ITERATION AND FAILURE: HOW DOES AN INQUIRY-BASED DESIGN

LAB COURSE IMPACT THE RESILIENCE LEARNING

OF MIDDLE SCHOOL STUDENTS?

by

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DEDICATION

For Mom, I wish you could have seen this.

ACKNOWLEDGEMENT

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ABSTRACT

A student's ability to face academic adversity is identified as resilience. It is described as being able to "bounce back" in the face of challenges. The question posed by this project is how does an inquiry-based design lab course impact the resilience learning of middle school students? The 55 middle school students at the Perkiomen School, in Pennsburg, PA, participated in such a course, where they were asked to use creativity to solve challenging problems in the classroom. The students completed pre- and post-treatment 8-Question Grit Scale surveys. They also described their experiences in the course using reflective assignments. They also participated in group interviews, and selected students participated in individual interviews.

The pre-treatment student grit scores ranged between 1.88 and 4.50 with a mean of 3.44, while the post-treatment survey showed a range of 1.75 to 4.50 with a mean of 3.38. The teacher-completed surveys regarding how they perceived each student's grit showed a similar range, 1.92 to 4.56 with a mean of 3.25.

The overall success of the treatment during the study was inconclusive. The overall student grit score dropped by a score of 0.06. The day student subgroup showed a decrease in grit score over the study of 0.03, though the boarding student subgroup also showed a decrease of 0.13. The findings of this study are encouraging, while though the mean grit score of all participants remained relatively unchanged, a majority of students did not show a negative change (33 of 54, 61%). While the idea of iteration and failure was always present in each activity, the students appeared to focus more on group dynamics when evaluating their progress. This leads to several interesting questions when planning future iterations of this course. Would the students benefit from a larger workspace which would allow for small workgroups and more independence? Would the course benefit from more time in the weekly class schedule, offering the students more opportunity to test their strategies? Lastly, given the relatively short time frame of the treatment period, would longer term surveying of the students validate the long term benefits of such a course?

INTRODUCTION AND BACKGROUND

While not a wholly scientific approach, if one were to use an Internet search engine (e.g. Google, Google, Inc. Mountain View, CA) and search the term "student resilience," one would find over eight million webpages that mention this phrase. Furthermore, teacher discussion boards are filled with dialog about how students are not willing or able to put in the work necessary to be successful. The faculty lunch table conversation, particularly about ninth grade students, is filled with terms like "not ready," "entitled," "helicopter parent," and "not tough."

A student's ability to be resilient in the face of academic adversity is an important characteristic for young people to develop in this era of competitive education. Students face the challenges of high stakes testing as demanded by regulatory agencies, the demands of highly competitive college placement, and qualifications for employment at all levels. It is believed by the author that the concepts of resilience, grit, and perseverance are as much in demand as any academic content. Science educators are always considering ways that curriculum can prepare students for future success, not just in science, but in all areas. Student success is important to all the stakeholders in education: parents, teachers, administrators, and, of course, the students themselves. Therefore, this research will be shared among all of those constituencies. This project moved forward with the gracious permission of Dr. Angela Duckworth, of the University of Pennsylvania and, as such, it will also be shared with her.

Statement of Purpose

The Perkiomen School, in Pennsburg, PA, is a traditional co-educational college preparatory school with a boarding and day population of approximately 340 students in

grades sixth through twelfth. The faculty and staff are guided by the school mission

statement, "The Perkiomen community inspires students to risk becoming their best" and

the motto Solvitur Vivendo, it is solved through living (Perkiomen.org,

http://www.perkiomen.org/page.cfm?p=1536, 2008). The school boasts a near one

hundred-percent college placement rate at a range of schools from Ivy League to small

colleges specializing in student support. Students come from all over the United States

and the world to prepare for a rigorous college experience. At the school, there is much

discussion about the readiness of our middle school students when they move into the

upper school. Many teachers, particularly English teachers, comment on how they seem

to be unable to independently complete difficult assignments. Middle school faculty

members often speak of "hand holding" as a way of "getting them through" course work

and in addition to pleasing parents. The concept of "helicopter parents" is one that has

been growing over the past few years and finding ways to give students the resilience, or

grit, to work through difficulties would be of great value. Michael Riendeau writes in the

Independent School blog that schools, such as his Eagle Hill School, are creating grit

based literature classes to instill the concepts of resilience, grit, and perseverance

(Riendeau, M., 2015).

Research Questions

The primary question for this action research project is "How does an inquiry-

based design lab course impact the resilience learning of middle school students?" The

hope was that the independent inquiry that is part of this course would give students the

ability to complete assignments, even if their original attempts were not successful. The

focal question led to asking the students how they perceive their own resilience. The middle school teachers were also asked how they perceive the students' resilience throughout the process. Finally, teachers in other curriculum areas were given surveys to see if student resilience performance is being translated to their classes as well.

This project was made possible by a strong support team. The team was unofficially headed by Lauren Lambert, the Assistant Headmaster for Academic Affairs at the Perkiomen School. Ms. Lambert acted as the direct supervisor and coordinator for the research activities. Ed Klavon, father of the investigator and a biology teacher of 39 years, served as a reader and inspiration for the project. Shaun Yorgey, Science Department Chair at Perkiomen, served as a sounding board throughout the research process. Mr. Yorgey is also one of the founding teachers of the design lab course. He expressed strong interest in the outcome of this project, as he resonated with its stated purpose. The final member of the support team was Greg Martin, history teacher and colleague, who is served as a "critical friend" for the project. Mr. Martin is more in favor of using the term perseverance, indicating a lack of fragility, over resilience. There is a fine distinction between the terms, resilience meaning a return to shape, implying the ability of students to bounce back. Perseverance indicates the ability to maintain course through difficult times. In addition to Mr. Yorgey, Jacob Hauser and Amber Goupil, all of whom were instructors in the design lab, were key supporters of the research. Lastly, while not on the actual support team, Christopher R. Tompkins, Headmaster of the Perkiomen School, provided advice and resources in the completion of this research.

In addition to the support team, Dr. David Willey volunteered to serve as the reader and Dr. Walter Woolbaugh served in the capacity of advisor.

CONCEPTUAL FRAMEWORK

As a middle school teacher at a private boarding school, one of the most trying times of the day can be sharing a lunch table with upper school teachers, particularly English teachers. Phrases like "they just can't do it," "they're not ready," "they can't write," and "they aren't tough" seem to be repeated endlessly. Teachers on all levels seem to bemoan the lack preparation their current students have received in previous grade-levels and the unwillingness of their students to persevere through difficult challenges. This ability to succeed in spite of these challenges is labeled resilience.

The question addressed in this research project was does an inquiry-based design course provide resilience learning opportunities to middle school students? In addition to this question, it is of great interest to find if students took resilience lessons from this course and applied them to other courses. Lastly, the attitudes of the traditional curriculum teachers with regard to the apparent resilience of the students were investigated by using a modified version of the Grit Scale.

Resilience has been given different definitions over the years, including "optimism- appraising situations without distorting them, thinking about changes that are possible to make in your life" (Perkins-Gough & Duckworth, 2013, p 14). Angela Duckworth, in her interview with Deborah Perkins-Gough (2013), identifies resilience as the ability to bounce back from adversity and that some people use the term specifically to children that come from at-risk environments. Duckworth herself uses the term *grit*,

referring to a student's ability to work hard and to remain focused on long-term passions. The segment of the interview that stands out is her discussion of her grit study at West Point Military Academy, which will be referenced shortly. Duckworth's work at West Point showed that her Grit Scale (Duckworth, Peterson, Matthews & Kelly, 2007, p. 1094) was a better indicator of new students completing the summer of physical training prior to their first year of school than was the Whole Candidate Score generated by the Academy in the admission process. Duckworth has "seen echoes of our West Point work" in different groups, such as National Spelling Bee contestants and new teachers at difficult schools. "Grit predicts success over and beyond talent (Perkins-Gough, 2013, p 14).

This study looks to link the development of resilience to the inquiry process. John Dewey, in *How We Think*, wrote on the concept of critical thinking and how inquiry plays a role in the development of our beliefs (Dewey, 1910). As students evaluate their conceptions of their world, it is an "act of inquiry to confirm or refute these beliefs" (p. 10). Dewey encouraged students to be skeptical about their beliefs and to evaluate them without bias. Inquiry, the act of asking questions to collect information, is a fundamental approach to challenging one's own belief systems and is vital to the development of academic understanding.

The BSCS 5E Instructional Model (or the 5E) was developed by Biological Science Curriculum Study (BSCS) which was charged in the 1960s to create a science curriculum that emphasized concept attainment over fact learning and investigations over lectures (History|BSCS, 2014). As it is a guided inquiry model, an understanding of this

learning cycle gives insight into its impact on the development of student learning capabilities. In the mid-1980s, BSCS developed the 5E model, which consisted of five phases: engagement, exploration, explanation, elaboration, and evaluation. The model made use of the works of Jean Piaget (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook & Landes, 2006), particularly the focus on cognitive science and the work on misconceptions. The 5E model is dynamic and interactive, using various techniques to allow students to interpret, redefine, and reorganize course content in ways to give it greater meaning to the student. *The BSCS 5E Instructional Model: Origins and Effectiveness* is a report prepared by BSCS for the Office of Science Education at the National Institutes of Health. This report summarized relatively recent research on science education, including sequencing of instruction and laboratory experiences, in order to facilitate student learning (Bybee, et.al, 2006). In order to develop support for the current instructional models, the report used a methodology that included information gathered by searching established databases; Internet search engines, and reviewing tables of content and citations in articles, journals, and summary chapters. Five research teams conducted the searches to provide a wide sweep of available information, and yet enough redundancy to catch details that may have been missed by one team or another. The findings of the report suggest positive trends for student mastery of science content and overall interest in science. The most significant finding is that there is a relationship between fidelity of use and student achievement (Bybee, et.al., 2007). Finally, the report also notes a significant void in the literature. That void is meaningful research with regard to the 5E Instructional Model's ability to help students understand the nature of

science, the complexity and ambiguity of empirical work, as well as practical and teamwork skills. This understanding of science, while not specifically used in the design lab course, is the underpinning of inquiry that drives the problem solving process.

In his 2005 article, *Playing the Game and Paying the Price: Academic Resilience among Three High-Achieving African-American Males* (Gayles, 2005), Jonathan Gayles labels resilience as an outcome for which he sought to identify meaningful aspects thereof. Academic resilience can be defined as an efficacious response in the presence of some academic risk. Ethnographic interviews were performed with three participants of a larger study. These students were identified as the highest achieving African-American males, based on grade point average, at the subject high school. Open ended questions were used to encourage the participants to offer personal interpretations and explanations to their realities (Gayles, 2005, p. 252). As the study progressed, questions were added based on key topics presented by the participants.

All three interviews showed two basic attitudes among the participants, diminished and distanced achievement and utilitarian achievement. All three boys diminished their academic achievement, regularly stating that grades "don't show how hard you worked" or "they have a good grade point average and they don't know nothing" (Gayles, 2005, p. 255). The participants were clear about the utilitarian value of their academic achievement, noting that this achievement had prospective meaning, but was not currently transformative for them.

The identification of attitudes surrounding resilience provides a context in which students place their academic achievement. While students in the project test group may

or may not have a similar context as the participants in the Gayle (2005) study, recognizing the students' context appears to be vital to developing resilience. This study proposes that the engagement phase of the design lab treatment can provide that context within the science classroom.

Parents' Perceptions of Their Child's Resilience and Competencies (Kärkkäinen, Räty, and Kasanen, 2009.) is a scholarly study that examined the parental views of 391 fifth-grade students with regards to their child's educability through their perceptions of their child's resilience. The authors balance the definitions of risk and achievement in how they approach the concept of resilience, particularly in their comparison of "at risk" students versus high achieving students, that are assumed to have high resilience. The aim of this study was to develop an empirical method for measuring parents' views of their child's resilience, and to examine the relationship between said views and their child's educational and psychological resilience. The authors examined how the parents' education levels and the child's gender affected the parents' perceptions.

The Kärkkäinen et al. (2009) study's methodology is part of a longitudinal study of fifth-grade children concerning parents' views of the child's schooling and educability. Of the 391 participants, 43% were academically educated and 57% were vocationally educated. The children were virtually of the same number based on gender. Mothers made up 64% of the respondents and the fathers made up the remaining 36% (Kärkkäinen, et.al, 2009). The respondents were presented a self-reporting survey with 25 agree/disagree statements built along their original 25-item Resilience Scale. Upon analysis, the data with regard to educational resilience shows that the following groups

perceive greater resilience in their children: academically educated parents over vocationally trained parents, mothers over fathers, and parents of girls over parents of boys (Kärkkäinen, et.al, 2009). The authors did however note certain limitations, however, there were no plans for a follow up study, and they could not assume that the parents' perception was static. The empirical scale for resilience is problematic, as it is quite subjective.

The Grit Scale was developed by Duckworth, along with Christopher Peterson, Michael Matthews, and Dennis Kelly, in *Grit: Perseverance and Passion for Long-Term Goals* (Duckworth, et.al., 2007) in a section of a three-part study research project testing the non-cognitive trait known as grit; identified as passion and perseverance for long term goals. The study team determined that grit may be as important to achievement as IQ or conscientiousness. To test this hypothesis, they needed to develop a brief, stand-alone measure of grit. This instrument must meet four criteria: show evidence of psychometric soundness, be valid for adolescents and adults in a variety of domains (not just school or work), have a low likelihood of ceiling effects in high achieving populations, and be a precise fit with the construct of grit (Duckworth, et.al., 2007). Because of the lack of pre-existing metric, the team developed what is now known as the Grit Scale, a questionnaire of 27 questions pertaining to the construct of grit. After running a trial including registered users of www.authentichappiness.org (n=1545), the scale was pared down to 12 items arranged in a 5-point scale with 1= "not at all like me" to 5= "very much like me" (Duckworth, et.al., 2007).

The next study of interest was the Duckworth et al. fourth study conducted at West Point Military Academy. The participants were 1218 of 1223 freshman cadets in 2004. Participants were sampled on the second and third days of the summer indoctrination period prior to beginning their freshman year. Separately, the team obtained the admission records of the students, including the Academy's Whole Candidate Score (WCS), which is used by the school to predict success of each student. At the end of the summer, the grit scores from the questionnaire and the WCSs were compared to the cadets' success in completing the summer program. The grit score was far more predictive to the success of each cadet's completion of the summer program, though the WCS was more predictive to the cadet's achieved grade point average and military service record. This study was of interest due to the similar length of time of the summer program to the proposed research period, showing that Grit Scale metric is appropriate for this period of time.

Finally, Duckworth's sixth study was of interest because of the age range of the participants. This study was centered on finalists of the 2005 Scripps National Spelling Bee. Of the 273 finalists, 175 volunteered, with parental consent, to complete a questionnaire during April and May, prior to the June competition. Once the competition was complete, the results were compared to grit, self-control, verbal IQ, and age. Grit predicted advancement to later rounds more reliably than IQ and self-control. As the research subjects were within the age range of the Scripps National Spelling Bee, this once again supported using the Grit Scale for this research project.

Tak-yan Lee's three stage study of longitudinal childhood resilience investigated the relationship between resilience-related beliefs and positive child development. (Lee, Kwong, Cheung, Ungar, & Cheung, 2010). The study involved 843 4th-grade students and their parents. During the first stage, parents responded to a 24-item inventory of adversities the students may have faced in their lifetime. In stages two and three, the parents were asked to complete a 25-item *Parental Assessment of Child's Habit.* During each stage, the children were asked to complete a 58-item, 9-item, or 11-item inventory of resilience inventory.

The findings consistently supported the hypothesis that a child's resilience contributes to the behavioral quality of life for that student (Lee, et. al., 2010, p. 448). The child's belief in his or her personal resilience fosters positive child development, and this seems important as it indicates the possibility that developing resilience in children can have a positive feedback effect with regard to their development. As students become more resilient, they develop in a positive direction, which in turn builds their confidence and their resilience. This contributes to a sub-question of concerning whether the placement of resilience education in a course design will transfer resilience to other curriculum areas.

James Catterall completed a data analysis extracted from the National Education Longitudinal Study of 1988 (Catterall, 1998). The study sample size was 24,588 eighth grade students of diverse backgrounds which yielded usable data on 20,706 in tenth, two years later. From the total pool of students in the sample, a subsample of 4,000 students indicated a lack of confidence in finishing high school as of eighth grade. The study also

identified another 7,000 students considered to be at risk due to reporting receiving

mostly C's or lower as English grades in sixth through eighth grade. The study focused

on how they were doing by the time they were surveyed during tenth grade (Catterall,

1998).

Catterall's study first goes on to discuss the definitions of the term risk and what

that means to an individual student. Catterall goes on to explain that while some

socioeconomic factors do increase student's "at risk" status, they are not always

predictive with regard to the student's resilience (Catterall, 1998, p. 323). It is not

appropriate to categorize individual students based on demographic categories. From

these definitions of risk, Catterall develops to approaches to resilience. First is

commitment resilience or grit as Duckworth (2007) would call it, which is a student's

commitment to finishing high school in the face of doubts of being able to do so in eighth

grade. The second form of resilience is academic resilience, measured by a student

reporting mostly C's or below in eighth grade but achieving at significantly higher levels

in tenth grade.

The area of commitment resilience is not of much interest for Perkiomen School,

as it is an independent college preparatory school where virtually all students are focused

on a college career. Catterall's (1998) conclusions about academic resilience, however,

do show relevance to Perkiomen's students, as he states "with mobility comes hope".

Catterall points out those students that scored low in eighth grade English were capable

of improving their grades by the end of tenth grade. From this, Catterall (1998)

encouraged educators not to apply labels, such as "at risk", as the data stated that "student mobility should reinforce more positive expectations for more students."

The value of the proceeding literature review was three-fold. First, articles such as Lee (2010) and Catterall (1998) were very helpful in that they provide encouragement with regard to the usefulness of resilience education. As Lee points out, building resilience in students leads to positive child development. Catterall's findings are that perseverance over time can lead to an increase in student achievement. Both Kärkkäinen and Duckworth provide methodologies that are appropriate to this action research project. Duckworth's Grit Scale is preferable to Kärkkäinen's metric, as it is more easily completed and has been used at many age levels, not just with students. Duckworth's work also gives support that using the Grit Scale over the proposed period of time is appropriate and gives valid results. Finally, direction has been provided by the Bybee's report on the effectiveness of the 5E model, and thus inquiry, and how it can be connected to resilience education.

METHODOLOGY

Treatment

The middle school design lab course served as the treatment for this research project. The lab's basic premise was to allow students to develop creative solutions to novel circumstances, and grading for this class was pass/fail and based on participation. The grading approach was to encourage the students to develop several creative solutions and to move the focus away from actual success of the project. The course meets twice weekly for 50 minutes each period. Students were assigned work groups and were

presented with a challenge. Outside of general guidance and encouragement to complete

tasks, the students developed their own strategies for completing their challenges

independently. Challenges in the past labs have included bridge building, erosion

control, boat design, and game design. The specific challenge during the research period

was game design. The game design project, thus the treatment as well, lasted 11 school

weeks between the dates of December 3, 2014 to February 26, 2015.

  The first step of the project was to play test commercial board games. While the

students were encouraged to have fun while playing, they were also given a set of criteria

by which to judge each game (Appendix A). These criteria were intended to guide

students toward understanding what features make a game entertaining and challenging.

The play testing phase lasted over eight class periods. Over the next eight class periods,

work groups of three to four students would design a board game to be presented to the

class. Other students would test play the new design, using the same criteria from the

first phase of the project. After each play testing, students were asked to reflect on the

process (Appendix B). This reflection was focused on process, rather than the specifics

of each game. Finally, the final version of the game was presented to the entire middle

school.

<div align="center">Instrumentation</div>

  The instrumentation was developed to allow for the triangulation of the project

data. Questionnaires and performance tasks both has limitations when applied to non-

cognitive abilities (Duckworth & Yeager, 2015, p. 239). Students and teachers may

misinterpret behaviors or lack insight into students' internal states, such as emotions or

motivation. Questionnaires may also engender reference biases in that students and teachers may use different frames of reference when making judgements. Performance tasks may also be misinterpreted by teachers as they are evaluated, as teachers may make inaccurate assumptions about the underlying reasons for the student behavior. Both types of instruments also exhibit some insensitivity. Questionnaires may not be sensitive to subtle changes over short periods of time. Performance tasks, particularly those that are being scored academically, may not reflect everyday behavior (Duckworth & Yeager, 2015, p239).

The primary instrument for this project is the 8-Question Grit Scale (Appendix C), which was developed to be an easy way to determine a respondents self-reporting level of grit (Duckworth, et. al., 2007). Duckworth and her team identified grit as passion and perseverance for long term goals. The Grit Scale is a short Likert Scale survey which focuses on the students' perceptions of their grit. It is designed to measure a student's self-perception of their ability to focus on long term projects and goals. Its ability to measure changes over time has not been thoroughly tested, but it is helpful in determining a student's self-evaluation of his or her own abilities.

Table 1
Research Matrix

Research Question	Instrument 1	Instrument 2	Instrument 3
Main Question: How does an inquiry-based design lab course impact the resilience learning of middle school students?	Grit Scale Student self-reporting on the 8 question Grit Scale Likert test.	Group and Individual Interviews	Student Product: Game design written reflection
Sub-Question: How does the resilience learning of boarding students differ from day students?	Grit Scale Student self-reporting on the 8 question Grit Scale Likert test	Modified Grit Scale A modified version of the Grit Scale completed by other curriculum teachers	Student Product: Game design written reflection
Sub-Question: How do teachers in other curriculum areas view the resilience learning of the students?	Modified Grit Scale A modified version of the Grit Scale completed by other curriculum teachers		

Because of this feature, it will be ideal in answering the main research question (Table 1.)

"*How does an inquiry-based design lab course impact the resilience learning of middle*

school students?", as well as the sub-question, : *How does the resilience learning of*

boarding students differ from day students? In order to measure the impact of the inquiry

designed lab, the Grit Scale was administered at the beginning of the treatment program,

and at the end. This gave an overall measure of how much student' self-perceived

resilience changed over time. As the main data instrument, it was administered to all the

program participants.

Once the treatment drew to its end, a modified version of the Grit Scale (Appendix D) was presented to the traditional curriculum teachers of the middle school students. This allowed teachers of each student to evaluate the resilience of each student in such a way to minimize reporting bias in the students' self-reporting on their own Grit Scales. The Grit Scale was also modified to by including third person pronoun in the place of first person.

In addition to the Grit Scale, the student reflection assignments were also collected in order to begin to develop their own narrative of the game design process, without focusing on the actual game mechanics. This allowed for the creation of a story concerning how each student progressed through the treatment, and developed their perceived themes and concepts about their resilience. The reflection assignments then informed the interview process. While a basic outline of interview questions was prepared prior to the treatment (Appendix E), the reflection assignments were used to develop additional probing questions for both group and individual interviews.

The research methodology for this project received an exemption by Montana State University's Institutional Review Board (Appendix F) and compliance for working with human subjects was maintained.

DATA AND ANALYSIS

The Perkiomen School in Pennsburg, Pennsylvania instituted an inquiry-based lab design course within the middle school program. This course is designed to give the students the opportunity to fail at a given task, and then re-think their projects in order to achieve success. This process of iterate, fail, iterate again is focused on developing the

students non-cognitive characteristic of resilience. The students self-reported their

resilience using the 8-Question Grit Scale (Duckworth, et. al., 2007), which was

triangulated with a modified Grit Scale completed by the middle school teacher. The

students reflected on the process using a written evaluation of their progress through the

treatment period. Lastly, the students and teachers participated in interviews to gain

greater insight into the course of treatment.

Table 2
Population Demographics (N=54)

Grade	M	F	Day	Boarding
Eighth	16	14	17	13
Seventh	7	5	12	0
Sixth	8	4	9	3
Total	31	23	38	16

The student population (Table 2.) is made up of a total of 54 students, 31 males

and 23 females. Included in the population is a boarding subset. Perkiomen School has a

significant boarding population, including international students. Because these students

partake in a different academic program, it is interesting to see how they differ from the

more traditional day student model. The program at the Perkiomen School is considered

college preparatory, even at the middle school level. Students are internally and

externally motivated to apply and attend college at various levels of rigor. In addition to

the design lab course, students participate in an integrated science course in the sixth

grade, a life science course in the seventh grade, and a physical science course in the

eighth grade. Finally, as an independent school, the Perkiomen School, with an annual

tuition of $29,950 for middle school day students and $52,500 for all boarding students,

does support a student population of various income levels. While some students do

receive financial aid, there are students that come to the school from substantial

affluence.
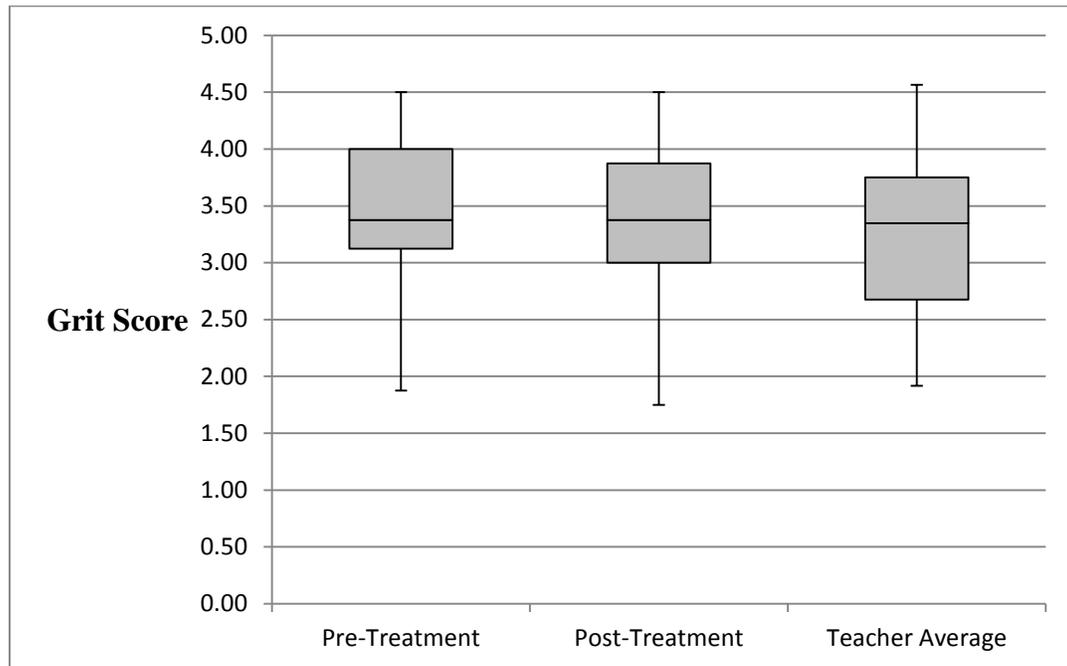
Figure 1. Range and means of student and teacher reported grit scores for study
participants, (*N*=54).

The pre-treatment student grit scores (Fig. 1) ranged between 1.88 and 4.50 with a mean

of 3.44, while the post-treatment survey showed a range of 1.75 to 4.50 with a mean of

3.38. The teacher-completed surveys regarding how they perceived each student's grit

showed a similar range, 1.92 to 4.56 with a mean of 3.25. On the whole, each

measurement showed the class to be somewhat gritty, but Grit Scores tended to decrease

slightly (Table 3).

Table 3

Comparisons of Grit Score Means between Day and Boarding Student Populations Subgroups (N=54)

Group	Pre-Treatment	Post-Treatment	Difference
Total	3.44	3.38	-0.06
Day	3.62	3.59	-0.03
Boarding	3.02	2.89	-0.13

The mean post-treatment survey showed a decrease by 0.06 from the pre-treatment survey (Table 3.). The day student population showed a drop of 0.03 over the course of the treatment, while the boarding population showed a mean drop in grit score of 0.13. The F-tests performed on the three relationships in question (Appendix H) showed little variance in the relationship between the pre-treatment and post-treatment student surveys while the relationship between the values in the other two, Boarding vs Day and Post-treatment vs Teacher Average, showed significant variance among groups (Appendix H). This impacted the choice of t-tests used for each analysis. The t-tests themselves showed that there was very little difference between the results of each of the three comparisons. The original prediction was that the design lab
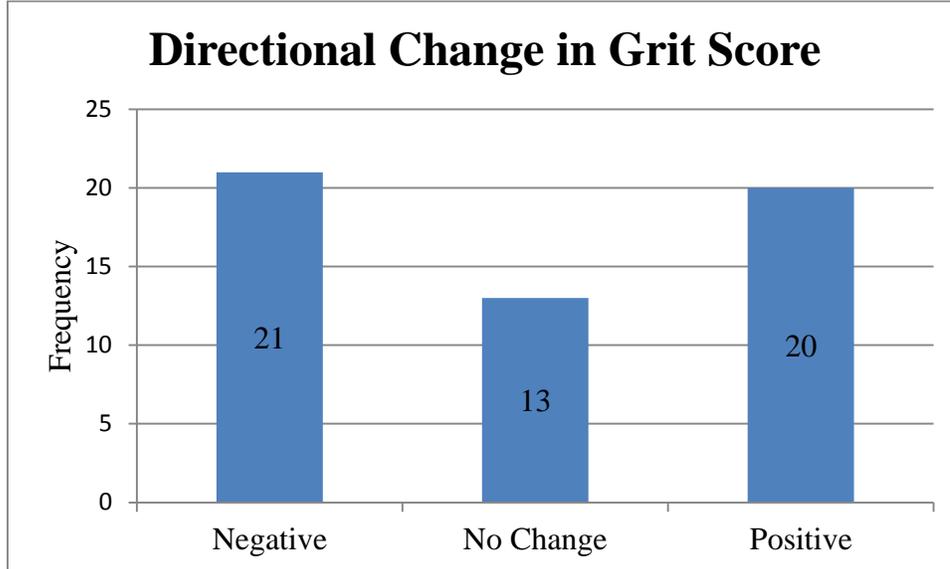
Figure 2. Directional change in grit score, (*N*=54).

course would increase the students' overall grit score, and while 20 (37% of the 54 total) students did show an increase, the majority of students (63%) showed either a decline or no change in their grit score (Fig 2.). When using a t-test (assuming common variance among the groups), the null hypothesis of no change in student reported grit scores was supported ($\pm$ t Critical, -1.659<0.512<1.659). The results from t-tests examining differences between Day vs. Boarding students Post-treatment Grit scores and Teacher Average scores also failed to reject the null hypothesis of no difference between values, with a -1.683<-1.290<1.683 and -1.661<1.060<1.661, respectively. However, the results do suggest that boarding students showed a relatively higher drop in Grit score during the post-test (Table 3, and Fig. 3)

Across all students, the students scoring the highest individual grit scores were a diverse group. For example, some were the highest performing students in their grade, while others were the lowest. It is possible that both groups have developed resilience

skills for different reasons. Two of the highest performing students that were interviewed

expressed their confidence to face challenges was buoyed by their grade scores. The

lowest performing student interviewed stated that he was "used (sic) to not doing good"

and this familiarity with challenges made him capable of dealing with them. On the other

hand, the student with the lowest grit score in all three surveys is an interesting case. She

is considered to be very bright by her teachers, but she is often delinquent or incomplete

with her work, however she is quite forth coming about her deficiencies and almost

seems to take pride in them.
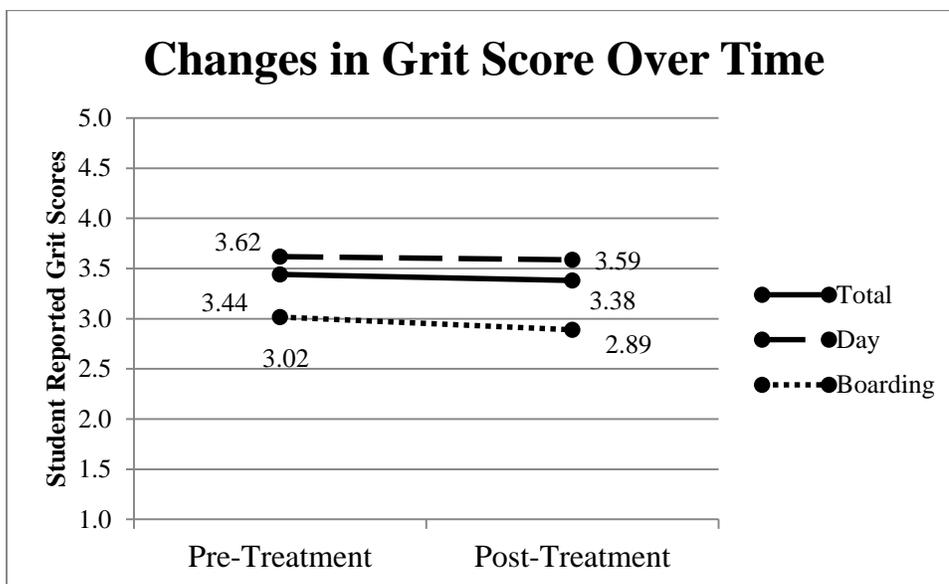
Figure. 3. Difference between pre- and post-treatment grit scores by study group, (*N*=54).

When analyzing the changes in means visually (Fig. 2), it became evident that

both the pre- and post-treatment values for each study group are centrally located at or

near the 3.0 score. The slope of each line is also rather flat, showing little change. It is

possible that the duration of the treatment may not have been long enough to recognize

any benefit in resilience among the students. Also, the benefits of any resilience learning

may have happened prior to the treatment, as the treatment did not coincide with the start of the course.

Group interviews began to shed light on the observed lack of change pre/post treatment during the resilience analysis. When asked about strategies employed to persevere through encountered challenges, the student responses always circled back to group dynamics. Interview group 1 was of particular interest, as they changed their project part way through the process. When asked why they changed their overall game design, their unanimous response was that they could not agree on the direction of the game. They did not overcome design challenges they were facing, so they "quit before they got angry at each other." In addition, all four interview groups referred back to team selection, collaboration skills, and consensus building as either their strengths in the project or their weakness.

The individual student reflection pieces also alluded to social themes affecting students, for example those that indicated difficult progress throughout the process noted the need to improve group communication, improve overall teamwork, and the need to develop clear goals for the group. Conversely, those students that reported a smooth game design process commented on overall cooperation and group harmony. When asked about what recommendations they thought other groups might find helpful, patience with teammates and an overall commitment completing the project were among the more common responses.

Individual interviews did begin to show some differences within the student population. Day students, who are United States citizens, described a distinctly different

experience in previous schooling than did the boarding students, who were primarily international students. The international students described educational systems that were much more regimented and less flexible than reported by the day students. One boy, an eighth grade student from Mexico, commented that if he met challenges he would keep trying until he was successful. An eighth grade Chinese boy also echoed this attitude and described a highly regimented educational experience. Two United States citizen girls, one in eighth grade and the other in seventh, both reported similar experiences which encouraged them to ask for help. While these two approaches are quite dissimilar, both serve improve the overall resilience of students. The regimented approach could very well impart an attitude of persistence in the students and perhaps ownership and obligation. The flexible approach can teach students how to evaluate limitations and to seek assistance when necessary.

The teacher reported grit score was used during part of the data triangulation in an attempt to alleviate any reporting bias by the students. While the overall teacher score was slightly lower that the post-treatment score reported by the students (Appendix G), this difference was not statistically significant. The range of difference between the student scores and teacher scores was -1.29 to 1.29. This gives the impression that while on the average there was little difference between the student and teacher reported scores, on an individual basis there were some rather important differences between how students view their resilience compared to their teacher's views.

INTERPRETATION AND CONCLUSION

The students in the Perkiomen School middle school participated in an inquiry based design lab course in order to give them an experience of iterative problem solving, allowing them to develop personal resilience skills. Throughout the course, students were assigned practical problems and projects that required planning, investigation, and multiple attempts in order to attain success. The course was designed as pass/fail to reward attempted solutions rather than only positive outcomes. The assigned project during the study was the creation of a board game.

The overall success of the treatment during the study was inconclusive, although some potential trends were observed. The overall student grit score dropped by a score of 0.06. The day student subgroup showed a decrease in grit score over the study of 0.03 and the boarding student subgroup showed a relatively larger decrease of 0.13. However, results of an F-test among these groups indicated the changes were not significant. The student post-treatment scores were compared to teacher reported scores in order to eliminate errors due to reporting bias from the students. The student reported mean of 3.38 was only 0.13 higher than the teacher reported mean and an F-test also found this difference to be insignificant.

When looking at the teacher reported grit scores, there were two approaches that could be utilized. When looking at the means of the student reported and teacher reported scores, there was little statistical difference between these numbers. However, there was a wide range of difference between these scores on an individual basis. It is possible that both students and faculty need to have a greater understanding of just what

resilience is and how to describe it as a trait, and how to evaluate resilience. If students and faculty perceive this non-cognitive skill differently, then reporting errors may become evident.

The difference between the day student and boarding student populations was not statistically significant, but it was noticeable, suggesting the presence of a trend. During student interviews, the predominantly international boarding students described a distinctly different learning experience than that of the United States citizen day students. The more regimented classroom model the international students experienced may have imparted a more fixed common mindset among the students, making them less likely to ask for help. In fact, during interviews, more than one international student stated that the desire to attend a school that allowed them to ask questions was paramount in their decision to leave home to attend school.

Reflective discussions with the primary design lab instructors have led to a productive analysis of the course. While the study's statistical analysis did show a small, but statistically insignificant, drop in the mean student grit score, 33 of the 54 study participants (61%) showed either no change or a positive change over the period of the treatment. The short time span over which the treatment took place might not have been long enough to ingrain new resilience scores in some of the students. With a major goal of the course being the development of these resilience skills, it would be prudent to continue surveying the students over multiple years to gauge how well the course is meeting this objective.

VALUE

In his article, *An Education President for the 21st Century,* Patrick Bassett (2008) identifies resilience as one of the components of the non-cognitive skills that make up character. He goes on to stress that these skills are essential for leadership and success in one's family, community, and the marketplace in the 21st century (Bassett, 2008). It is incumbent upon teachers to provide opportunities for students to develop and practice resilience skills in the classroom, where students can safely challenge themselves while be supported by the classroom environment should they fail. The Perkiomen Middle School design lab course provides one such experience. Students are challenged to create novel solutions for engaging scenarios and they are encouraged to risk being wrong when testing their plans and strategies.

The findings of this study are encouraging, even though the mean grit score of most participants remained relatively unchanged, a majority of students did not show a negative change. While the idea of iteration and failure was always present in each activity, the students appeared to focus more on group dynamics when evaluating their progress. This leads to several interesting questions when planning future iterations of this course. Would the students benefit from a larger workspace which would allow for small workgroups and more independence? Would the course benefit from more time in the weekly class schedule, offering the students more opportunity to test their strategies? Lastly, given the relatively short time frame of the treatment period, would longer term surveying of the students validate the long term benefits of such a course? These are

important questions to be considered when developing the next experience for the middle school students.

Upon reflection, three future changes in the study are recommended. First, the overall time frame may have been too short. By moving the initial phase to the beginning of the school year, the benefits to resilience learning might be more evident. Second, it may be necessary to have the students and the faculty be better informed with regard to the definitions that pertain to resilience, thus creating a clear understanding of the measurement. A greater understanding by both parties may alleviate the wide range of differences in the individual scores. Finally, as the returning sixth and seventh grade students will be once again taking the design lab course, it will be interesting to see how their resilience learning differs from those students that are taking the course for the first time.

<u>Personal Impact</u>

Throughout the entire length of this project three things have become evident to me. First, I have gained a great appreciation for those that do this kind of work on more professional level. It is ironic for me to find that completing this project required a significant amount of grit and resilience on my part. There have been obstacles of many kinds before me, and yet this project has come to fruition. The development of a research project has given me much to think about with regard to pursuing more research. Second, the process has shown me that as educators we do not always know just exactly how our lessons will be perceived. While the stated goal was for students to reach a goal, fail or encounter obstacles, and reiterate the creative process; it became apparent in both

the reflection pieces and the interviews that the students were more focused on the collaborative process. As an educator, it is vital that I communicate clearly with my students about all the lessons they should be learning. While the inquiry process does not necessarily provide the map, students should know what the goal of each lesson is. Finally, I am very proud of my institution, the Perkiomen School, for implementing such a course as the design lab. The non-cognitive skills, such as resilience, are a vital part of the educational process and investing in such a course is a tribute to forward thinking educators.

Moving forward, I am personally intrigued by the results given by the boarding population. I am curious about how the English proficiency of each student impacted the Grit score of each student. Did a low proficiency contribute to a lack of understanding when self-reporting or did it prevent teachers from properly assessing a student's resilience by misinterpreting certain behaviors? I would like to work with our English as a Second Language department in order to look for a link between English proficiency and resilience in English language learners.

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APPENDICES

APPENDIX A

BOARD GAME ANAYLS SHEET

Aesthetics – Does the game have a "cool" look and feel? Do the colors, pictures, designs, themes, etc. stand out and enhance the enjoyment of the game?	
Strategy – What is the object of the game? What elements of playing the game involve skill?	
Chance – What elements of the game are controlled by chance? How are the probabilities determined?	
Rules – Are the rules clear? Are they complex or simple? Is there anything about the rules that is particularly difficult to grasp?	
Gameplay – How smoothly does the game flow from turn to turn? Are the other players involved in some way when it isn't their turn?	
What elements of playing the game are enjoyable, and why?	
What elements of playing the game are boring, and why?	
Overall Rating	1　　2　　3　　4　　5　　6　　7　　8　　9　　10

APPENDIX B

GAME DESIGN REFLECTION ASSIGNMENT

1. At what stage are you in the game design process?

    a. How long did it take you to reach this point?

    b. Has your progress been smooth or difficult? Explain why you feel this way?

2. What have you learned about the design process? How will this make your future progress easier?

3. What are the obstacles you predict for your continued progress?

4. What tips would you give other groups about designing a game like yours?

APPENDIX C

THE 8-QUESTION GRIT SCALE

Directions for taking the Grit Scale: Please respond to the following 8 items. Be honest – there are no right or wrong answers! **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

1. New ideas and projects sometimes distract me from previous ones.

   o   Very much like me

   o   Mostly like me

   o   Somewhat like me

   o   Not much like me

   o   Not like me at all

2. Setbacks (delays and obstacles) don't discourage me. I bounce back from disappointments faster than most people.

   o   Very much like me

   o   Mostly like me

   o   Somewhat like me

   o   Not much like me

   o   Not like me at all

3. I have been obsessed with a certain idea or project for a short time but later lost interest.

   o   Very much like me

   o   Mostly like me

   o   Somewhat like me

   o   Not much like me

   o   Not like me at all

4. I am a hard worker.

   o   Very much like me

   o   Mostly like me

   o   Somewhat like me

   o   Not much like me

o   Not like me at all

5. I often set a goal but later choose to pursue (follow) a different one.

o   Very much like me
o   Mostly like me
o   Somewhat like me
o   Not much like me
o   Not like me at all

6. I have difficulty maintaining (keeping) my focus on projects that take more than a few months to complete.

o   Very much like me
o   Mostly like me
o   Somewhat like me
o   Not much like me
o   Not like me at all

7. I finish whatever I begin.

o   Very much like me
o   Mostly like me
o   Somewhat like me
o   Not much like me
o   Not like me at all

8. I am diligent (hard working and careful).

o   Very much like me
o   Mostly like me
o   Somewhat like me
o   Not much like me
o   Not like me at all

APPENDIX D

MODIFIED 8-QUESTION GRIT SCALE

Directions for completing the Modified Grit Scale: Please respond to the following 8 items. Be honest – there are no right or wrong answers!

Student Name: _____

9. New ideas and projects sometimes distract the student from previous ones.

   o Very much like the student

   o Mostly like the student

   o Somewhat like the student

   o Not much like the student

   o Not like the student at all

10. Setbacks (delays and obstacles) don't discourage the student. The student bounces back from disappointments faster than most people.

    o Very much like the student

    o Mostly like the student

    o Somewhat like the student

    o Not much like the student

    o Not like the student at all

11. The student has been obsessed with a certain idea or project for a short time but later lost interest.

    o Very much like the student

    o Mostly like the student

    o Somewhat like the student

    o Not much like the student

    o Not like the student at all

12. The student is a hard worker.

    o Very much like the student

    o Mostly like the student

    o Somewhat like the student

    o Not much like the student

    o Not like the student at all

13. The student often sets a goal but later choose to pursue (follow) a different one.

   o   Very much like the student

   o   Mostly like the student

   o   Somewhat like the student

   o   Not much like the student

   o   Not like the student at all

14. The student has difficulty maintaining (keeping) focus on projects that take more than a few months to complete.

   o   Very much like the student

   o   Mostly like the student

   o   Somewhat like the student

   o   Not much like the student

   o   Not like the student at all

15. The student finishes whatever he or she begins.

   o   Very much like the student

   o   Mostly like the student

   o   Somewhat like the student

   o   Not much like the student

   o   Not like the student at all

16. The student is diligent (hard working and careful).

   o   Very much like the student

   o   Mostly like the student

   o   Somewhat like the student

   o   Not much like the student

   o   Not like the student at all

APPENDIX E

INTERVIEW QUESTIONS

"What can you tell me about school and your past experiences?" Was school hard or easy, and why do you think that?

Describe what you feel is the hardest part of science class.

1. Why is this area the hardest part for you?
2. What do you do to make it easier?
3. Where did you learn to do that?

When faced with difficult questions, what ways do you use to solve them?

1. Do you ask for help and from whom?
2. Can you give me an example of a difficult question you might have had?
3. When you have a difficult question, what makes you decide when to give up and ask for that help?
4. What makes you decide a question is difficult?

What kind of preparation do you feel is important for answering difficult questions?

1. Which one of your classes asks you the most challenging questions? Can you give me an example?

What could a teacher do if they wanted to help students with difficult questions?

1. Why do you think that might work?

APPENDIX F

INSTITUTIONAL REVIEW BOARD EXEMPTION

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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M E M O R A N D U M

TO: Tim Klavon and Walt Woolbaugh

FROM: Mark Quinn, Chair *Mark Quinn CY*

DATE: December 11, 2014

RE: *"Iteration and Failure: How Does an Inquiry-based Design Lab Course Impact the Resilience Learning of Middle School Students?"* [TK121114-EX]

The above research, described in your submission of December 11, 2014, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

__X__   (b) (1)   Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

__X__   (b) (2)   Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

_____   (b) (3)   Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

_____   (b) (4)   Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

_____   (b) (5)   Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

_____   (b) (6)   Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX G

STUDENT DATA

Student Grit Scores by Category (N=54)

Student #	Grade	Boarding /Day	Pre- Treatment	Post- Treatment	Difference	Teacher Average	Diff P-T
106	8	D	1.88	1.75	-0.13	1.92	-0.17
109	8	D	3.88	4.13	0.25	3.41	0.72
110	8	D	2.50	2.50	0.00	2.71	-0.21
130	6	D	3.63	3.13	-0.50	3.88	-0.75
135	7	D	4.00	4.25	0.25	3.75	0.50
139	7	D	4.25	3.38	-0.88	2.42	0.96
140	8	B	4.38	3.88	-0.50	*	
149	7	D	3.00	2.88	-0.13	3.75	-0.88
165	8	D	2.38	2.63	0.25	3.92	-1.29
186	6	D	4.25	4.25	0.00	3.25	1.00
189	7	D	3.13	3.50	0.38	3.17	0.33
190	8	B	3.13	3.00	-0.13	3.53	-0.53
195	8	D	3.38	3.38	0.00	2.31	1.06
199	8	B	2.63	2.63	0.00	2.67	-0.04
211	8	D	2.50	2.75	0.25	2.67	0.08
212	6	B	4.00	3.50	-0.50	3.19	0.31
215	6	D	3.88	4.13	0.25	3.13	1.00
216	8	B	2.63	2.50	-0.13	2.54	-0.04
223	8	D	3.75	3.50	-0.25	3.75	-0.25
230	7	D	4.38	3.88	-0.50	3.54	0.33
249	6	D	3.63	3.63	0.00	3.63	0.00
260	6	D	4.25	4.25	0.00	3.50	0.75
262	8	D	3.25	3.50	0.25	2.59	0.91
268	6	B	3.00	2.75	-0.25	2.25	0.50
274	8	B	3.38	3.38	0.00	3.50	-0.13
280	8	B	3.38	3.88	0.50	*	
281	8	D	4.00	3.25	-0.75	3.97	-0.72
298	8	B	3.13	3.13	0.00	3.75	-0.63
305	7	D	3.50	4.00	0.50	3.58	0.42
306	7	D	2.38	2.38	0.00	2.45	-0.08
309	7	D	3.38	2.75	-0.63	2.00	0.75
320	7	D	3.38	3.38	0.00	2.71	0.67
323	8	B	2.50	3.00	0.50	3.50	-0.50
325	6	D	4.25	4.50	0.25	4.56	-0.06
338	8	D	2.63	2.50	-0.13	3.42	-0.92
346	6	D	3.75	3.50	-0.25	4.19	-0.69
378	8	B	4.13	3.25	-0.88	2.21	1.04
391	8	B	2.75	3.00	0.25	2.67	0.33
395	8	D	3.88	4.00	0.13	2.91	1.09
395	8	D	3.13	3.13	0.00	2.54	0.58
405	8	D	3.75	3.25	-0.50	4.29	-1.04
416	7	D	4.50	4.25	-0.25	2.96	1.29
417	8	B	3.25	3.50	0.25	*	
422	6	D	4.13	4.38	0.25	3.81	0.56
423	7	D	3.38	3.00	-0.38	3.71	-0.71
428	6	B	4.00	4.00	0.00	3.44	0.56
443	8	B	2.75	3.25	0.50	*	
444	8	D	4.00	4.13	0.13	4.53	-0.41
459	8	D	3.75	3.13	-0.63	3.17	-0.04
477	6	D	4.13	3.63	-0.50	4.19	-0.56
482	7	D	3.25	3.25	0.00	2.75	0.50
497	8	B	3.13	3.25	0.13	2.70	0.55
555	8	D	3.13	3.25	0.13	4.17	-0.92
798	8	D	3.50	3.63	0.13	3.29	0.34
		Mean	3.44	3.38	-0.06	3.25	0.11

* Teacher score not given

Diff P-T is the difference between the Post-Treatment Grit Score and the Teacher Average Grit Score

APPENDIX H

STATISTICAL ANALYSIS OF GRIT SCORE DATA

T-tests between study groups (a. Student self-reporting pre- vs. post-treatment b. Student self-reporting Day vs. Boarding students c. Student self-reporting post-treatment vs. teacher reported grit scores) (n=54)

a.

	Pre-Treatment	*Post-Treatment*
Mean	3.440	3.380
Variance	0.395	0.351
Observations	54	54
Pooled Variance	0.373	
Hypothesized Mean Difference	0	
df	106	
t Stat	0.512	
P(T<=t) one-tail	0.305	
t Critical one-tail	1.659	
P(T<=t) two-tail	0.610	
t Critical two-tail	1.983	

b.

	Boarding Student	*Day Students*
Mean	3.242	3.438
Variance	0.193	0.414
Observations	16	38
Hypothesized Mean Difference	0	
df	41	
t Stat	-1.290	
P(T<=t) one-tail	0.102	
t Critical one-tail	1.683	
P(T<=t) two-tail	0.204	
t Critical two-tail	2.020	

T-tests between study groups (a. Student self-reporting pre- vs. post-treatment b. Student self-reporting Day vs. Boarding students c. Student self-reporting post-treatment vs. teacher reported grit scores) (n=54) (Continued)

c.

	Post-Treatment	Teacher Average
Mean	3.380	3.248
Variance	0.351	0.451
Observations	54	50
Hypothesized Mean Difference	0	
df	98	
t Stat	1.060	
P(T<=t) one-tail	0.146	
t Critical one-tail	1.661	
P(T<=t) two-tail	0.292	
t Critical two-tail	1.984	

F-test for Variance Among the Groups (a. Student self-reporting pre- vs. post-treatment
b. Student self-reporting Day vs. Boarding students c. Student self-reporting post-
treatment vs. teacher reported grit scores) (n=54)

a.

	Pre-Treatment	Post-Treatment
Mean	3.440	3.380
Variance	0.395	0.351
Observations	54	54
df	53	53
F	1.124	
P(F<=f) one-tail	0.336	
F Critical one-tail	1.578	

b.

	Boarding	Day
Mean	3.242	3.438
Variance	0.193	0.414
Observations	16	38
df	15	37
F	0.466	
P(F<=f) one-tail	0.057	
F Critical one-tail	0.452	

c.

	Post-Treatment	Teacher Average
Mean	3.380	3.248
Variance	0.351	0.451
Observations	54	50
df	53	49
F	0.779	
P(F<=f) one-tail	0.187	
F Critical one-tail	0.629	