthy degree of preparation. In the same breath as their call for collaboration, Yeager and Dweck warn that interventions should not be undertaken without “deep knowledge of the underlying psychology” (p. 312) lest they become superficial exercises long on language but short on insight. The current study was informed by referring to a representative sample of current books and articles that document the emerging understanding of physical and chemical brain processes that occur during the course of learning. In the opinion of the teacher/researcher, his ability to speak to these aspects with a degree of authority was requisite to the success of the interventions and facilitated the ability to imbed messages into daily instructional cues that support mindset well after the end of the interventions.

Teacher role. A study by Schmidt et al. (in press) called for consideration of the teacher’s role in developing growth mindsets and provided impetus for the current study. Specifically, these researchers observed that even when teachers were not directly involved in the administration of mindset interventions, they played an integral role in sustaining student beliefs consistent with growth mindset. This conclusion led the researchers to speculate how much more influence teachers could wield by assuming the central role of intervention administrator. Though the design of the current study left no provision for
comparison of teacher characteristics, their importance could logically be inferred from the noted importance of grading systems even without Schmidt et al.’s recommendation. 

The professional experience of the teacher/researcher regarding colleagues’ awareness of links between mindset, motivation, and achievement is limited to utterances during the course of informal discussion. Although minimal and unscientifically collected, these data suggest that collegial belief in the ability of all students to learn (a growth mindset) is, at best, nominal. Schmidt et al. (in press) suspect that teachers’ self-reports are likely an awareness “of the social desirability of endorsing a growth mindset” (p. 22). These researchers concluded that regardless of whether teacher use of messages that promote growth mindset reflected implicitly held beliefs or were explicitly triggered by participation in the study, the usage measurably improved the effectiveness of the mindset intervention.

Implications for Teacher Preparation

Implications for teacher preparation are rather broad, as are expectations of the National Council for Accreditation of Teacher Education (NCATE). As the recognized authority on teacher preparation, “NCATE expects that the knowledge bases that support each professional education program rest on established and contemporary research, the wisdom of practice, and emerging education policies and practices” (NCATE, 2010-2014, p. 3). It is the decided opinion of the teacher/researcher that cognizance of mindset and accommodation of it qualifies as an “emerging educational practice” of such profound importance that it merits consideration as a requisite topic within NCATE’s standards.
Cognizance of the pernicious effect of a fixed mindset on student learning behaviors and student achievement and, by contrast, the beneficial effects of a growth mindset would enable teachers to identify theories of intelligence held by their students and to adjust instructional practices to account for and influence them. Experience gained by the teacher/researcher via performance of the current study, independent reading, informal research, and professional development exercises inspires the suggestion of some means of simultaneous coverage of the topics of student motivation, goal orientation, self-theories of intelligence, and neurophysiology. Optimally, preservice teachers could enroll in a class that synthesizes each of these topics and covers assessment strategies that are consistent with instructional practices that accommodate mindset, e.g., Marzano’s (2006) Method of Mounting Evidence. Short of such a comprehensive class, it might be more practical to look for appropriate classes in which to embed the various lessons—perhaps classes on student motivation or educational philosophies.

Implications for Professional Development

Perhaps a greater opportunity for dissemination of these concepts lies in professional development. Compared to adjusting curricular requirements for preservice teachers, it would be far more manageable to design presentations of the material to suit any of a broad spectrum of professional development settings. In fact, the teacher/researcher had the opportunity to participate in one such session within the past academic year by accompanying Dr. Lee Shumow as she presented to a group of approximately 60 middle and high school science teachers about the benefits of growth mindset and the pernicious
effects of fixed mindset. As news of the potential benefits realized by understanding mindset spreads within the educational community, interest should increase and professional development on changing mindset may become more common.

**Implications for Research**

Results of the statistical analyses suggest that although both interventions significantly taught neurophysiology and, in due course, manipulated mindset, neither intervention was better at doing so than the other. The conclusion that students in the pen-pal intervention exhibited higher levels of engagement and enthusiasm was based almost entirely on observations of student behavior made and interpreted by the teacher/researcher. Larger sample sizes and a more thorough examination of student engagement and enthusiasm (i.e., less reliant on researcher observation) would most likely provide more and better data upon which to base an answer to the questions: Which intervention is better? And how might each intervention be made better?

In retrospect, the statistical comparison of the relative efficacy of the current study’s version of the pen-pal intervention with the term-paper intervention lacked the sophistication necessary to reach conclusions regarding the three specific constructs alluded to in the Aronson et al. (2002) study: the stability, accessibility, and likelihood of application of nascent attitude changes. It would be advisable for future studies involving this specific intervention to consider methodological options designed to isolate accessibility, resilience, and influence.
The scope of the study wherein the student participants were more of a “captured audience” was limited to the first semester of a single academic year. Additional valuable data could be collected by surveying mindset and assessing neurophysiology retention at the end of the spring semester and again during the course of participants’ 12th-grade school year.

Additional research involving multiple single-case inquiries should, over time, provide the comparative data necessary to draw more and better inferences regarding the efficacy of each intervention. The paucity of data in the form of participant feedback regarding enthusiasm and engagement and the sample size placed larger than desirable reliance on the professional opinion of the teacher/researcher in order to try to answer the qualitative question posed at the outset of the research.

Regarding research into consideration of gender, the low power of the parametric tests to discover a statistically significant result pertaining to differences in goal orientation and belief in the efficacy of effort, along with the absence of data necessary to explain the differentiated response of boys and girls, suggests the need for research that includes more comprehensive data collection and analytic measures including comparison with a larger sample size and possibly case studies in order to discern responses to intervention on an individual scale.

**Gender Implications**

Despite the absence of gender from formal consideration in the current study’s last three research questions, the fact that “there might be a difference in how males and
females respond to different interventions” (Pallant, 2013, p. 321) provides rationale for performing additional parametric tests in order to better inform teaching and research implications. A cursory look at the results of these additional tests along with brief discussion follows.

Analysis of mean scale scores suggest that girls were more likely to respond to the term-paper intervention by adopting more of a mastery-goal orientation and boys were more likely to do so in response to the pen-pal intervention. Speculation as to why this was so might start with consideration of stereotype threat (Aronson, 2004; Aronson et al., 2002; Dweck, 2000)—a condition which could logically be expected to manifest itself as either performance-approach or performance-avoidance goal orientations.

It appears that the girls in both interventions and boys in the pen-pal intervention increased in their belief in the efficacy of effort to change intelligence but not to a statistically significant level. A notable aspect of test results was that although boys in the term-paper treatment suffered a decay in their belief in the value of effort, boys in the pen-pal treatment group were more likely to develop beliefs in effort associated with growth mindset after their participation.

Test results suggested that boys and girls in the pen-pal condition achieved similar reductions in levels of test anxiety. And although girls who wrote term papers achieved statistically similar reductions in their level of test anxiety (to girls in the pen-pal intervention), boys in the term-paper treatment actually suffered an increase in their manifestation of test anxiety. Of course, it is hoped that any intervention would, at the very least, do no harm.
Girls were more likely than boys to employ positive strategies associated with an incremental theory of intelligence. This result runs counter to Dweck’s (2000) suggestion that the typically higher levels of compliance exhibited by girls in the early grades (likely resulting in person-praise) predisposes them toward an entity theory of intelligence. It may be that whereas compliance in grade school implies a stable trait, compliance in high school has become a means to an end. In the experience of the teacher/researcher, females who populate these higher level science classes are more likely to exhibit advanced study and learning strategies (e.g., note-taking during lectures and textbook reading assignments, better organizational skills, and remaining attentive during class) when compared to their male classmates.

Whether these superior strategies are a manifestation of stereotype threat or merely the result of a higher incidence of inferior strategies by males is debatable and beyond the scope of the current study. What remains is that these efficacious strategies are statistically more likely to be employed by female students and, if it turns out that the surest way to elicit growth mindset is by explicitly teaching growth-mindset attributes, female students would be better situated to make the transition.

In grade school, the person praise typically elicited by compliance has been shown to foster an entity theory of intelligence (Dweck et al., 1978; Kamins & Dweck, 1999). It may be that by the time these students reach high school, their teachers are less likely to offer trait praise and more likely to offer process praise, especially given the influence of Common Core instructional strategies that seek to match an emphasis on efforts to synthesize learned material to student sophistication. The abstract thought processes
requisite for successful synthesis and creation of original work would be supported by
teaching practices that promote many of the positive learning behaviors identified as
consistent with a growth mindset, e.g., error correction, perseverance at a task, and a
willingness to try alternate strategies.

The Teacher/Researcher’s Preference
for the Pen-Pal Intervention

A difference between this study and that conducted by Aronson et al. in 2002 was
that the pen-pal letters generated during the course of the current study’s intervention were
addressed and delivered. Collaboration with two fifth-grade teachers in order to provide
the high school students with (quite) real pen pals added a dimension of authenticity whose
influence is difficult to gauge. Having qualitatively concluded that the pen-pal intervention
was superior to the term-paper intervention in terms of generating a higher overall level of
student enthusiasm, the pen-pal intervention offers the tantalizing potential to affect twice
as many students.

Nearly 50 elementary school students received letters during the course of the
intervention. Had their role been limited to that of passive recipients, it still seems
reasonable to presume that some level of residual benefits accrued to at least a small
percentage of these students.

However, the manner in which the intervention was implemented was such that
these younger students were not passive recipients. The original letters were personally
delivered to the elementary school students late in the fall term by the teacher/researcher.
After a mail call-style distribution, the students were instructed to open and read their
letters and highlight salient points. The teacher/researcher then conducted a class
discussion that focused on collecting and recording resonant letter passages on the room’s
blackboard. The discussion served the same purpose as one held with the high school
students early in the intervention—namely, to identify relevant information, uncover
misconceptions, and introduce the students to the “language” of mindset. By year’s end,
four letters had been exchanged between the high school and grade school students and
there was evidence of a modest degree of familiarity and use of mindset terminology and
strategies by the fifth-grade teachers.

Limitations

The decision to act as a teacher and sole researcher served as a de facto means of
narrowing the study. Limiting participation to students of the teacher/researcher made the
resulting data more manageable. Further, reliance on a single administrator of the study’s
intervention assured consistency and continuity of its implementation. The complexity of
the multistep intervention process made the value of such consistency difficult to overstate.

Exclusive use of the teacher/researcher’s own students, the school district’s two-
year science graduation requirement, and the vertical alignment of the science curriculum
wherein physics was offered during students’ third year at the earliest combined to limit the
studied population to upper-level, college-bound high school science (physics) students.
Although it was true that students were randomly assigned to the teacher/researcher’s class
sections, the elective nature of these particular course selections represented a modifier to
the classically held construct of random sampling, effectively suppressing the
generalizability of the study’s results (Marshall & Rossman, 2011).

The racial demographics of students in the study was 55% White, 25% Hispanic,
10% African American, and 10% other. This was markedly different from the profile for
the entire building, in which the breakdown at the time of the study was roughly 38%
White, 44% Hispanic, 13% African American, and 5% other. Additionally, the small
sample, though convenient and resulting in more manageable data, served to make the
resulting parametric statistics more susceptible to outliers and extreme data.

The study’s mixed-method design relied on participant observation. This particular
method of data collection must acknowledge the possibility that the researcher’s
administrative role might have influenced student behavior. Specifically, the possibility
existed that students might have exhibited superficial behavior in view of the perception
that the researcher controlled their grades. Participation as teacher/researcher may have
additionally compromised data collection in view of teacher/researcher obligations that
limited capture of nuanced qualitative data that may have provided a more dependable
answer to the question regarding enthusiasm and engagement.

The absence of a control group introduces the dangers inherent in comparing two
things rather than one thing against nothing (Wolcott, 1994), thereby restricting inferences
that can be drawn from the results of the research. Such a comparison is somewhat
antithetical to the traditions of qualitative research wherein the promise of the research is
The teacher/researcher’s personal and professional enthusiasm for the potential benefits of the pen-pal intervention to students’ learning based on informal pilot tests posed a potential limitation to application of the study’s results. The primary measures taken to mitigate biases were member checks and reflective journaling. Despite belief in the analysis and conclusions reached during the course of the research, hindsight suggests that an additional guard against bias would have been to conduct formal peer reviews.

Although the study sought to establish a connection between how two different instructional strategies influence mindset, it was not within the study’s scope to investigate the nature of how the lessons mediated changes in mindset, exactly how cognitive and retention gains by either approach were achieved, or how gender might have explained any differences. This particular limitation invites future research into the exact nature of how changes anticipated at the outset of the study may have occurred.

Conclusion

As teachers are compelled to designate more instructional time to noninstructional activities, a premium is placed on the remaining time with students. It follows that the decision-making process on how to spend that time most wisely becomes more rigorous. If or when teachers consider instructional strategies that accommodate (or even seek to influence) student mindset, decisions based upon a purported, static prevalence of one mindset or the other may be suspect. The ambiguous result of the statistical analysis that sought to determine the prevalence of mindset is likely less a function of an inadequate instrument and more a function of a fluid disposition. The myriad domains (academic and
nonacademic) through which students travel during the course of the day, as well as the variety of situations that foster fixed mindsets (e.g., stereotype threat or gender-centered feedback), suggest the absence of either a reliable profile of a fixed mindset student or a dependable degree of stasis of mindset. In short, it seems safe for practitioners to presume some degree of fixed mindset at some point for most students.

The salient differences in the interventions were originally thought to reside in how the information was being taught and less consideration was given to what was being taught. The inability of the current study to confirm a conjectured comprehensive superiority of one intervention over another to influence student mindset may have revealed a more important truth: the medium may well be less important than the message. Students benefit from writing research papers in pen pal letters that explore mindset.

The implication that the pen-pal intervention influenced nearly twice as many students as well as several grade school teachers is important. Informal feedback from grade school teachers who participated includes accounts of their efforts to emphasize incremental theories of intelligence. In combination with conclusions reached by Schmidt et al. (in press) regarding the importance of teacher understanding of mindset and instructional practices that support it, enhancing teachers’ ability to support student belief in a growth mindset could more effectively leverage possible academic achievement gains for all students.
REFERENCES


APPENDICES
APPENDIX A

A PILOT STUDY
In order to better prepare for the proposed research, the teacher/researcher performed a pilot study during the 2012-13 school year. The study was confined to an alpha version of the pen-pal project. No attempt was made to pilot the term-paper approach in view of its ubiquity within the educational milieu.

Two classes of 11th-grade honors physics students and one class of 11th-grade regular physics students took part. Although participation was voluntary, 100% of the students elected to do so. After having completed a survey designed to assess individual self-theories of intelligence, the students listened to a presentation introducing rudimentary neurophysiology as it pertains to learning. The presentation was designed to provide a level of information sufficient to facilitate anticipated small-group dynamics but insufficient to undermine the longer term learning process.

Consistent with procedural steps associated with the Jigsaw teaching and learning activity (Aronson & Patnoe, 2011), students were assigned to small groups typically numbering three, with an occasional grouping of four students. Within these small groups, each student was asked to choose a research focus from among three options: self-theories of intelligence, how the brain learns, and what sorts of environmental and/or personal behavior factors affect learning.

At a later date, students reassembled in the school library during a class period in which they worked in groups of eight or nine according to the area of specialization selected within their small groups. These larger teams were charged with producing a one- or two-page document by period’s end that summarized their findings. The research was orchestrated by a leader and collated by a recorder nominated within each of the three
groups. Resources available to the students included internet access and books set aside by the library staff.

A subsequent class period was devoted to the exercise wherein students reconvened within their small groups and each of the experts shared their findings. After several more days when students could continue research on their own time, the entire class took part in a discussion designed to share the wealth of research and to address any misconceptions. At the end of the period, each student was provided with the name of a pen pal—a fifth-grader from an elementary school within the district. The high school students were instructed to write a first draft of a letter that addressed all three aspects of the material thus far covered in class in an age-appropriate fashion. It was made clear to the students that they were welcome to perform additional research on their own if they believed they needed to do so.

When the drafts had been submitted and reviewed, they were returned with teacher comments, and another class discussion was held to clarify misunderstandings. Second drafts were solicited and followed up with another short class discussion of teacher feedback. Third drafts were solicited and checked against marked-up second copies. In this way, the accuracy of the information communicated by the high school students and the appropriateness of the language used were assured. An envelope-addressing “party” was conducted during the last part of another class period.

In a step not directly related to the high school students’ participation, the signed and sealed letters were delivered by the researcher/teacher and distributed to the eager fifth-grade students. After allowing time for opening and reading, a class discussion was held in which the students were encouraged to contribute things taught to them by their high school
pen pals. The teacher/researcher recorded as many of the comments on the classroom blackboard as possible, locating each comment on the board such that, by session’s end, there appeared a cohesive, logical summary according to three options of high school expertise. A noteworthy aside was the longitudinal feedback from the teachers regarding their successful efforts to embed into their lessons the terminology introduced to their students by the letters. According to the teachers, these efforts were reflected by their students’ heightened awareness of the control they had over their learning.

During the balance of the school year, three more sets of letters were written and exchanged between the high schoolers and their elementary school pen pals. Among the insights afforded by the pilot program were the stark differences in the enthusiasm for learning between the two levels of high school students (honors versus regular physics students), how the novelty of the program generated unparalleled interest among the high school students, how the strategy might be improved, and how best to perform the proposed research.

The purpose of the pilot program was to determine the feasibility of the project, not to measure shifts in mindset. A rudimentary mindset survey was tested without follow-up and no attempt to measure gains in neurophysiology knowledge was made at all. Valuable insight into the intervention’s logistics was gained including neurophysiology resource development, time demands, and student expectations.
APPENDIX B

DISTRICT APPROVAL REQUEST
Dear XXXXXXXX School District XXXX Administrator:

My name is Steve Stern. I am a science teacher at XXXX High School. I am writing to determine what requirements must be fulfilled in order to carry out a doctoral dissertation research study within the confines of my classroom during the 2013-14 academic year.

The study evolved from Carol Dweck’s book on self-theories of intelligence, aptly named *Self-Theories: Their Role in Motivation, Personality, and Development*. Dr. Dweck’s research over the last 30-plus years has concluded that students equally and overwhelmingly harbor one of two diametrically opposed perspectives on their intelligence. Otherwise known as mindset, these theories suggest that individuals either have the ability to affect their level of intelligence through effort (the “growth” mindset) or they do not (the “fixed” mindset). Those endowed with a growth mindset are much better positioned to learn owing to their belief in effort, their desire for challenge, their orientation toward learning goals (versus performance goals), and their resiliency in the face of academic setbacks. On the other end of the mindset spectrum are students who believe in the immutable nature of their level of intelligence. So imbued, these students devalue effort as an indicator of low intelligence, are wary of challenge for the risk of exposure it presents, and adopt a performance-goal orientation wherein the object of their desire is either to look good compared to peers or avoid any potential of comparison.

I would like to teach all my physics students a short unit this year on neurophysiology with the goal of helping all of them better appreciate the importance of and science behind a growth mindset. My proposed research will invite students in two of my classes to do the research with the goal of writing persuasive letters to fifth-grade students in the district as a third class does the research with the goal of authoring a term paper on the topic. By surveying the students regarding their perceptions of intelligence and assessing their neurophysiology acumen before and after the lesson, I hope to be able to present a comparison of how students in both groups responded to the lesson.

The steps required for each type of instructional practice (hereafter referred to as “the interventions”) will necessitate five to six days of class time with some out-of-class time at the discretion of the students. As the study is primarily about neurophysiology, the unit is consistent with the goals of a science teacher, although the more profound goal of reducing or eliminating barriers to learning makes it consistent with education at any level. The time spent on the subject will not impoverish student participants in terms of other physics curricular goals.
Data collected in terms of student assessment scores and student responses to survey questions will be quantitatively analyzed in order to compare the results of the interventions. *These data will not affect participants’ class grades.* Additionally, (audio only) recordings and researcher field notes made during pertinent class sessions to facilitate recall will be used to gauge less tangible aspects of student response, including level of engagement in, and enthusiasm for, the lessons.

In a manner parallel to the data collected during the 2012-13 school year by Northern Illinois University professors, I intend to seek consent from students aged 18 and over and the parents and/or guardians of younger students as well as the assent of younger students. I am writing to determine what the School District XXXX would like to see in the way of assurances that the research will be carried out in a manner that will not bring harm to our students. For the record, last year’s requirement by the district was to make copies of all student consent and assent forms to keep on file in the district office. Copies of the two different consent forms and the assent form are attached. Note that the research cannot proceed without NIU Institutional Review Board approval, a part of which is an assurance from the district of its approval.

It is my hope that the district will look approvingly on the process and confer its blessing so that we can move forward to the benefit of all participating students and, eventually, to interested teachers throughout the district or across the country. I am happy to answer any questions about the program.

Sincerely,

Steven K. Stern  
XXXX High School Science Department

Attachments:

1. 18+ student consent form  
2. Parents of under 18 consent form  
3. Under 18 student assent form
APPENDIX C

PARTICIPANT RECRUITMENT SCRIPT
You are invited to participate in a research project wherein I hope to be able to collect data that will enable me to compare and contrast two instructional practices designed to influence how students think about their level of intelligence. I hope that what you share with me this semester will help you become better students and help teachers better diagnose what students believe about intelligence and intervene to elicit healthier student conceptions of whether they can become “smarter.” You will have the opportunity to learn about the brain and intelligence. The unit of instruction will take approximately six days of class time spread over approximately six weeks.

If you agree to participate in this study, your performance on three assessments will be tracked, and your responses on three surveys will be collected and analyzed in aggregate (as a group). Each assessment will take 25 minutes or less to complete. Your final project will also be reviewed for research purposes. It is important to note that your performance on the assessments will be used to evaluate the comparative efficacy of the instructional practices, but it will not affect your grade in the course. Additionally, the researcher will make note of behavior indicative of student reaction to the instructional practices according to a form designed specifically for this purpose. A video camera (with the lens cap in place) will be used to make audio recordings as a means to facilitate recall of classroom behavior pertinent to the study.

There are no foreseeable risks or discomforts to you during this study. Although your participation in the class exercise is mandatory, your participation in the study (taking the assessments or filling out the surveys) is optional. The benefits you may personally receive from participating in this study include the possibility of better understanding the
process of learning and, with that, greater personal control over your learning behavior.

You will be asked to indicate individual assent to be involved prior to participation, and will be free to withdraw from participation at any time without penalty or prejudice.

Details of your participation are contained in the consent and assent forms that will be distributed prior to the start of the study. I am happy to answer any questions you may have.
APPENDIX D

CONSENT FORMS
Dear Adult Student,

You are invited to participate in the research project titled *Teacher Practices that Address Mindset* being conducted by Mr. Steve Stern, a teacher at XXXXXXX High School and graduate student at Northern Illinois University (NIU). The purpose of the study is to compare and contrast two particular instructional strategies designed to influence how students think about their level of intelligence. I hope that what you share with me this semester will help you become better students, help teachers better diagnose how students perceive intelligence, and inform teachers about how to elicit healthier students’ conceptions of whether they can become “smarter.” You will have the opportunity to learn about the brain and intelligence. The unit of instruction will take approximately six days of class time spread over approximately six weeks.

If you agree to participate in this study, your performance on three assessments will be tracked, and your responses on three surveys will be collected and analyzed in aggregate (as a group). Each assessment will take 25 minutes or less to complete. Your final project will also be reviewed for research purposes. It is important to note that the assessments will not form a part of your grade in the class and will be used only to measure how much, if at all, you and your peers benefited from the intervention. Additionally, the researcher will make note of behavior indicative of student reaction to the instructional practices according to a form designed specifically for this purpose. A video camera (with the lens cap in place) will be used to make audio recordings as a means to facilitate recall of classroom behavior pertinent to the study.

There are no foreseeable risks or discomforts to you during this study. Although your participation in the class exercise is mandatory, your participation in the study (taking the assessments, filling out the surveys, observation of your reaction to the lesson, and/or evaluation of your performance on the assignment) is optional. The benefits you may personally receive from participating in this study include the possibility of better understanding the process of learning and, with that, greater personal control over your learning behavior. You will be asked to indicate individual assent to be involved prior to participation and will be free to withdraw from participation at any time without penalty or prejudice.

Information obtained during this study will be part of a published dissertation and may be published in educational journals or presented at educational meetings, but any information that could identify you will be kept strictly confidential. Your name will not be used. All information gathered during the study will be kept confidential by the use of code names for participants and the destruction of all data one year after the dissertation is completed and defended. Your name and the name of your school will not be included in the resulting publication.

Your consent to participate in this project does not constitute a waiver of any legal rights or redress you might have as a result of your participation. By signing below, you
acknowledge that you have received a copy of this consent form and have agreed to participate in the study.

You are aware that your participation is voluntary and may be withdrawn at any time without penalty or prejudice and that if you have any additional questions concerning this study, you may contact Mr. Steve Stern at (XXX) XXX-XXXX, NIU faculty advisor and dissertation committee co-chair Dr. Mary Beth Henning at (815) 753-8591, or dissertation committee co-chair Dr. Jennifer Schmidt at (815) 753-8425. You understand that if you wish further information regarding your rights as a research subject, you may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

____________________________________
Signature of Student/Date

I agree to audio-taping of pertinent class sessions:

____________________________________
Signature of Student/Date

(Please sign and return to Mr. Stern)
Dear High School Physics Student (under 18 years old),

You are invited to participate in a research study titled Teacher Practices that Address Mindset being conducted by Mr. Steve Stern, a teacher at XXXXXXXX High School and graduate student at Northern Illinois University (NIU). The purpose of the study is to compare and contrast two particular instructional strategies designed to influence how students think about their level of intelligence. I hope that what you share with me this semester will help you become better students, help teachers better diagnose how students perceive intelligence, and inform teachers about how to elicit healthier students’ conceptions of whether they can become “smarter.”

If you agree to participate in this study, your performance on three assessments will be tracked, and your responses on three surveys will be collected and analyzed in aggregate (as a group). Each assessment will take 25 minutes or less to complete. Your final project will also be reviewed for research purposes. It is important to note that the assessments will not form a part of your grade in the class and will be used only to measure how much, if at all, you and your peers benefited from the intervention. Additionally, the researcher will make note of behavior indicative of student reaction to the instructional practices according to a form designed specifically for this purpose. A video camera (with the lens cap in place) will be used to make audio recordings as a means to facilitate recall of classroom behavior pertinent to the study.

There are no foreseeable risks or discomforts to you during this study. Although your participation in the class exercise is mandatory, your participation in the study (taking the assessments, filling out the surveys, observation of your reaction to the lesson, and/or evaluation of your performance on the assignment) is optional. You will be asked to indicate individual assent to be involved prior to participation and will be free to withdraw from participation at any time without penalty or prejudice.

Information obtained during this study will be part of a published dissertation and may be published in educational journals or presented at educational meetings, but any information which could identify you will be kept strictly confidential. Your name will not be used. All information gathered during the study will be kept confidential by the use of pseudonyms for participants and the destruction of all data one year after the dissertation is completed and defended. Your name and the name of your school will not be included in resulting publications.

If you have any additional questions concerning this study, you may contact Mr. Steve Stern at (XXX) XXX-XXXX, NIU faculty advisor and dissertation committee co-chair Dr. Mary Beth Henning at (815) 753-8591, or dissertation committee co-chair Dr. Jennifer Schmidt at (815) 753-8425. If you wish further information regarding your rights as a research subject, you may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588.
I agree to participate in this research study with Mr. Stern.

Signature of Student/Date (Please sign and return to Mr. Stern)

I agree to audiotaping of class sessions (Please sign and return to Mr. Stern)
Dear XXXX High School Physics Student Parent or Guardian:

My name is Steve Stern. I am your child’s physics teacher this year. I am writing to inform you of a research study I wish to pursue during the upcoming academic school year. The purposes of the study are to fulfill requirements in my pursuit of a doctoral dissertation through Northern Illinois University and to discover possibly new and better ways to help your child learn.

Shortly, you will receive a form to enable you to determine whether or not you consent to your child’s participation in the study. Although I believe the form provides sufficient detail to make that decision (you are invited to contact me in the event it fails to do so), proper protocol suggests that this letter preface the consent form.

First of all, participation in the study cannot affect your child’s grade. The study calls for the dissemination of information to students that has been shown to benefit students who may be skeptical about their abilities. The main purpose of the research is to help determine the most effective means of dissemination.

A significant amount of research, combined with my personal and professional experiences, have sufficiently convinced me to include study of this material as an integral part of my physics classes. This means that I have incorporated the material into the curricular goals of the class (with the approval of the science department chairman, the high school principal, and the district office), effectively making your child’s participation in the lesson mandatory. However, your child’s participation in the study is voluntary, amounting to allowing me to use responses on survey items, performance on assessments having to do specifically with the lessons’ subject matter, and utterances made during the course of classwork to facilitate a comparison of two methods of instructional practice. In every case, the confidentiality of student responses, assessment performance, and statements made in class will be maintained in accordance with strict guidelines administered by Northern Illinois University. Additionally, students may withdraw from study participation at any time without threat of retribution or retaliation.

The steps required of each type of instructional practice will require five to six days of class time during the fall term with some out-of-class time at the discretion of the students. As the study is primarily about neurophysiology, the unit is consistent with the goals of a science teacher. The more profound goal of reducing or eliminating barriers to learning makes it consistent with education at any level. The time spent on the subject will not impoverish student participants in terms of other physics curricular goals.

I am happy to answer any questions about the proposed research at your convenience. Please take advantage of return e-mail or my office phone extension to communicate questions or concerns.

Sincerely,

Steven K. Stern
XXXX High School Science Department
Dear Parents and Guardians,

Your child is invited to participate in a research study titled *Teacher Practices that Address Mindset* being conducted by Mr. Steve Stern, a teacher at XXXX High School and graduate student at Northern Illinois University (NIU). The purpose of the study is to compare and contrast two particular instructional strategies designed to influence how students think about their level of intelligence. Your child will have the opportunity to learn about the brain and intelligence. The unit of instruction will take approximately six days of class time spread over approximately six weeks.

If you and your child agree to participate in this study, your child’s performance on three assessments will be tracked and your child’s responses on three surveys will be collected and analyzed in aggregate (as a group). Each assessment will take 25 minutes or less to complete. Additionally, your child’s final project will be evaluated for *research purposes only*, and observations of your child’s reaction to the lesson may be made in order to gauge overall student reaction. It is important to note that the assessments will not form a part of your child’s grade in the class and will be used only to measure how much, if at all, students benefited from the lesson. Additionally, the researcher will make note of behavior indicative of student reaction to the instructional practices according to a form designed specifically for this purpose. A video camera (with the lens cap in place) will be used to make audio recordings as a means to facilitate recall of classroom behavior pertinent to the study.

There are no foreseeable risks to your student in participating in this study. As mentioned above, your child’s grade at the school is completely unrelated and unaffected by participation in this study.

The benefits your child may personally receive from participating in this study include the possibility of better understanding the process of learning and, with that, greater personal control over his or her learning behavior.

Information obtained during this study may be published in educational journals or presented at educational meetings, but any information which could identify your child will be kept strictly confidential. Notations of classroom observations will be transcribed with code names, and all data will be destroyed one year after the dissertation is completed and defended. The name of your child and the school he/she attends will not appear in any publications.

Although participation in the class exercise is mandatory, your child’s participation in the study (taking the assessments, filling out the surveys, observation of reaction to the lesson, and/or evaluation of performance on the assignment) is *optional*. You and your child’s decision whether or not to participate will not negatively affect you or your child.
child will be asked to indicate individual assent to be involved prior to participation and will be free to withdraw from participation at any time without penalty or prejudice.

Any questions about the study should be addressed to Mr. Steve Stern at (630) XXX-XXXX, NIU faculty advisor and dissertation committee co-chair Dr. Mary Beth Henning at (815) 753-8591, or dissertation committee co-chair Dr. Jennifer Schmidt at (815) 753-8425. If you wish further information regarding your rights or your child’s rights as a research subject, you may contact the Office of Research Compliance at Northern Illinois University at (815) 753-8588.

I agree to allow my child/ward to participate in this research study and acknowledge that I have received a copy of this consent form.

________________________________________
Student Name

________________________________________
Signature of Parent/Guardian Date (Please sign and return to Mr. Stern)

________________________________________
I agree to audio-taping of pertinent class sessions (Please sign and return to Mr. Stern)
APPENDIX E

INTERVENTION EXPLANATION HANDOUT
Pen-Pals Project

As an adjunct to our study of physics, we will work occasionally on an in-class activity that will eventually become an individual activity. Specifically, we will work within our Learning Style Groups (LSGs) to research the brain and how students learn. By combining research into separate facets, each LSG will eventually compose a letter suitable for fifth-grade students to understand. From that point, each person will be assigned a particular student and will proceed to personalize his or her letter to include some details that will “humanize” the letter. From there, we will send the letters to your pen pal and see if we get a response.

The subject of the letter is the brain and how learning occurs. By combining sufficient brain physiology and the latest in brain research with current theories about the plasticity of human intelligence, your job is to impress upon these young learners that no one is preordained to a particular academic fate based on how much “brains” they did or didn’t get at birth. Rather, research shows that intelligence is malleable and poor performances are reflections of curable ignorance (through time and effort), not immutable stupidity.

Starting with your LSG, you must designate which member will research which of the three areas of expertise outlined below. As a class, we will go to the library, at which point, all of the homogeneous “experts” will work together to generate a document that answers basic questions. Using these three documents as an outline, your instructor will lead a class discussion designed to answer basic questions, uncover misconceptions, and confirm suspicions. The next step will be for students to create rough drafts of a letter to a fifth-grade student for submission, feedback, class discussion, and, ultimately, teacher approval. Paper copies will be submitted for final approval, after which the letters will be sent off to the grade school.

The three areas of expertise:
1. Mindset: What do many students think about their level of intelligence?
2. Brain Physiology: How does the brain learn new things?
3. Obstacles to Learning: What effect do diet, drugs, alcohol, and amount of sleep have on the brain and its learning process?

Remember, you’ll be writing to 10- and 11-year-olds. As with any well-written document, keep your audience in mind when you write your letter.
Effects on class grades:
The decision whether or not to participate cannot affect your grade in the class. The exercise is designed to elicit a learning perspective that could improve your efficacy as a student, and your participation is purely voluntary.

Research Methodology:
Access the ERIC (Ebsco) database through the main XXXX High School library portal. Enter search terms that will produce a manageable number of results. Scan titles for viable articles. Linking to the article’s abstract will provide further detail. View the full PDF file of articles you select. Print only the parts of the article that will help you answer your questions.

Additionally, several books have been obtained specifically for the purposes of this research. They are on reserve in the library and may not be checked out.

Neurophysiology and Learning Term-Paper Project

As an adjunct to our study of physics, we will work occasionally on an in-class activity that will eventually become an individual activity—namely the authorship of a term paper. After working in class to develop a common understanding of the facets of neurophysiology pertinent to the project, we will work independently to research teacher-specified facets of neurophysiology that help explain how students learn. The rationale for the exercise is that during the course of researching and writing a term paper, each student will develop a personal perspective on intelligence and learning based on factual data that may have been previously unknown.

By combining sufficient brain physiology and the latest in brain research with current theories about the plasticity of human intelligence, your job is to gather information sufficient to enable you to reach conclusions regarding whether or not students are preordained to a particular academic fate based on how much “brains” they did or did not get at birth according to commonly held theories of intelligence. Although extant research suggests that intelligence is malleable and poor performances are reflections of curable ignorance (through time and effort), not immutable “stupidity,” your research and writing is meant to form the basis of personal conclusions that are more likely to endure.

As a class, we will go to the library for a brief lesson in research, after which students will perform independent research to generate a document that answers the basic questions listed below. Accountability for progress during this initial research stage will be facilitated via the requirement of each student to submit a tentative outline of the paper by period’s end. Your instructor will use these outlines to conduct a class discussion designed to answer basic questions, uncover misconceptions, and confirm suspicions. The next step will be for students to modify these initial outlines for resubmission, feedback, additional
class discussion, and, ultimately, teacher approval. After approval, students will be expected to work on the paper independently, submitting drafts at agreed-upon deadlines.

**The three areas of expertise:**
1. Mindset: What do many students think about their level of intelligence?
2. Brain Physiology: How does the brain learn new things?
3. Obstacles to Learning: What effect do diet, drugs, alcohol, and amount of sleep have on the brain and its learning process?

**Effects on class grades:**
The decision whether or not to participate cannot affect your grade in the class. The exercise is designed to elicit a learning perspective that could improve your efficacy as a student and your participation is purely voluntary.

**Research Methodology:**
Access the ERIC (Ebsco) database through the main high school library portal. Enter search terms that will produce in a manageable number of results. Scan titles for viable articles. Linking to the article’s abstract will provide further detail. View the full PDF file of articles you select. *Print only the parts of the article that will help you answer your questions.*

Additionally, several books have been obtained specifically for the purposes of this research. They are on reserve in the library and may not be checked out.
APPENDIX F
TERM-PAPER GRADING RUBRIC
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Exemplary (8-10)</th>
<th>Good (6-7)</th>
<th>Acceptable (4-5)</th>
<th>Unacceptable (0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content x 4</td>
<td>The writer presents balance of relevant and legitimate information and shows a thoughtful, in-depth analysis of the topic. Reader gains important insights.</td>
<td>The writer presents a basic analysis of the topic. Reader gains some insights.</td>
<td>The writer provides only basic or general information about the topic. Reader gains few insights.</td>
<td>The writer’s information about the topic is vague or inaccurate. Reader is confused or may be misinformed.</td>
</tr>
<tr>
<td>Purpose x 2</td>
<td>The writer's central purpose is readily apparent to the reader. The writer has clearly considered the intended audience appropriately.</td>
<td>The writing has a clear purpose or argument, but may sometimes digress from it. There is indication of consideration of the intended audience</td>
<td>The central purpose or argument is not consistently clear throughout the paper. Little evidence of consideration of the intended audience is present.</td>
<td>The purpose or argument is generally unclear. No consideration of the intended audience is evident.</td>
</tr>
<tr>
<td>Organization x 2</td>
<td>The ideas are arranged logically. They flow smoothly from one to another and are clearly linked to each other. The reader can follow the line of topic development.</td>
<td>The ideas are arranged logically and are usually clearly linked to each other. For the most part, the reader can follow the line of topic development.</td>
<td>In general, the writing is arranged logically, although occasionally ideas fail to make sense together. The reader is fairly clear about what writer is communicating.</td>
<td>The writing is not logically organized. Frequently, ideas fail to make sense together. The reader cannot identify a line of topic development and loses interest.</td>
</tr>
<tr>
<td>Feel</td>
<td>The writing is compelling. It hooks the reader and sustains interest throughout.</td>
<td>The writing is generally engaging but has some dry spots. In general, it is focused and keeps the reader’s attention.</td>
<td>The writing is dull and not engaging. Although the paper has some interesting parts, the reader finds it difficult to maintain interest.</td>
<td>The writing has little personality. The reader quickly loses interest and stops reading.</td>
</tr>
<tr>
<td>Mechanics X 2</td>
<td>The writing is free or almost free of errors.</td>
<td>There are occasional errors, but they do not represent a major distraction or obscure meaning.</td>
<td>The writing has many errors, and the reader is distracted by them.</td>
<td>There are so many errors that meaning is obscured. The reader is confused and stops reading.</td>
</tr>
</tbody>
</table>

(Capstone) Total: _________

Figure 9: Term paper grading rubric.
APPENDIX G

STUDENT MINDSET SURVEY
This is NOT a test! It is an opinion survey. I will be asking you for your thoughts and opinions about school and being a student so that I can learn how to help you do better in school.

There are no right or wrong answers—different people have different ideas about all of these things. It is very important that you give your own opinion, not what someone else told you to think. There is nothing to be gained by giving answers you think sound right; doing that will limit the effectiveness of this tool.

Your answers will be kept private. Your set of answers will be assigned to a randomly generated number so they cannot affect your grades in any way. If you have any questions about anything, feel free to ask for help.

There are two kinds of questions on this survey. One kind will ask a question and you will type your opinion into a text box by clicking into the box with your mouse and then typing your answer.

The other type of question has a statement, and you will rate how much you agree or disagree with the statement by clicking on the bubble below your answer for that question.

Please take a look at the questions on this page, and ask for help if you have any questions about how to do this.

The first set of questions asks what you think about intelligence. Intelligence is the same thing as smartness. Here are some things people say about intelligence. Tell us how much you agree or disagree. Remember, there is no right or wrong answer; I am interested in what you think.

**Intelligence**

1. Your intelligence is something you can't change very much.
   - [ ] Disagree a lot
   - [ ] Disagree
   - [ ] Disagree a little
   - [ ] Agree a little
   - [ ] Agree
   - [ ] Agree a lot

2. You have a certain amount of intelligence, and you really can't do much to change it.
   - [ ] Disagree a lot
   - [ ] Disagree
   - [ ] Disagree a little
   - [ ] Agree a little
   - [ ] Agree
   - [ ] Agree a lot
3. No matter who you are, you can change your intelligence a lot.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

4. You can always greatly change how intelligent you are.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

5. You can learn new things, but you can't really change your basic intelligence.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

6. No matter how much intelligence you have, you can always change it a good amount.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

The next set of questions asks what you think about goals. Here are some things people say about their goals. Tell us how much you agree or disagree. Remember, there is no right or wrong answer; I am interested in what you think.

**Goals**

7. I like schoolwork best when I can do it perfectly without any mistakes.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot
8. The main thing I want when I do my schoolwork is to show how good I am at it.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

9. An important reason why I do my schoolwork is because I like to learn new things.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

10. Sometimes I would rather do well in a class than learn a lot.
    ( ) Disagree a lot
    ( ) Disagree
    ( ) Disagree a little
    ( ) Agree a little
    ( ) Agree
    ( ) Agree a lot

11. I like schoolwork that I'll learn from even if I make a lot of mistakes.
    ( ) Disagree a lot
    ( ) Disagree
    ( ) Disagree a little
    ( ) Agree a little
    ( ) Agree
    ( ) Agree a lot

12. I like schoolwork best when I can do it really well without too much trouble.
    ( ) Disagree a lot
    ( ) Disagree
    ( ) Disagree a little
    ( ) Agree a little
    ( ) Agree
    ( ) Agree a lot

13. It is much more important for me to learn things in my classes than it is to get the best grades.
    ( ) Disagree a lot
    ( ) Disagree
    ( ) Disagree a little
    ( ) Agree a little
    ( ) Agree
    ( ) Agree a lot
14. I like schoolwork best when it makes me think hard.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

15. It is very important to me that I don’t look stupid in class.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

16. An important reason I do my schoolwork is so I won’t embarrass myself.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

17. An important reason I do my work for class is so others won't think I'm dumb.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

18. My goal in science class is to perform better than the other students.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

19. My goal in science class is to learn as much as possible.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot
The next set of questions asks what you think about effort. Effort is the same thing as how hard you try. Here are some things people say about effort. Tell us how much you agree or disagree. Remember, there is no right or wrong answer; I am interested in what you think.

**Effort**

20. To tell the truth, when I work hard at my schoolwork, it makes me feel like I’m not very smart.
   - Disagree a lot
   - Disagree
   - Disagree a little
   - Agree a little
   - Agree
   - Agree a lot

21. If my homework is really easy, it makes me feel like it is a waste of time doing it.
   - Disagree a lot
   - Disagree
   - Disagree a little
   - Agree a little
   - Agree
   - Agree a lot

22. It doesn't matter how hard you work--if you’re not smart, you won’t do well.
   - Disagree a lot
   - Disagree
   - Disagree a little
   - Agree a little
   - Agree
   - Agree a lot

23. When something is hard, it just makes me want to work more on it, not less.
   - Disagree a lot
   - Disagree
   - Disagree a little
   - Agree a little
   - Agree
   - Agree a lot

24. You only know you're good at something when it comes easily to you.
   - Disagree a lot
   - Disagree
   - Disagree a little
   - Agree a little
   - Agree
   - Agree a lot
25. If you’re not good at a subject, working hard won’t make you good at it.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

26. If a subject is hard for me, it means I probably won’t be able to do really well at it.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

27. The best way to tell if you're good at something is to see how quickly you catch on to it.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

28. If you're not doing well at something, it's better to try something easier.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

29. If you don’t work hard and put in a lot of effort, you probably won’t do well.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

30. The harder you work at something, the better you will be at it.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot
31. If an assignment is hard, it means I’ll probably learn a lot doing it.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

32. In school, my main goal is to do things as easily as possible so I don’t have to work very hard.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

33. I try to spend as little time on my schoolwork as I can get by with.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

The next set of questions asks what you think about test anxiety. Test anxiety refers to how nervous you get before a test. Here are some things people say about test anxiety. Tell us how much you agree or disagree. Remember, there is no right or wrong answer; I am interested in what you think.

**Test Anxiety**

34. When I take tests, I worry a lot about questions I can’t answer.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

35. A lot of times I am so nervous during a test that I can’t remember facts I have learned.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot
36. I usually have an upset feeling when I take a test.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

37. I worry a great deal about tests.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

38. When I take a test I think about how badly I am doing.
   ( ) Disagree a lot
   ( ) Disagree
   ( ) Disagree a little
   ( ) Agree a little
   ( ) Agree
   ( ) Agree a lot

The next set of questions asks what you think about learning strategies. Learning strategies are things you might do that help or hurt how well you learn something. Here are some things people say about learning strategies. Tell us how much you agree or disagree. Remember, there is no right or wrong answer; I am interested in what you think.

**Learning Strategies**

How often do you do each of these things when you work on your schoolwork?

39. When I study, I put important ideas in my own words.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

40. When I study, I copy my notes over to help me remember material.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always
41. When I study for a test, I practice saying the important facts over and over to myself.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

42. When I read material for class, I say new words over and over to myself to help me remember.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

43. I write outlines for the chapters in my book to help me study.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

44. When I do homework, I look back over my class notes to remember what the teacher said.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

45. I don’t do practice exercises and end of chapter questions unless I have to.
   ( ) Not at all true
   ( ) Rarely true
   ( ) Occasionally true
   ( ) Sometimes true
   ( ) Mostly true
   ( ) Very true

46. I find that when the teacher is talking, I think of other things and don’t really listen to what is being said.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always
47. I often find that I have been reading for class but don’t know what it is all about.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

48. When I am studying, I ask myself questions to make sure I know the material.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

49. When I'm reading, I stop and review what I have read.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

50. When I take a test, I usually guess a lot so I can finish quickly.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

51. I use flash cards and quiz myself with them to help me remember things.
   ( ) Never
   ( ) Rarely
   ( ) Occasionally
   ( ) Sometimes
   ( ) Most of the time
   ( ) Always

Thank you for taking this survey!! Your answers will help me do a better job of helping you learn.
APPENDIX H

NEUROPHYSIOLOGY ASSESSMENT
Name _______________________

Neurophysiology Assessment

NOTE: Your score on this test will not affect your grade in the class. Instead, it will be used to assess the effectiveness of the unit.

Multiple-choice: Select the response that best answers the question.

1. A synapse is a(n) ________________.
   a. chemical messenger that triggers muscle contractions
   b. automatic response to sensory input
   c. neural network
   d. junction between a sending neuron and a receiving neuron
   e. neural cable containing many axons

2. The function of dendrites is to ________________.
   a. receive incoming signals from other neurons
   b. release neurotransmitters into the spatial junctions between neurons
   c. coordinate the activation of the parasympathetic and sympathetic nervous systems
   d. control pain through the release of opiate-like chemicals into the brain
   e. transmit signals to other parts of the brain

3. Your life would be most immediately threatened if you suffered destruction of the ____________.
   a. amygdala
   b. hippocampus
   c. angular gyrus
   d. corpus callosum
   e. medulla

4. Pruning, as in relationship to brain cells, refers to ____________.
   a. elimination of unnecessary brain cells
   b. fewer but faster connections
   c. brain cells grow in number
   d. both a & c
   e. both a & b
5. An axon is ________________.
   a. a cell that serves as the basic building block of the nervous system
   b. a layer of fatty tissue that encases the fibers of many neurons
   c. an antagonist molecule that blocks neurotransmitter receptor sites
   d. the extension of a neuron that carries messages away from the cell body
   e. a junction between a sending and receiving neuron

6. Which of the following is the component of the limbic system that plays an essential role in the processing of new memories?
   a. Hypothalamus
   b. Thalamus
   c. Hippocampus
   d. Medulla
   e. Cerebellum

7. In transmitting sensory information to the brain, an electrical signal travels from the _______ of a single neuron.
   a. cell body to the axon to the dendrites
   b. dendrites to the axon to the cell body
   c. axon to the cell body to the dendrites
   d. dendrites to the cell body to the axon
   e. axon to the dendrites to the cell body

8. According to researchers, the brain is not fully developed until early 20s. What is the final area of the brain to be pruned and fully formed?
   a. Hindbrain
   b. Limbic system
   c. Prefrontal cortex
   d. Temporal lobe
   e. Occipital lobe
9. The teen brain is undergoing rapid and massive change, rendering it extremely inefficient. Which of the following behaviors often demonstrated by teenagers is/are due to the instability, volatility, and unpredictability associated with this brain maturation process?

I. higher susceptibility to the pleasures of alcohol and nicotine
II. lower sensitivity to the detrimental effects of alcohol and nicotine
III. the urge to stay up late and sleep late

a. I only  
b. II only  
c. III only  
d. I & II only  
e. I, II, & III

10. ____________ emotions are associated with __________ memory.
  a. Strong/shallow  
b. Strong/deep  
c. Bland/deep

**Fill in the Blank:** Use the word bank to fill in the spaces. Some words or terms may be used more than once and others not at all.

adaptability  
circadian rhythms  
dopamine  
learning  
lethargy  
memory  
potassium  
receptor sites  
sleep or sleeping  
stress  
tryptophan  
ultradian rhythms

11. ________________ refers to the capacity humans have to change their own brains.

12. When __________ occurs, the brain physically changes by creating or modifying existing connections between nerve cells.

13. Most drugs (cocaine, alcohol, etc.) work by increasing the __________ levels in the pleasure centers of the brain, mimicking a “natural high,” but doing so at a more concentrated rate.
14. Over time, repeated drug use causes the brain to reduce ________________, thereby increasing the tolerance for a particular drug.

**Short answer:** Use the space provided to write brief answers to the questions.

15. What is *neuroplasticity*?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

16. Why is new (learned) information that is relational (connected by some commonality) more easily stored and accessed than unrelated (rote) items?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

17. What important process occurs during sleep having to do with the events of the previous day?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

**Chronology of Learning:** Despite the complexity of many of the brain functions, that of learning is relatively simple. Put these learning steps in the order that they occur:

a. Much of the new data is held in the frontal lobe for 5 to 20 seconds to determine its worth.
b. If any of the input data suggest danger, the amygdala is activated, a process that prepares the body for quick response.
c. In the event that value is assigned to input, the new learning is routed to the hippocampus for further worth assessment. New data assessed as trivial are dumped.

d. If deemed significant, the new information is organized and indexed by the hippocampus and stored in the cortex.

e. Input is processed in the thalamus as well as other specific areas of the brain in order to gain an overall “first impression” of the input.

f. Input is received from the five senses or from internal imagination or reflection.

18. Correct order, first to last: _____, _____, _____, _____, _____, _____

**Learning Environment:** Name three things that teachers can do to enhance the physical learning environment of their students:

19.

20.

21.
APPENDIX I

FIELD NOTES FORM
1. How do students who experience either intervention differ with respect to the degree to which they espouse various mindset-related beliefs, including beliefs about the nature of ability, goal orientation, and perceptions of the role of effort?
2. How do students differ with respect to comprehension and retention of course content on neurophysiology?
3. How do students differ with respect to how engaged students are in the activity as manifested in their response to (and enthusiasm for) the activity, their persistence at the task, the apparent enjoyment derived from participation, and any other salient indicators of experiential differences that may arise during the course of the study?

<table>
<thead>
<tr>
<th>Day/Date/Location:</th>
<th>Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details:</td>
<td>Present:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lesson Aspect</th>
<th>Observations/Evidence</th>
<th>Student Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the general student reaction to the session?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do the students seem engaged in the lesson?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there students disengaged in the lesson?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do the students appear interested in the lesson?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there students who appear disinterested?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Special moments on audiotape to be reviewed:

Figure 10. Field note record.
APPENDIX J

FIFTH-GRADE STUDENT FEEDBACK FORM
Figure 11. Fifth-grade student feedback form.
APPENDIX K

ANCOVA ASSUMPTION TESTS
The assumptions above and beyond those associated with ANOVA include:

*Lack of correlation between covariates:* Pearson r values greater than or equal to 0.8 suggest strong correlation (see Table 12).

<table>
<thead>
<tr>
<th>Table 12</th>
<th>ANCOVA Assumption Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gender</td>
</tr>
<tr>
<td>Gender</td>
<td>Pearson Correlation</td>
</tr>
<tr>
<td>N</td>
<td>68</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed).**Correlation is significant at the 0.01 level (2-tailed).

Pearson r-values suggest that the covariates display a sufficiently weak correlation. Only gender/preintervention test anxiety (r = -0.307) and gender/preintervention learning behavior (r = 0.439) rise to levels of medium correlation.

**Linearity:** Whether by gender or intervention, each pairing of the dependent variable (postintervention scale scores) with this covariate (preintervention scale scores) meets the linearity requirement as indicated by the scatterplots.

**Homogeneity of regression:** It is assumed that “the relationship between the covariate and the dependent variable for each of [the] groups is the same” (Pallant, 2013, p. 310). The results of the check for this sameness are shown in Table 13. Following Pallant’s prescription, homogeneity of regression can be assessed in two ways. Graphically, a review of the scatterplots generated during verification of linearity suggests that each pair of graphed lines have similar slopes. Statistically, a univariate general linear model that identified each mindset scale after intervention as the dependent variable,
preintervention mindset as the covariate, and gender as the independent variable yielded the following significance values, further suggesting that the homogeneity of regression assumption has been met with the single exception of the test of between-subjects effects (using intervention group as the fixed factor), which indicates a significant effect for interaction between the outcome variable and the covariate for the total mindset scale.

Table 13
Homogeneity of Regression Intervention and Gender Significance Values

<table>
<thead>
<tr>
<th>Between-Subjects Effects: Dependent Variable x Covariate</th>
<th>Fixed Factor: Intervention Group Sig.</th>
<th>Fixed Factor: Gender Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postintervention intelligence mindset x preintervention intelligence score</td>
<td>.092</td>
<td>.817</td>
</tr>
<tr>
<td>Postintervention goal mindset x preintervention goal score</td>
<td>.312</td>
<td>.376</td>
</tr>
<tr>
<td>Postintervention effort mindset x preintervention effort score</td>
<td>.194</td>
<td>.127</td>
</tr>
<tr>
<td>Postintervention test anxiety mindset x preintervention test anxiety score</td>
<td>.912</td>
<td>.055</td>
</tr>
<tr>
<td>Postintervention learning behavior mindset x preintervention learning behavior score</td>
<td>.661</td>
<td>.723</td>
</tr>
<tr>
<td>Postintervention total mindset x preintervention total score</td>
<td>.017</td>
<td>.840</td>
</tr>
</tbody>
</table>

*Independence of covariate from treatment:* By virtue of experimental design (administering a survey preintervention from which the scale scores were calculated), the preintervention scale scores are independent of the treatment. The assumption that the covariate is independent from the treatment was checked by running an ANOVA wherein gender was the outcome (dependent variable) and intervention type was the predictor (independent variable) (see Table 14). The output table suggests that the main effect for treatment was not significant, $F(1,66) = 0.461, p = .499$, showing that effects for gender varied little between intervention types.
Table 15

Tests of Between-Subjects Effects (Dependent Variable: Gender)

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>.118&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>.118</td>
<td>.461</td>
<td>.499</td>
</tr>
<tr>
<td>Intercept</td>
<td>140.118</td>
<td>1</td>
<td>140.118</td>
<td>548.263</td>
<td>.000</td>
</tr>
<tr>
<td>Intervention type</td>
<td>.118</td>
<td>1</td>
<td>.118</td>
<td>.461</td>
<td>.499</td>
</tr>
<tr>
<td>Error</td>
<td>16.867</td>
<td>66</td>
<td>.256</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>173.000</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>16.985</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> r squared = .007 (adjusted r squared = -.008)
APPENDIX L

TERM PAPER AND PEN PAL LETTER EXAMPLES
Term Paper Example

How We Learn

On average, students spend about seven and a half hours a day at school learning, but how much is this learning affecting the student? Quite a few factors contribute to how well and how effectively one learns new material, and how that affects one’s overall self-theory of intelligence. Three aspects – Neurophysiology, Mindset, and Obstacles, ultimately contribute to one’s success in learning. Neurophysiology is how the brain works, Mindset is how an individual feels about his own intelligence, and Obstacles are what get in the way of learning. With proper cooperation between Neurophysiology of the brain, Mindset, and Obstacles, one will experience greater satisfaction and success in learning.

Without the brain, humans would not be able to function. Without a brain, humans would not be able to move or function. The brain would not be there to remind a person to breathe, so in all likelihood, a person could not live without a brain. The brain is a very important factor when it comes to learning new material. When learning new information it is received through the five senses. From the five senses the information is sent and passes through the Thalamus to be sorted in the Cerebral Cortex (“Thalamus”). The next stop in the learning process is the Hippocampus where the sorted information is stored as memory (Arenodsky). This can be labeled as the recognition network – the process in which the brain perceives information and converts it into knowledge. There is also an affective network of the brain which controls a student’s motivation, interest, and stress. The final part of the brain can be classified as the strategic network, or the part of the brain that is used for planning and executing goal-related actions (“Recognition”). The strategic network
directly affects the affective network in such a way that if a student does not plan well, it contributes to the stress and motivation of that student. This affects me every day. When I do not plan accordingly, I find myself stressed and unmotivated to even do my schoolwork. These feelings, the stress, negatively affects my learning; if I feel positively about a situation, then I learn more, but if I negatively approach a situation, my brain associates what I try to learn with something negative.

Many factors can negatively affect how the brain reacts when learning. These are called obstacles. Two major obstacles specifically affect the brain and learning. Drugs, being bad in nature, specifically impact the chemical structure of the brain which influences how well you can retain information. Some Drugs mimic and alter neurotransmission, greatly upsetting the chemical balance in the brain (Sherman). Not only are drugs dangerous, but they are also bad for intellectual health. The high or temporary sense of euphoria is lost once the drug wears off, and the user must use drugs again to ever feel that type of high. One way this affects students is the fact that once you feel a chemical high, no other activity can amount to that type of pleasure. This leads students to lose interest in extracurricular activities and school, consequently changing their mood about learning.

Another obstacle that affects learning is sleep. Sleep may seem like a minor thing, but it relates to the health of the brain and the health of the student’s learning. Teenagers need about nine hours of sleep on average. The reason sleep is so important is because it is necessary for the nervous system to function correctly, and without sleep, a person usually suffers from impaired memory and reduced ability to do things such as a simple math calculation. There are different types of sleep, the most important being REM sleep, or
rapid eye movement sleep when dreaming occurs. REM sleep stimulates the brain regions used in learning, and sleep is when the brain has time to stop and organize the information that has been collected throughout the day (“Brain”). Avoiding drugs and maintaining a healthy sleep schedule will help a student preserve a healthy and ready-to-learn brain.

How obstacles affect Neurophysiology contribute to a student’s overall Self-Theory of intelligence. There are two types of theories of intelligence that students can possess – a fixed mindset and a growth mindset. A fixed mindset is when students believe that they have a certain amount of intelligence and that’s it, nothing can change it. While students with growth mindsets believe that they can develop their intelligence with time (Dweck 2010). Students with fixed mindsets try avoiding activities that make them look dumb rather than take an unwanted grade and try to improve. They worry about how their peers and teachers see them – as either smart or stupid. On the other hand, students with growth mindsets use assessments to judge how much they need to improve and not what their score classifies them as (Dweck 2007). Some students can also have mixed views on their own intelligence depending on the subject. Personally, I have mixed views on my intelligence. When it comes to certain subjects like Algebra I know that I can improve my skills, and I work hard to understand concepts that at first I don’t grasp. When it comes to physics, at first I believed that I would never understand, but then my mindset changed, and I realized that if I work hard I will eventually master the concepts that evade me at first. With choir both views of intelligence exist. I believe that I can master a piece of music with hard work and time, but when it comes to sight reading, I try to avoid it. I feel that I will never be good at sight reading, no matter how long I practice it, because each example is unique –
differentiated by different notes and different rhythms. When it comes to sight reading, I find myself wanting to avoid it because it will only show how bad I am at it. I want to have a different outlook and mindset when choir is involved, but it is difficult to change my views on sight reading.

Researching this topic has opened my mind to how my health and mindset affect my learning. If I have a fixed mindset, it is likely that I will not completely understand a topic because I am too worried with looking “smart.” In contrast, if I possess a growth mindset, my knowledge will expand because I am invested and interested in learning for the sake of learning and not how my grade is affected by my setbacks. In order to optimize my ability to learn I must receive a sufficient amount of sleep (to let my brain do what it needs to do), and avoid unhealthy habits. Overall, I believe that my exploration of the idea of theories of self-intelligence has opened my eyes to ways that I can enhance my learning, and possibly change my outlook on my own intelligence.

Works Cited


Pen Pal Letter Example

Dear James,

Hi my name is Matthew and I am your new pen pal! I am in the eleventh grade and in high school. Back in the day when I was in fifth grade, life was simple. At least that is what I thought back then. Recently, I have learned that the choices that we make in life are never simple, even at your age. The way things work and happen are never simple. For every action you make there is a reaction. Whether or not the reaction is a good one or a bad one is based off of your actions. The cool thing about that is the fact that you are in control of your actions. You have the ability to do whatever you want, be whatever you want, go wherever you want to go in life. It is up to you and your decisions. You have many things to form opinions about and I will try to guide you in the right direction. There is your mindset, your understanding of how the brain works, and physical factors.

Mindset, or the way that you think about things, will play a big part in the way you learn over the next few years. There are two distinct mindsets. The better of the two is a growth mindset while the worst is having a fixed mindset. A growth mindset will make you a better student. With a growth mindset, you will accept a challenge. If you mess up, it is...
not the end of the world and you are always eager to learn more. Fixed mindsets are the complete opposite. You will always be setting yourself up to fail. If you have a fixed mindset, you may be less eager for challenge and will feel embarrassment if you are wrong. The key to success is to have a growth mindset. You will always be prepared for anything. You will accept any challenge and learn from it even if you fail completely because you know that the failure is temporary.

The next thing I want to tell you about is how your brain works. The brain is kind of like silly putty: it will change when you learn something new, but it will also change when you forget something. You may think that your brain is a specific size and that it will not get any bigger, but let me tell you that it will indeed get bigger. When you learn something your brain will actually get heavier. On the other hand when you forget something your brain will actually get lighter. Your brain is not fixed. You can change it by learning more and expanding your horizons.

The last things that I want to tell you about are more physical than mental. Eating breakfast is very important and it will ensure that you are thinking to the best of your ability when you are at school in the morning. If you make healthy choices for breakfast it will help you even more! I cannot tell you enough about sleep, it will make you or break you. If you get adequate amounts of sleep you will be more successful in school. If you do not get enough sleep you will probably get worse grades. I hope that you know that drugs are bad for you. Drugs will prevent your brain from working correctly and you will kill your brain cells by doing them. Outside factors are just as important as the mental factors. You and
only you can determine your future, and if you start doing things the right way right now
you will only see benefits in the future.

Well I hope you learned something and that you’ll write back to me and tell me
something about yourself and what I’ve tried to teach you.

Your new friend,

Matthew
APPENDIX M

ADDITIONAL PARAMETRIC ASSUMPTIONS

NECESSARY FOR A 2-WAY ANCOVA
Homogeneity of regression slopes: It is assumed that “the relationship between the covariate and the dependent variable for each of [the] groups is the same” (Pallant, 2013, p. 310). A univariate general linear model that identified each mindset scale after intervention as the dependent variable, preintervention mindset as the covariate, and gender as the independent variable yielded the following significance values, suggesting that the homogeneity of regression assumption has been met (see Table 15).

<table>
<thead>
<tr>
<th>Between-Subjects Effects</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postintervention intelligence mindset x gender</td>
<td>0.817</td>
</tr>
<tr>
<td>Postintervention goal mindset x gender</td>
<td>0.376</td>
</tr>
<tr>
<td>Postintervention effort mindset x gender</td>
<td>0.127</td>
</tr>
<tr>
<td>Postintervention test anxiety mindset x gender</td>
<td>0.055</td>
</tr>
<tr>
<td>Postintervention learning behavior mindset x gender</td>
<td>0.723</td>
</tr>
<tr>
<td>Postintervention total mindset x gender</td>
<td>0.471</td>
</tr>
</tbody>
</table>

Independence of the covariate from the treatment: The assumption that the covariate is independent from the treatment was checked by running an ANOVA wherein gender is the outcome (dependent variable) and intervention type is the predictor (independent variable) (see Table 16). The output table suggests that the main effect for treatment is not significant, $F(1,66) = 0.461, p = .499$, showing that effects for gender vary little between intervention types.
Table 16

Tests of Between-Subjects Effects (Dependent Variable: Gender)

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>.118</td>
<td>1</td>
<td>.118</td>
<td>.461</td>
<td>.499</td>
</tr>
<tr>
<td>Intercept</td>
<td>140.118</td>
<td>1</td>
<td>140.118</td>
<td>548.263</td>
<td>.000</td>
</tr>
<tr>
<td>Intervention Type</td>
<td>.118</td>
<td>1</td>
<td>.118</td>
<td>.461</td>
<td>.499</td>
</tr>
<tr>
<td>Error</td>
<td>16.867</td>
<td>66</td>
<td>.256</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>173.000</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>16.985</td>
<td>67</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R Squared = .007 (Adjusted R Squared = -.008)