SCIENCE NOTEBOOKS AND CONNECTIONS TO STUDENT SELF-EFFICACY

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Learning is a process of growth and development. Much recent research, led by Carol Dweck, connects the neuroplasticity of the brain to the learning process. Students that approach learning with an incremental mindset are able to effectively take risks and learn from mistakes as they construct knowledge and cultivate neural growth. There are many strategies that elementary educators can use to incorporate incremental mindset as they generate positive attitudes and encourage development in the classroom. One fundamental component that will enhance students' approach to learning is positive self-efficacy. By building students' belief in their ability to perform in the academic environment, teachers can increase academic success and create classrooms where scholastic risk-taking and advancement are the norm. Science notebooks are a specific tool that can be used to develop students' scientific and observational skills. The following research determined the relationship between science notebook entries and observations, students' self-efficacy levels, and academic success as measured by a unit assessment. Results showed no significant correlation between variables. However, disaggregation of data sets provided meaningful information and allowed for improvement in teaching strategies for specific students and for the class as a whole.

I chose to research the effect of science notebooks on students' self-efficacy for two reasons. First, I know that I will be implementing a variety of strategies to cultivate incremental mindset in my classroom. A number of studies highlighted in this paper reveal the importance of understanding brain plasticity and attitudes of growth. Incremental mindset will be a central component of my classroom environment, and I wanted to learn more about the effectiveness of a specific tool (the science notebook) in developing aspects of incremental mindset. I chose to narrow the research's focus to self-efficacy because of its impact on students' attitudes and approaches to learning. My interactions with students center on affective components of the learning process (feelings, motivation, and enjoyment of learning) and I believe that positive self-efficacy will directly influence increased academic performance. Furthermore, it is the foundation for a lifelong relationship with learning. Students with positive self-efficacy develop belief in their ability to progress and grow, motivating them and leading directly to an increase in incremental mindset. Second, I chose to center the study on science notebooks because of the variety of elements that they add to the learning process. Science notebooks allow for individual observation, creativity, and reflection. They encourage students to make connections and find meaning in their activity. They turn already engaging scientific experiments into opportunities for building literacy. I wanted to find out if they could also directly influence the development of self-efficacy.

The research in this study is important to me because of my investment in developing incremental mindset and using science notebooks in my teaching practice. I believe in the benefits that come from an attitude of growth, and will strive to build that attitude in my students. I am also very invested in improving my teaching practice. As a novice teacher, I am constantly testing and improving tools and strategies in the classroom. By conducting this

research, I was able to obtain qualitative data regarding the effectiveness of the science notebook as an instrument for my students. Also, I wanted to gain more specific insights into the learning process for individual students in my class. This research provided opportunities to get feedback directly from the students. Furthermore, this study is important for other teachers as the possibilities for implementing incremental mindset continue to expand. Based on findings by Carol Dweck and other researchers, it is imperative for all teachers to address their students' attitudes. By creating mindsets of growth and true engagement with the process of learning, teachers can help build a love of learning that will last beyond grade school. This research documents the connections between science notebooks and incremental mindset, providing information about one possibility for creating positive connections to learning in the classroom.

The first part of this paper is a literature review centered on growth mindset. It begins on page 5 and is entitled "Internal and External Influences on Incremental Mindset." The second part of the paper contains the study itself. It begins on page 23 and is entitled "Science Notebooks and Connections to Student Self-efficacy."

Internal and External Influences on Incremental Mindset

Within the classroom, instruction that best facilitates learning must focus on many aspects of each student's learning process. Successful teaching conveys content and assesses understanding while also addressing students' attitudes, emotions, and interpretations of learning. Effective teachers focus instruction on the learning preferences of each student while simultaneously creating personal connections between the content and the learner. Teachers have the ability to further impact students' academic achievement by addressing mindset. Mindset refers to the established attitude and belief system that shapes each person's approach to behavior and decision-making. By understanding and addressing the factors that influence students' learning mindset, teachers can direct student attitude, connection with the learning process, and academic achievement.

Many studies have explored mindset and its effect on learning (Erdley, Cain, Loomis, Dumas-Hines, & Dweck, 1997; Robins & Pals, 2002; Molden & Dweck, 2006; Blackwell, Trzesniewski, & Dweck, 2007; Yeager & Dweck, 2012; Paunesku, Walton, Romero, Smith, Yeager, & Dweck, 2015). Incremental mindset is defined as a growth-based approach to learning, challenges, and development. The concept of incremental mindset incorporates an understanding of the brain's potential to grow and change. Brain research shows that humans have the intellectual ability to develop as they experiment, make mistakes, and learn from experiences (Willis, 2010). Appreciating the potential for brain malleability and incorporating incremental mindset can contribute to increased academic performance and heightened resiliency in response to adversity. In the classroom, teachers are able guide students as they develop the resources that create incremental mindset. This paper will investigate the concept of incremental

mindset and the internal and external factors that enable growth-based teaching strategies to promote student academic success.

Incremental Mindset

Academic achievement and resiliency are directly dependent upon mindset. In the educational environment, mindset affects students' approach, attitude, and reaction to learning challenges. Mindsets guide individual thought processes and provide structure as students make decisions and employ knowledge in new situations. Dweck (2006) has identified and analyzed two contrasting approaches to learning: incremental mindset and entity mindset. Both approaches reflect personal interpretations of learning and perceptions of success as academic challenges are addressed. Incremental or growth-oriented mindsets perceive intellectual capabilities as malleable and dynamic. Students who approach learning as a changeable growth process are motivated by mistakes and challenges. In contrast, students with fixed mindsets view academic abilities as set and unchanging, and interpret poor performance as a reflection of low intelligence. Incremental mindsets create successful learning by producing positive learning habits. The following key components significantly benefit incremental thinkers.

Self-evaluation

Self-evaluation is the practice of consistently assessing personal behavior to improve performance in new situations. Students with an incremental mindset consistently focus on learning and growth through self-evaluation. Every event that occurs is an opportunity for development and provides feedback to learners as they construct knowledge (Yeager & Dweck, 2012). Students constantly learn and develop strategies for success by observing and improvising. Self-evaluation occurs throughout the learning process and allows students to assess their actions to determine continued behavior. Moreover, students with incremental mindsets

utilize a consistent belief in the progression of learning to maintain positive, focused attitudes as they self-evaluate. Chen and Siegler have described learners' strategy evaluation process as the Overlapping Waves Theory (2000). They state that strategic change through self-evaluation leads to increasing successful application and execution of new strategies. Just as a variety of ocean waves interact, overlap, and overtake one another, students' strategy development is constantly in flux as different approaches are tested, used, or discarded according to their success. The ability to constantly learn, adapt, and experiment enables growth and development. Self-evaluation provides the necessary reflection, assessment, and motivation to initiate progression. Incremental mindset creates the positive attitude that allows self-evaluation to be effective.

Approach to Challenge

Personal interpretation of success and failure is another key element of mindset. Students with incremental mindsets have a more positive and successful approach to challenges and adversity than students with entity mindsets. Research by Robins and Pals (2002) examined how incremental and entity thinkers responded differently to academic success and failure in real-world contexts. Their study analyzed information collected from students during a transition period between high school and college. It tested cognitive, affective, and behavioral results of incremental and entity thinking as students encountered academic challenges in their first year of college. Student self-evaluations measured incremental and entity mindsets, and the researchers rated academic achievement in relation to high school GPA and SAT results. Throughout the subjects' first year of college, they completed question-based self-assessments on academic experiences. Students evaluated themselves for attributes of goal orientation, academic achievement, affective responses, behavioral responses, and self-esteem changes. Students with incremental mindsets demonstrated the development of learning goals, increased effort in the

face of challenges, positive affective and behavioral responses, and increased self-esteem (all *p* values < .05). In contrast, students with fixed mindsets relied on performance assessment, lacked confidence in their abilities, and suffered from negative emotional states (all *p* values < .05) (see Figure 1). Instead of placing blame and having a negative attitude towards failure, incremental mindsets motivate individuals when they encounter adversity. Robins' and Pals' research shows that academic resiliency enables students to focus, work harder, make better learning connections, and develop intellectual abilities.

Affective Response

Academic performance is also strongly affected by the emotional condition of the learner (Willis, 2010). Emotional responses are closely tied to mindset. Affective reactions reflect positive or negative mindset and lead directly to growth-based or fixed responses in learners. Specifically, Robins and Pals' research supports the claim that students with fixed mindsets suffered academically due to lack of self-esteem in academic achievement. When these students did well, they equated their performance emotionally with luck or less rigorous challenge. When they failed, they placed blame on what they saw as poor personal intelligence. In contrast, students with incremental mindsets maintained or increased their self-esteem by attributing success with effort ($p < .05$). Success was seen as positive achievement, and failure as an opportunity for learning and growth. The consistent self-esteem that results from incremental mindsets creates strong emotional benefits for learners that lead to increased academic performance. Yeager and Dweck (2012) specifically believe that incremental mindsets allow students to approach adversity as a chance to learn. Positive emotional controls allow this to happen. Rather than worrying about achievement or failure, students with incremental mindsets reappraise stressful situations to uncover new possibilities and create meaningful learning

experiences. Confronting challenge with emotional control requires internal attributes that further enhance learning and result in successful academic practices.

Internal Factors that Affect Mindset

To have a deeper impact on learning, teachers must understand the benefits of incremental mindset and the factors that will help promote incremental thinking in the classroom. Three internal processes directly affect student behavior: emotional engagement, self-regulation, and self-efficacy. Emotional engagement guides the learning process. Self-regulation and goal setting utilize process-based information to promote future actions. Self-efficacy, or belief in performance ability, puts an affective filter on individual approaches to challenge. Incremental mindset acts as a control that both affects and is affected by each of these processes. Teachers can help students build confidence in growth-based mindsets by facilitating understanding of the influence and interplay of these internal processes.

Emotional Engagement

The foundational building blocks for successful student growth, academically and non-academically, are tied to emotional development. Emotions fundamentally impact each student's mindset (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011). To develop successful habits, students must understand how and when to regulate their emotions. Emotional engagement is the connection that a student feels between emotions and external inputs. It is directly connected to incremental mindset through attitude. Students' emotional approach to their learning process can fundamentally affect their construction of knowledge. A study by Hagelskamp, Brackett, Rivers, and Salovey (2013) coded video segments of classes in a two-year social-emotional learning program named RULER through ratings from blinded independent observers. The authors were testing the effectiveness of emotional literacy

instruction in creating increased emotional support, instructional support, and classroom organization. Emotional support addressed encouragement, caring, and positivity in the classroom. Instructional support focused on feedback, scaffolding, and promotion of student well-being. Classroom organization was a measure of teacher strategies that produce efficient, goal-oriented learning. Fifth- and sixth-grade students from 62 schools participated in the study over a two-year period. Teachers attended training and integrated curriculum designed to increase students' understanding of emotion-based words such as "excitement, shame, alienation, and commitment" (p. 534). Lessons throughout the year were videotaped, returned, and assessed by the Classroom Assessment Scoring System (CLASS) to measure classroom interaction quality. The CLASS scale rated the effectiveness of emotional and instructional support in each classroom. Findings revealed increases of .48 of a standard deviation for emotional support and .71 of a standard deviation for instructional support from comparison schools to RULER schools (Hagelskamp et al., 2013). The growth in student emotional connection and instructional focus on emotional development shows a clear relationship between emotional engagement and incremental mindset. Classroom interactions revealed that improved attention to emotional engagement resulted in more productive teaching and learning. As classroom instruction addressed emotions and affective input, student interactions displayed increased emotional engagement. The ability to respond to challenge and cope with emotional uncertainty was affected by students' attitudes. Therefore, emotional engagement led to the development of incremental mindsets, which provided students with internal strategies for emotional control.

The connections between positive emotional engagement and academic performance have further motivated the transition from behaviorist conceptions of learning to affective, student-based learning environments. Although political agendas within the American education

system remain focused on performance-based assessment, the implementation of emotion-centered theories shows an attempt to address the affective foundation of student learning. Curriculum such as that used in the Hagelskamp, et al. study places attention on recognizing, understanding, and using emotions. The responsibility to address emotional development as a part of each student's education has become recognized as necessary for successful academic achievement. To become effective learners, students must become emotionally engaged. Learning to understand and control emotions requires application of an incremental mindset. The process of developing emotional management simultaneously entails development of incremental mindsets. Students learn from experience, utilize opportunities to grow, and achieve increasing academic success as internal development occurs.

Self-regulation and Goal Setting

Self-regulation, the ability to utilize a personal evaluative feedback process, is another internal mechanism that is connected to incremental mindset. Recurring assessment, attention to knowledge construction, and strategy development arise through application of self-regulation (Zimmerman, 1990). The conception of learning as a progression of intellectual development allows students with a growth-oriented mindset to utilize self-regulatory practices to improve. Academic performance provides feedback to students and incremental improvements can be made. Success and failure are part of the learning process, and growth-oriented mindsets address both as opportunities. Strategies that work can be reused, while strategies that fail are discarded (Chen & Siegler, 2000). The ability to utilize successful strategies allows students with incremental mindsets to regard learning as a process, not as an end product. Self-regulation enhances the effectiveness of the progression process and allows for more successful approaches to academic challenges.

Furthermore, self-regulation entails effective goal setting. Goal setting involves spending time and resources planning for the future and monitoring progress towards an objective. Students who successfully set goals develop realistic intentions, dedicate time and energy to achieving objectives, and evaluate the extent to which they meet their aims. Setting goals and evaluating progression towards those goals develops the internal ability to evaluate growth and develop emotional responses to success and failure. In short, successful goal setting involves incremental thinking. Research has also shown that a difference exists between the types of goals children set. Learning goals, which emphasize progress and opportunity, shape attitude and response in a positive, growth-oriented manner. Performance goals, on the other hand, result in dependent, helpless reactions because they stress end results, assessment, and demonstration of ability (Erdley, Cain, Loomis, Dumas-Hines, Dweck, 1997). Learning goals are closely correlated with incremental mindset and performance goals with fixed mindset. The success of goal setting strategies is determined by the internal attitudes that accompany the process. Goal setting with an incremental mindset allows students to address the process of learning and development instead of the result. Successful goal setting provides feedback as students develop perceptions of their progress, work to strengthen weaknesses, and select the most effective learning strategies. Furthermore, the goal setting process reinforces and promotes continued development of incremental mindset.

Self-efficacy

Self-efficacy is a final internal factor that is directly shaped by incremental mindset. Self-efficacy is an individual's belief in her or his personal ability to perform in a specific situation. As with emotional engagement, this internal control can determine attitudes of success or failure. Increased self-efficacy in academic situations can influence emotions and impact behavior.

Bandura's (1977) theory of self-efficacy identifies four primary sources of information that provide input to the development of personal belief systems: performance, vicarious experience, verbal persuasion, and emotional investment. All are connected with incremental mindset and the tendency to view challenging situations as opportunities for growth. Performance has the most influence on positive self-efficacy and is especially important. In relation to self-efficacy, successes build positive belief in performance while failures decrease confidence and assurance. However, as Bandura observes, the experience of failure can actually have a positive effect on personal efficacy and future performance. This is where incremental mindset becomes most influential. Students who understand failures as opportunities rather than setbacks will look for the growth potential in that situation. As experience develops, cognitive connections grow and students apply past understandings to new situations. Past failures result in successes and reinforce the individual's belief that even difficult challenges can be overcome through practice and focused effort.

Research on the effectiveness of teaching incremental mindset shows that understanding the incremental learning process leads to increased academic success. The brain builds connections and strengthens neural pathways through repetition and practice (Willis, 2010). When students learn about the brain's ability to grow, their self-efficacy grows. A study by Paunesku, Walton, Romero, Smith, Yeager, and Dweck (2015) investigated the effect of mind-set interventions to develop academic achievement. The research tested two mindset interventions focused on "growth mind-set of intelligence" and "sense of purpose" (p. 785). The study also investigated the opportunities for successful application of mindset interventions on realistic, large-scale models. For this reason, the researchers chose to administer interventions through computer-based applications consisting of two separate 45-minute educational units. The

growth mindset unit taught students about the science behind brain malleability and incremental theories. The purpose-based unit targeted education as a means to make large-scale impact on the surrounding community and the world. Both sessions used readings followed by reflection and writing to reinforce learning.

The study population consisted of 1,594 students from thirteen high schools. Grades were analyzed prior to and post intervention to determine changes in academic performance. The results were also analyzed to determine if mindset interventions were more influential for underachieving students. Scores showed that the sessions positively affected GPA in core academic subjects for previously underachieving students. Students considered "at risk" displayed achievement increases due to growth mindset intervention ($p = .048$) and sense of purpose intervention ($p = .021$). After researchers combined intervention conditions to account for general influence of mindset interventions, at risk students showed significant improvements ($p = .011$). The research findings demonstrate the ability of incremental mindset to affect students' approach to academic performance as influenced by self-efficacy. Furthermore, these mindset interventions were effective on a large scale. Instead of producing decreases in self-esteem and feelings of helplessness, students with an incremental mindset block failure from affecting their self-efficacy. Instead, they understand the experience of failure as a learning opportunity. They identify the limitations that led to the failure, develop knowledge and skills in those areas, and apply increased self-efficacy as they continue to learn.

External Factors that Affect Mindset

In addition to supporting emotional development, self-regulation, and self-efficacy, teachers can promote incremental mindset through their interactions with students and the learning community. Teachers have an enormous amount of responsibility for molding the

mindset of each student they instruct. This occurs as they respond to student needs, work through social and academic challenges, utilize flexible teaching practices, and empower student independence and leadership. In sum, teachers act as the primary model for students during day-to-day educational experiences. Their influence affects students' academic outlook and provides teachers with a powerful tool for developing incremental mindsets in students. The quality of teacher-student interactions directly creates positive learning mentorship for students. Developing individual bonds and knowledge of each student's circumstances provides a foundation for caring, confident relationships. Learning and understanding personal biographies includes understanding the sociocultural, linguistic, cognitive, and academic backgrounds of individual students (Herrera, 2010). Direct personal knowledge of students enables teachers to effectively address the internal factors that will inspire the development of incremental mindset.

After developing foundational knowledge and personal connection with each student, teachers further initiate positive, growth-based mindsets through the quality of their classroom interactions. Students are adept, perceptive, and able to sense teachers' investment. Attitudes change when teachers work to intentionally build understanding of each student through practices such as family visits, student-teacher lunches, and support at extracurricular activities. Hughes (2011) found that children have increased academic self-efficacy and involvement in the school setting when they feel supported by teachers' kindness, affirmation of individuality, and encouragement. Her study examined the connection between student and teacher perceptions of relationship support and student self-efficacy, behavior, and achievement. The research was conducted on a group of 714 third grade students from a racially and ethnically diverse population. Students were considered at-risk academically based on literacy test scores that fell below their school's median. The longitudinal study collected information over a four-year

period. Student data came from interviews and standardized achievement testing, and teacher data was gathered from questionnaires. Students and teachers rated their relationships by participating in the National Relationships Inventory (NRI). The NRI interview process asked participants to evaluate social support and conflict during interactions in the classroom. Students also rated their own sense of belonging and academic self-efficacy. Academic achievement was measured through the WJ-III Tests of Achievement, and cognitive ability was measured with the Universal Nonverbal Intelligence Test. Results showed that student-rated engagement, teacher-rated behavioral interactions, and academic success in reading and math all corresponded to students' assessments of "teacher-student relationship quality" (TSRQ). TSRQ accounted for a 3.2% to 7.4% additional variance in student-rated engagement, a positive rate of change of .056 ($p < .001$) in teacher-rated behavior, an increase of .011 ($p < .05$) in reading achievement, and an increase of .008 ($p < .05$) in math achievement. The invested, emotionally supportive nature of teacher interactions produced statistically significant improvements in academic self-efficacy, behavior, and achievement.

Teachers in Hughes's study understood how to successfully relate to their students. They developed caring, affirming relationships with students and successfully created the quality interactions that produce incremental mindsets. These students perceived teachers' involvement in their personal development. As a result, they were able to successfully cultivate emotional engagement, self-regulatory practices, and self-efficacy. When students learned to trust teacher instruction, follow teacher guidance, and model behaviors and habits after teachers, they developed confidence in the teacher's leadership. Their teachers' relationships and leadership connected directly with the internal factors of incremental mindset to cause increased academic

success. Teachers who cultivate emotionally supportive relationships through relatedness can utilize those connections to create incremental mindsets in the students they teach.

A positive, supportive classroom climate also promotes incremental thinking. When teachers emphasize and model respect, care, and support within the classroom, their interactions with students set the tone for growth and process-based learning. Positive classroom climate creates an atmosphere where students are comfortable learning from mistakes, sharing thought processes, and respecting others' opinions. Incremental mindset is reliant upon these positive conditions to enable effective, growth-based learning. Students who feel safe within their classroom community are more likely to take risks, acknowledge mistakes, and learn from failures. As students are supported in this socially tenuous process, they develop confidence and understand the potential of growth-based learning. They become comfortable with mistakes and create stronger cognitive connections as they learn from their experiences.

Furthermore, positive classroom environments nurture teacher well-being and resiliency. Jennings and Greenberg (2009) reviewed research on the effects of nurturing classrooms and linked positive classroom climates to teachers' social and emotional health. Mediating social interactions between students and successfully conveying content knowledge is demanding. Teachers with self-regulation skills and confident emotional control have an increased ability to handle the emotional challenges of teaching. Conversely, harmful classroom climates can lead to a repeating cycle of emotional exhaustion, increased negative interactions, and feelings of ineffectiveness. Teachers must be especially aware of their mindset to prevent the negative attitude and fixed approach to classroom engagement that can develop through challenging social and emotional interactions. In creating a classroom climate based on incremental learning,

teachers are effectively enabling their own continued positivity and health. Incremental mindset is the key to this process.

Summary and Future Study

Incremental mindset positively affects students' learning experiences, classroom interactions, and academic success. Further research should examine strategies that link external factors of incremental mindset development to academic achievement. Specifically, connections between the social influence of students' families and incremental thinking will provide a basis for creating positive classroom climate and extending relationships outside of the classroom. Teachers can further develop incremental mindset expectations in the classroom by teaching students' family communities about the benefits of growth-based thinking. To examine the effect that external social relationships have on students' mindset, research should analyze changes in mindset and academic achievement when family communities are educated about the benefits of incremental mindset. As families become involved in students' approach to learning and mindset, the classroom community will become stronger. Research that illuminates the influence of family social interactions on student mindset will guide teachers that want to instill growth-based learning habits through their teaching practice. The ability to involve the community in this process can empower teachers to more effectively interact with family communities.

Teachers that promote incremental mindsets in the classroom and the surrounding community create positive, growth-based environments that benefit students, families, and themselves. Through emotional engagement, self-regulation, and self-efficacy, students create an attitude that focuses on addressing the process of learning. Incremental mindset allows for creativity, mistakes, and meaningful learning without academic dependency on the notion of progress relative to scores and grades. Learning occurs concurrently with emotional growth, and

individuals acquire affective skills that will be utilized for success throughout life. The relationships that impact and guide students' decisions also contribute to incremental mindset. Teachers and learning communities exert influence on students' actions and thought processes. In nurturing, positive classrooms, students become comfortable making mistakes, learning from the process, and communicating knowledge with classmates and the teacher. These experiences develop the emotional and social skills that lead to academic achievement through incremental mindset. Effective teachers build relationships that guide the process of learning and promote classroom climate that supports the development of positive, growth-based attitudes.

Mindset is a critical element of successful and meaningful learning. Growth-oriented mindsets promote engagement with learning and maintain investment in the process of acquiring new knowledge. Understanding the internal and external factors that affect student mindset will allow teachers to cultivate incremental attitudes towards learning. Growth-based incremental thinkers view learning as a process, not a product. Instead of trying merely to complete their education, students with an incremental mindset understand that learning is a life-long endeavor. As students become comfortable in growth-based learning environments, confidence, positivity, and resiliency increase. Additionally, the classroom environment that develops through the application of incremental mindset contributes to the resiliency of teachers who promote growth-based approaches to learning. The incremental connections that develop between the learner and the learning process support and enhance the academic potential of each student and create learners with lifelong investment in learning.

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Figure 1

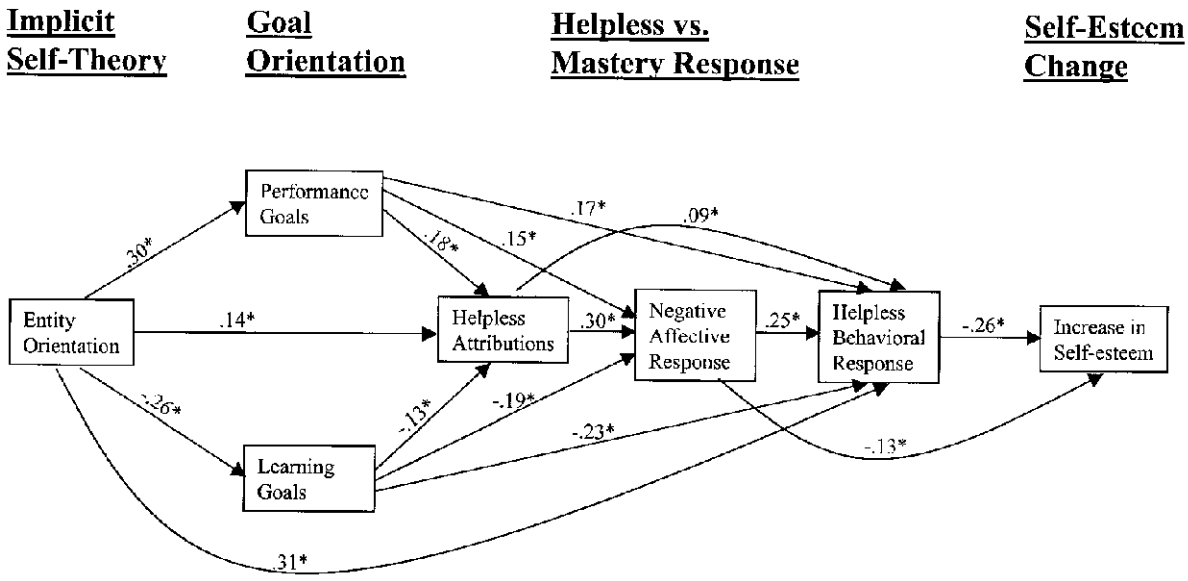

FIGURE 1 Path model linking implicit self-theories, goal orientation, helpless vs. mastery response patterns, and self-esteem change. Path coef®cients are standardized regression coef®cients. All paths are signi®cant at $p < .05$.

Science Notebooks and Connections to Student Self-Efficacy

In addition to content knowledge, young students develop many skills and habits during the learning process. One of the most important attributes of a successful learner is an incremental approach to learning (Yeager & Dweck, 2012). The positive practices that develop from incremental mindset support self-confidence and build the foundation for effective intellectual growth. As an elementary educator, it is crucial to provide opportunities for students to acquire positive self-efficacy in connection with intellectual development. The following research aims to improve understanding of the effect of science notebooks on the learning process and students' learning behaviors. During the research period, students routinely observed, documented, diagrammed, and recorded information in their science notebooks. Students practiced utilizing their notebooks to take class notes throughout each unit and added many of their own notes as they completed observations and experiments. Research analysis reflects the connections between students' success using their notebooks, as evaluated by a systematic scoring rubric, and their self-efficacy, as evaluated by a questionnaire accompanying the end of each unit assessment. Specifically, individual student trends that became apparent upon analysis of the research data provided a number of clear insights into teaching practice and student performance.

Literature Review

By understanding and addressing the factors that influence students' learning mindset, educators can guide student attitude, connection with the learning process, and academic achievement. To enable effective learning, teachers must address students' mindset and learning habits (Costa & Kallick, 2000). Elementary school students are constantly testing, assessing, and

adjusting their learning habits based upon the success of the strategies they use (Chen & Siegler, 2000). To maximize opportunities for growth, effective teachers provide learning tools and opportunities for students to employ them. The science notebook is one such tool. It is an important part of the successful development of scientific learning, allowing students to practice observation, recording, organization, and big picture thinking. The notebook is also an instrument for developing students' incremental mindset and providing analytical feedback on student performance and attitude.

Many studies have explored mindset and its effect on learning (Erdley, Cain, Loomis, Dumas-Hines, & Dweck, 1997; Robins & Pals, 2002; Molden & Dweck, 2006; Blackwell, Trzesniewski, & Dweck, 2007; Yeager & Dweck, 2012; Paunesku, Walton, Romero, Smith, Yeager, & Dweck, 2015). Incremental mindset is defined as a growth-based approach to learning, challenges, and development. The concept of incremental mindset incorporates an understanding of the brain's potential to grow and change. Cognitive research shows that humans have the intellectual ability to develop as they experiment, make mistakes, and learn from experiences (Willis, 2010). Appreciating the potential for brain malleability and incorporating incremental mindset into instruction can contribute to increased academic performance and heightened resiliency in response to adversity. Most importantly, incremental mindset promotes associations between the learner and the learning process that enhance students' academic potential and create learners with a lifelong investment in learning (Molden & Dweck, 2006).

Successful development of incremental mindset relies on three components: consistent self-evaluation, a growth-based approach to challenges, and a positive emotional condition. Self-evaluation provides the necessary reflection, assessment, and motivation to initiate growth. Resiliency in the face of challenge enables students to focus, work harder, and make better

learning connections. Emotional strength provides students with the ability to reappraise stressful situations and uncover new possibilities without shutting down. In sum, students that employ an incremental mindset during learning will have a greater ability to thrive in all learning environments.

Strong self-efficacy is a predictive component of incremental mindset (Blackwell et al., 2007). Self-efficacy is an individual's belief in her or his personal ability to perform in a specific situation. Bandura (1977) identifies four primary sources of information that provide input to the development of positive self-efficacy: performance, vicarious experience, verbal persuasion, and emotional investment. All are connected with incremental mindset and the tendency to view challenging situations as opportunities for growth. The use of scientific notebooks should strengthen students' self-efficacy through providing performance feedback, enabling vicarious observation and learning to occur, and creating emotional investment. Students who practice scientific observation, recording, and connection-making should develop valuable learning skills that can be applied in a variety of contexts. The following research was designed to determine the connection between the quality of students' science notebook entries, their performance on the unit assessment, and self-efficacy.

Methods

Participants

Research participants consisted of a combined class of twenty-five 4th and 5th grade students from Mandy Elementary School in Colorado Springs. 4th grade participants were nine and ten years old and, with five females and seven males. 5th grade participants were ten and eleven years old, with eight females and five males. Many students had attended Mandy

Elementary for their entire primary school careers, and nine of the 5th grade students were returning for a second year in the supervising teacher's classroom. Three participants were new to the school. The majority of the students were White (64%). The remainder of the group consisted of Hispanic students (20%) and Black students (16%). Family socioeconomic information was not collected.

Deeper analysis focused on three participants based upon observed distinctions within and between data sets. SID22 was a female 4th grade participant. She began the year with below grade-level literacy scores but consistently made growth on weekly assessments over the course of the study. She had a quiet and shy demeanor that combined with her low literacy abilities to create reluctance and hesitancy when learning. SID3 was a male 5th grade participant. He was returning for a second year with the supervising teacher, and had an Individualized Education Program (IEP) for literacy problems related to dyslexia and focus. He occasionally left class for counseling in relation to high stress levels from childhood trauma. SID19 was a male 4th grade participant. He was an intelligent student with a proven ability to retain many facts and details from reading. However, he had issues with focus during lessons and also struggled with student responsibilities, including projects and homework. His home life was taxing and involved care for siblings in a one-parent household.

Instruments

The class utilized science notebooks as an everyday tool to document, organize, and analyze scientific observations. Over the course of each unit, students recorded information daily. Notebooks were then used to review information and study for unit assessments. At the end of each unit, a questionnaire asked students to provide voluntary feedback about their self-efficacy and confidence as scientists in relation to the material covered. The questionnaire aimed

to capture students' underlying feelings of confidence and success directly after they had taken the unit assessment. It was also intended to provide a snapshot of their belief in their own abilities as a reflection of their scientific notebook completion. The questionnaire did not collect student demographic information because it did not pertain to the research question. Notebooks were scored according to a rubric adapted from Getty, Taylor, Mooney, and Kuerbis (2009). The rubric evaluated science notebooks in four categories: format, completion, quality and type of observations and recordings, and big picture understanding (Appendix B).

Procedures

Data was collected by the participant-researcher during a six-month student teaching placement. A trial of the questionnaire and data collection process was run on the 5th grade students in December, and concrete data was collected over the course of a life science unit in January and February. The questionnaire was attached to the end of the assessment, and students completed it immediately after finishing. Prior to the test, the questionnaire was introduced to the class, and individualized direction was provided to students as they completed it. The information was gathered and compiled into a spreadsheet to view and analyze the complete set of data. The individual data sets were assessed in relation to students' science notebook scores, their self-evaluation of their abilities, and their test scores. Analysis processes involved charting data to compare trends and to evaluate inconsistencies and irregularities among individual students and sets of students.

Intervention

During the research period, science notebooks were used daily. At the beginning of the year, student expectations regarding the use and intention of notebooks were developed. Instruction revolved around an understanding of the notebooks as an important personal tool for

each student to record content information, observations, diagrams, questions, vocabulary, and big picture concepts. During class, instruction was differentiated so that students with higher organizational needs would have a reference when creating their individual entries. Some students were fully self-sufficient when developing structure for their notebooks. Others modeled entries on examples displayed on the class document camera. Students understood expectations for observation and recording in their notebooks. The class was very familiar with our mantra, courtesy of MythBusters: "The only difference between screwing around and science is writing it down." Throughout the research period, attention was given to improving each student's scientific abilities by providing feedback about their science notebook entries. Notebooks were collected and evaluated on a routine basis to provide consistent guidance and direction. Additionally, the review session prior to each test was based on a full-class question-and-answer session drawn from students' notebook entries.

Results and Discussion

Analysis began with consideration of total scores and average scores for students' science notebooks (Table 1). Achieving a proficient score on the science notebook required general organization, adherence to creating a standardized format for recording data, and the use of big picture concepts from the unit to make connections (Appendix B). For the four individual categories assessed on the science notebook scoring rubric, average class scores ranged from 2 to 2.4 (Table 1). Therefore, if a student averaged lower than 2 on their total science notebook score, analysis of their performance across other categories for the unit occurred to assess the relationship between science notebook performance, other assessments, and instruction.

Two details became clear with regard to gender. First, all students with low average science notebook scores (below 2.0) were male (Table 1). These students were from both 4th and

5th grade, and all struggled with focus and energy issues during science lessons. Five of the seven students scored in the proficient range on the assessment, showing that they had command of the material even though their notebooks did not reflect that understanding. Second, six of the seven male students evaluated themselves at or below a median score (3 out of 5) in regards to their ability to record observations individually (Question 6 in Appendix A; Table 3). Their mentality reflected an understanding of their lack of focus in regard to their science notebooks. These male students clearly self-assessed their performance and knew they were not proficient. Other studies have shown that gender discrepancy exists between males and females in regards to self-regulated learning (Duckworth & Seligman, 2006). Based on observations by the participant-researcher, these male students did struggle with science notebook work in part due to lower self-regulation and self-discipline skills.

Next, students' answers on the self-confidence questionnaire were examined. This survey asked students to rate their abilities in three areas: their aptitude as scientists and perceived success on the test, their ability to individually work as scientists to recreate and record similar experiments, and their understanding of big picture concepts and ideas from the unit (Appendix A). Eight total questions allowed students to rate themselves on a scale of one to five, with five representing the highest level of self-confidence. As a result, the maximum total compiled score was forty points. Students' total point scores, their average scores, and their answers to particular questions were assessed in relation to knowledge about their past performance and biography.

Some results were expected. First, higher average student self-ratings on the questionnaire correlated to test scores in the proficient and above proficient range (Figure 2). With the exception of two students, every individual whose average self-efficacy rating was at least four points out of five scored proficiently (> 80%) on the test. Additionally, only two

students whose average self-rating was below four points scored proficiently on the test (Table 2). Overall, the range of student ratings was fairly balanced over the two grade levels with high and low scoring students in both the 4th and 5th grade. Again, analysis by gender produced a noticeable result. The data from the questionnaires showed female students to be more heavily represented at the top of the range of scores for self-efficacy. The tendency of females to rate themselves more highly is possibly attributable to generalized traits of young female students (Snowman & McCown, 2014), and possibly to the general academic performance of the class. Individual self-efficacy questions were also analyzed to determine the nature of certain students' beliefs and attitudes. As expected, many students consistently rated themselves well (4 or 5) on each question. However, some students rated themselves poorly on all questions or on particular questions, leading to more detailed analysis.

Examination of the relationships between the data sets provided in-depth details. Student scores on the science notebook rubric, the self-confidence survey, and the test were compiled and analyzed. Initially, overall trends displayed characteristics that were expected based on the participant-researcher's interactions with students. Scores from the assessment were clustered in the proficient range, with six students approaching expectations (< 70%) and seven students exceeding expectations (> 90%). In comparing students' performance with their responses on the questionnaire, some variation was observed in notebook and test scores versus perceived success. There was not a direct positive correlation between high notebook score and high self-evaluation ratings, resulting in a null hypothesis (Figure 2). There are a number of possible explanations for this disconnect (Recommendations). To further investigate the relationships between science notebooks, test performance, and self-efficacy, an assessment of the data on a student-by-student basis occurred. The analysis of individual data allowed for close evaluation of the performance

of each student across their scores and provided a wealth of details that helped in re-evaluation and adaptation of instruction to better address students' learning needs.

When comparing the average science notebook scores with the average questionnaire answers, the first student who stood out was SID22. She had a very low average score on the self-efficacy questionnaire, but a moderately high average on the science notebook rubric score (Figure 2). In working with this student in the past, she has displayed a lack of self-confidence and understanding of her learning ability. Although her low self-confidence had been previously apparent, instruction and student-teacher interactions have not focused on building her self-efficacy. There are a number of opportunities that will help SID22 develop self-confidence and allow her to see the connection between growth mindset and understanding of her potential as a learner. First, SID22 must experience intentional and varied possibilities to demonstrate her learning. These will include materials that require a response to questions, chances to discuss answers and reasoning with partners and with small groups, and periodic self-understanding check-ins (short worksheets that ask students open-ended questions to allow them to ensure they know crucial material that has been covered). Second, more one-on-one communication with SID22 will allow for comments on her work, feedback, and exterior support to back up the development of her confidence levels. Finally, an increase in the use of growth mindset terminology and discussion will build her awareness of positive self-confidence. More consistent reference to the possibilities of brain growth, practicing positive learning habits, and developing self-efficacy skills will grow her incremental mindset and self-confidence.

A second student, SID3, had a very low science notebook score in conjunction with a low self-efficacy score in relation to the other participants (Figure 2). For this student, it will be effective to apply techniques to raise his self-confidence. However, he is also struggling with

science notebook completion, organization, and big picture ideas (he scored only one point in categories C1, C2, and C4; Table 1). SID3 is on an IEP for his high literacy needs, and struggles with writing, reading, and comprehension. The science notebook format is heavily based on all three components, so two changes to teaching strategy will be implemented to improve SID3's literacy skills. First, instruction for SID3 will provide scaffolded strategies for completing his science notebook entries. To begin, he will need structured worksheet prompts that allow him to fill in the necessary information that is part of a successful notebook entry (title, date, key scientific words, etc.). A page with these prompts will be offered to SID3 and other low-scoring students to add structure and organizational framework to their notebook entries. The second change to instruction involves working individually with SID3 to provide writing and comprehension development strategies based on his scientific notebook. He has demonstrated confidence and successful performance with mathematics, and also gets very excited about science. His energy can be channeled towards his science notebook, and the resulting improvements and literacy developments will provide continuous feedback as he develops writing and comprehension skills. In short, his notebook will become an important tool in his literacy growth.

The third student, SID19, had a very low notebook score in combination with a very high self-efficacy questionnaire score and a proficient test score (Figure 2). Clearly, he had understanding of the material and was confident about his knowledge, but lacked the skills or motivation to complete the daily observational process that is part of successful scientific notebook recording. There are a number of domestic difficulties SID19 is experiencing, and his data reflect his biographical background as it has become evident over the school year. He has very minimal family support and consistently deals with inconsistencies at home. He also has a

number of evening responsibilities that revolve around care for siblings. For this reason, his homework completion has often been sporadic, and his desire to succeed academically lacks support from adults at home. He is a bright student with an incredible memory, but his school performance often lags. In the past, individualized instructional assistance and alteration of academic responsibilities have been provided. However, the science notebook is a unique type of assignment. It requires routine attention and organization for successful development of scientific skills and collection of data. As a result, specific daily efforts to ensure that SID19 is adding to his science notebook will become part of teaching practice. He loves to read, so establishing a connection between his enjoyment of reading and new scientific information will improve the process of adding to his notebook. Finally, integration of reading materials will focus on examples of successful scientists who recorded and organized their data before presenting their findings in written format.

Throughout analysis, the most important realizations became apparent when assessing the relationship between students' science notebook scores and ratings on the self-efficacy questionnaire. A positive correlation was expected between high notebook scores and high self-efficacy, but there was no connection between the two. However, data illuminated three students whose scores raised questions about their abilities and confidence and about teacher instruction. Data from notebooks, self-efficacy scores, and assessments, in conjunction with knowledge of students' biography and learning habits, can improve future instruction. It will also allow for more differentiated instruction across the class. Making positive changes based on research will build stronger relationships between the students' science notebook work and their self-efficacy. Additionally, increased instructional focus on big picture connections and prediction in the

science notebook process will help further support students as they use science notebooks to develop positive attitudes and learning habits.

Recommendations

Initially, further research needs to focus on the collection and analysis of additional data. The amount of valuable information gleaned from the data set in this study proves the significance of examining students' self-efficacy in relation to their performance. Supplemental data will serve to continue to guide teaching decisions in relation to individual students. It will also provide depth to the relationship between students' science notebooks, their self-confidence, and their performance. Most importantly, making observations about students' scientific skills and the ability to come to big picture conclusions will provide accurate instructional guidance towards the ultimate goal: producing a self-sustaining spark that fuels each student's desire to apply scientific strategies to their everyday life.

Students in intermediate elementary school are experiencing an important transition from the introductory education of primary elementary to the advanced and intricate learning that they will engage in for the rest of their lives. It is therefore crucial for all upper elementary instruction to be directed to the emotional and cognitive needs of each individual student. Teachers must continually progress by assessing student performance through data, analyzing that information, and reflecting to build improved instruction. Within this cycle, additional data will provide continued direction to teaching practices and will enable adjustment of strategies to best engage each learner. The connection between students' development of positive learning habits and their self-efficacy as scientists will continue to grow through calibration of instruction to meet students' needs.

Finally, further research should be directed towards individual components of the science notebooks. Assessing science notebook performance will help determine which strategies are most helpful for students as they learn to be scientists. Detailed and insightful notebook entries can cause growth in big picture thinking for students as they review the information collected and connect it across the course of a unit and beyond. Furthermore, integrating student knowledge across content areas provides experience with the way learning occurs every day. As students make big picture connections that incorporate different subjects, they gain first hand understanding of the interconnections of knowledge in their world. Further research can continue to determine the effect of big picture thinking and interconnection on students' self-efficacy. Findings should guide instruction to most effectively create opportunities for students to develop cognitively as they make these connections.

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Table 1

Science Notebook Data

SID	Grade	Gender	C1	C2	C3	C4	SNBTotal	SNBAverage	Test
1	5	M	2	3	3	2	7	1.75	89
2	5	M	2	2	3	2	12	3	86
3	5	M	3	3	3	3	5	1.25	77
4	5	M	2	2	2	2	7	1.75	63
5	5	M	3	3	3	3	8	2	69
6	5	F	3	3	3	1	12	3	83
7	5	F	3	3	3	3	11	2.75	69
8	5	F	2	2	1	2	8	2	94
9	5	F	3	3	3	2	9	2.25	97
10	5	F	3	3	3	3	11	2.75	87
11	5	F	1	1	2	1	12	3	94
12	5	F	3	3	3	3	11	2.75	69
13	5	F	3	2	2	1	12	3	96
14	4	M	3	3	2	2	5	1.25	77
15	4	M	1	1	2	1	8	2	74
16	4	M	2	1	1	1	6	1.5	77
17	4	M	1	2	2	1	10	2.5	100
18	4	M	3	2	2	1	11	2.75	60
19	4	M	3	2	1	2	5	1.25	86
20	4	M	3	3	3	2	7	1.75	49
21	4	F	3	3	2	3	10	2.5	91
22	4	F	3	2	3	2	10	2.5	66
23	4	F	1	2	2	2	12	3	91
24	4	F	3	3	2	3	8	2	83
25	4	F	1	2	2	2	10	2.5	80
Average			2.4	2.4	2.3	2.0			

Note. Abbreviations include SID: Student ID, C1, C2, C3, C4: Category 1, Category 2, Category 3, Category 4, and SNB: Science Notebook

Table 2

Self-Efficacy Questionnaire Data

SID	Grade	Gender	SETotal	SEAverage
1	5	M	35.5	4.4375
2	5	M	34	4.25
3	5	M	25	3.125
4	5	M	26	3.25
5	5	M	28	3.5
6	5	F	32	4
7	5	F	29	3.625
8	5	F	32	4
9	5	F	39	4.875
10	5	F	37	4.625
11	5	F	37	4.625
12	5	F	32	4
13	5	F	36	4.5
14	4	M	27.5	3.4375
15	4	M	28	3.5
16	4	M	32	4
17	4	M	35	4.375
18	4	M	25	3.125
19	4	M	36	4.5
20	4	M	24.5	3.0625
21	4	F	31	3.875
22	4	F	19.5	2.4375
23	4	F	38	4.75
24	4	F	24	3
25	4	F	33	4.125

Note. Abbreviations include SID: Student ID and SE: Self-efficacy

Table 3

Self-Efficacy Questionnaire Answers

SID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
1	4	4	4	5	5	3.5	5	5
2	4	4	4	5	5	4	4	4
3	3	3	3	2	5	2	3	4
4	3	4.5	2.5	1.5	2	4.5	4.5	3.5
5	4	4	5	4	3	1	4	3
6	3	5	3	4	5	5	4	3
7	4	3	4	3	5	3	3	4
8	4	4	4	5	5	4	3	3
9	4.5	5	4.5	5	5	5	5	5
10	4	4	4	5	5	5	5	5
11	5	4	5	4	5	4	5	5
12	3	4	3	5	4	3	5	5
13	4	5	4	5	5	5	4	4
14	4	3	4.5	3.5	3.5	3	2.5	3.5
15	3	4	3	4	5	3	2	4
16	3	4	4	5	5	1	5	5
17	5	4	5	3	4	4	5	5
18	3	2	3	3.5	4	2.5	4	3
19	4	5	4	5	5	3	5	5
20	2	3	2	4	4	3	2.5	4
21	3	4	3	3	4	4	5	5
22	2	2	1	1	5	4	1.5	3
23	4	5	4	5	5	5	5	5
24	3	4	3	2	3	3	2	4
25	4	3	5	4	5	2	5	5

Note. Abbreviations include SID: Student ID and Q1, Q2, etc.: Question 1, Question 2, etc.

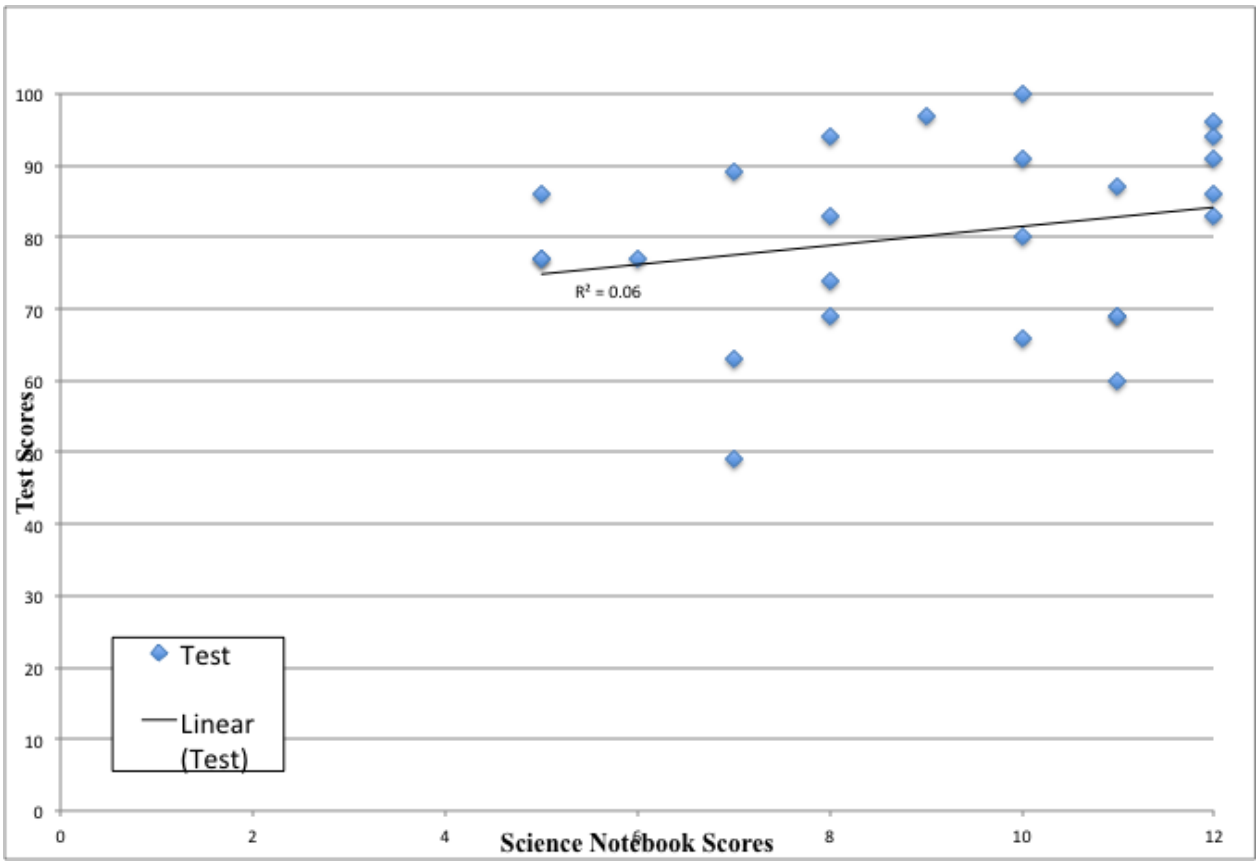

Figure 1. Student scores. This figure displays students' scores on science notebooks in conjunction with their performance on the unit assessment *(n=25).*

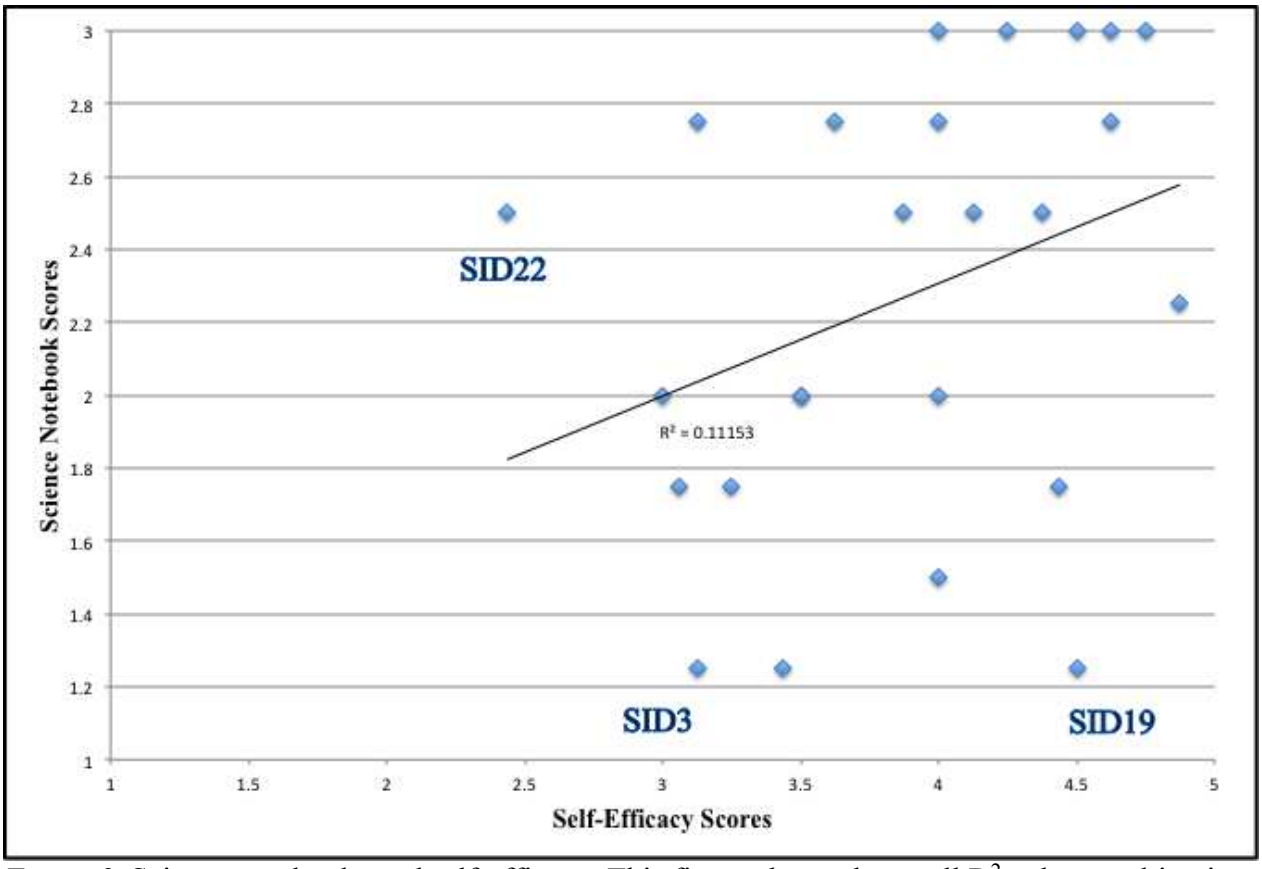

Figure 2. Science notebooks and self-efficacy. This figure shows the small R^2 value resulting in a null hypothesis and also highlights scores for SID22, SID3, and SID19 *(n=25)*.

Appendix A

Self-Efficacy Questionnaire

Please answer the following questions by rating yourself on a scale of 1 to 5.

1=Low 3=Medium 5=High

1. How confident are you about the correctness of your answers?

   1 2 3 4 5

2. Rate your abilities as a scientist (for example: hands-on experiments, diagramming, vocabulary knowledge, etc.)

   1 2 3 4 5

3. How successful do you think you were on the test?

   1 2 3 4 5

4. How well could you individually oversee the construction of a terrarium and aquarium if asked to do so?

   1 2 3 4 5

5. How well could you individually care for a terrarium and aquarium?

   1 2 3 4 5

6. How well could you individually record scientific observations and changes over an extended period of time?

   1 2 3 4 5

7. How well do you understand the relationships that exist in our world?

   1 2 3 4 5

8. How well do you understand the impact of human actions on the world around us?

   1 2 3 4 5

Appendix B

Science Notebook Rubric

Category	0	1	2	3
1. SNB Format and Completeness R (entries/ lessons)	SNB contains 0 or 1 of: Table of contents Page numbers Dates Headings Ratio of completeness is less than 25%	SNB contains 2 of: Table of contents Page numbers Dates Headings Ratio of completeness is between 25% and 50%	SNB contains 3 of: Table of contents Page numbers Dates Headings Ratio of completeness is between 50% and 75%	SNB contains all 4 of: Table of contents Page numbers Dates Headings Ratio of completeness is above 75%
2. Observe and Record **a. Multiple Representations** **b. Quality of Observations**	 Student uses only 0-1 means to represent observations of science activities Observations do not contain accurate descriptions and labels	 Student uses 2 means to represent observations of science activities Observations contain limited or inaccurate descriptions and labels	 Student uses 3 means to represent observations of science activities Observations contain mostly accurate descriptions and labels	 Student uses 4 means to represent observations of science activities Observations contain rich and accurate descriptions and labels
3. Test and Conclude	Student does not present any evidence or findings from investigations to develop explanations or support conclusions	Student only pieces of evidence or findings from investigations to develop explanations or support conclusions OR makes illogical conclusions	Student uses evidence and findings from investigations to develop explanations or support conclusions	Student consistently and logically uses evidence and findings from investigations to develop explanations and support conclusions.
4. Think and Wonder About Big Ideas in Science	No statements by student regarding curiosity and wondering about the underlying concepts and big ideas for the unit	Statements about what the student is thinking or wondering are limited or not relevant to the unit with minimal connections to underlying concepts and big ideas for the unit	Statements by the student indicate what they are thinking or wondering in science with some connections to underlying concepts and big ideas for the unit	Statements by the student are insightful and clearly indicate what they are thinking or wondering in science with multiple connections to underlying concepts and big ideas for the unit