EXAMINING RELATIONSHIPS BETWEEN ACTIVITIES WE USE TO ENGAGE STUDENTS IN LEARNING AND THEIR ATTITUDES TOWARD SCIENCE

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ABSTRACT

Student engagement has been positively linked to academic achievement (Finn & Rock, 1997), persistence between grade levels (Kuh et. al. 2008), positive attitude toward school (Cothran & Ennis, 2000), and self-concept of ability in the classroom (Fullarton, 2002). One area of student engagement is a teacher implementing a type of learning activity in their classroom (Bonwell & Sutherland, 1996). If science teachers implement learning activities students prefer to engage in, students may also increase their attitude toward science. The purpose of this study is to explore relationships between student reported preferences in learning activities and their attitudes toward science. Learning activities used to engage students were organized into seven groups that established a conceptual framework called the Framework for the Observation of Categorization of Instructional Strategies (FOCIS) (Tai, 2013). The research questions that will be addressed in this study are:

1. Do student reported preferences in learning activities predict student reported positive attitudes toward science at the elementary, middle, and high school grade levels?
2. Do these relationships differ across elementary, middle, and high school grade levels?
3. Do these relationships change between the Fall 2012 and Spring 2013 semesters within a single academic year for students across elementary, middle, and high school grade levels?

Results showed those students who reported having a preference for *discovering* types of activities (i.e. researching, experimenting, finding new knowledge), significantly predicted a positive *value of science in society, self-concept,* and *enjoyment and desire* attitudes toward science at the elementary, middle school, and high school grade levels in the Fall 2012 and in the Spring 2013.

DEDICATION

To my father, who gave up finishing his doctorate so he could provide for our family. I will never forget the endless nights of quizzing me so I would be prepared for my science classes.

To my mother, who encouraged me to never settle and to keep searching for new ideas and challenges.

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CHAPTER 1

Student Engagement

Student engagement is seen as a process relating to the attention, interest, investment, and effort students expend in the work of learning (Marks, 2000). This definition is consistent with other researchers' definitions of student engagement: students' willingness to participate in routine school activities, such as attending classes, submitting required work, and following teachers' directions in class (Chapman, 2003); students' involvement and participation (Finn, 1993); a student's investment in and effort toward their learning, understanding, or mastering knowledge, skills, or crafts (Newmann, Wehlage, & Lamborn, 1992, p. 12); students' participation in school that leads to a sense of belonging (Williams, 2003, p.8). Defining student engagement as such signifies there are three components: a behavioral component described as a student participating; an emotional component described as the student's self-identification in the classroom; a cognitive component described as students seeing value in engagement (Axelson & Flick, 2010).

There are positive outcomes from students being engaged in the classroom. Student engagement has been positively linked to academic achievement (Finn & Rock, 1997), persistence between grade levels (Kuh et. al. 2008), positive attitude toward school (Cothran & Ennis, 2000), and self-concept of ability in the classroom (Fullarton, 2002). Developmentally, students learn by engaging and paying attention to people, events, and surroundings they find meaningful and enjoyable (Marks, 2000). If students have performance success because of their engagement, Finn (1989) believes a cyclical process occurs. Finn labels this cycle as the participation-identification model. In this cycle, student participation in school activities leads to improved performance outcomes. Then, these positive outcomes lead the student to feeling a sense of belonging and self value with the school. Finally, the positive identification of the self with the school further motivates the student to participate in the classroom. As we've briefly defined student engagement and seen some of the benefits, we address how educators attempt to improve student engagement in learning.

Strategies for Student Engagement

There are many recommended strategies on how to improve student engagement in learning. The majority of strategies appear to include improving student interactions (Willms, Friesen, & Milton, 2009), making curriculum more relevant (Claxton, 2007), posing challenging questions (Taylor & Parsons, 2011), allowing students to explore their own questions and interests (Windham, 2005), setting high academic standards through assessment, and engaging them in activities.

Respectful relationships and interactions between teachers and students are shown to improve student engagement (Pianta, Hamre, & Allen, 2012). Jones (2008) describes how teachers can improve relationships with their students by viewing instruction as relationship building rather than classroom management. Through a relationship building lens, teachers negotiate classroom rules with their students rather than mandate them, observe effectiveness as students actively engaged rather than passive and quiet, encourage students to take risks in their own exploration rather than be passive, promote discussion among students instead of absolute attention, and give positive reinforcement rather than negative feedback.

Students also desire their teachers to know how they learn (Willms, et. al., 2009). It is an unrealistic expectation for teachers to anticipate each of their students will learn in the same manner. Each student brings a variety of background knowledge and interests to the classroom. Strong relationships between teachers and students may not develop if teachers fail to recognize the variety of characteristics among their students. One approach teachers can use to connect with their students is by understanding their learning styles. Gardner (1997) presents eight different types of intelligences, or styles of learning, students may possess: linguistic intelligence is the ability to use language through reading, writing, listening, and speaking to learn; logical intelligence exhibits learning by classifying, categorizing, and thinking abstractly about patterns, relationships, and numbers; spatial intelligence refers to the ability to represent the spatial world internally in your mind; kinesthetic intelligence is using parts of your body to make something or solve a problem; musical intelligence is the capacity to hear and recognize patterns and learn through melody; interpersonal intelligence shows people learning by relating and collaborating with others; intrapersonal intelligence shows people learning by working alone and having an understanding of yourself; naturalist intelligence learners excel through examination of living things and environmental issues. Teachers can find, recognize, and address different combinations of multiple intelligences in their instruction to more effectively interact with their students.

A second strategy for teachers to improve student engagement in learning is by making curriculum relevant to students (Claxton, 2007). To accomplish this, teachers can connect topics with student interests and concerns, and have students' problem solving and progress genuinely matter to them. Students desire that their learning apply to real-life scenarios whenever possible as opposed to being theoretical and text-based (Dunleavy & Milton 2009). Working with authentic problems or community issues engages students and builds a sense of purpose to the learning experience. "The work students undertake also needs to be relevant, meaningful, and authentic. It needs to be worthy of their time and attention" (Willms, 2003). Teachers can form connections between learners and the social contexts in which they are learning and make curriculum and instruction relevant to their experiences and cultures in order to keep students in school engaged and motivated.

Inclusive instruction is a method of lesson planning and teaching that teachers may use to make their curriculum more relevant to their students (Causton-Theohairs, Theohairs, & Trezek, 2008). It requires teachers to think about the larger contextual positioning of the lesson to make connections between the content and students' backgrounds. Teachers focus on who the students are, how the lesson is relevant to their lives, and how authentic their responsibilities are in the lesson.

Another strategy recommended to engage students in their learning is to pose challenging questions that build students' intellectual abilities and skills. The use of increasingly more complex questioning is one method to challenge students and develop their intellectual abilities and skills. Bloom's (1956) six categories of cognitive domain offer a guideline for creating more complex questions. Each category describes a desired behavior starting from the simplest behavior to the most complex: knowledge level includes recollection of facts; comprehension level is described as understanding meaning of problems; application level is using a concept in a different context; analysis level deconstructs, compares, and contrasts separate components to understand the whole; synthesis level combines individuals parts together to create a new meaning; evaluation level is defined as making judgments for the most effective solution. Challenging questions can be used as an overall guide to a lesson or for formative assessments during the lesson. In a 2008 study, Crowe, Dirks, & Wenderoth examined how the use of Bloom's Taxonomy in biology classes could enhance student engagement and learning. Results showed the use of increasingly more complex questioning during the lesson helped students become more engaged in the classroom, enhance their mastery of the material, and answer questions that required higher-order cognitive skills.

Higher cognitive questions are also referred to as open-ended, interpretive, evaluative, inquiry, inferential, and synthesis questions (Cotton, 2001), and often allow students to explore these questions based on their own background and interests. Increases in the use of higher cognitive questions, especially with older students, are positively related to length of student responses, number of contributions volunteered by students, and the number of student-to-student interactions.

A fourth strategy to improve student engagement is through the use of assessment (Handley & Williams, 2011), especially if it occurs during the learning process (Crooks, 2001). Assessments occurring during classroom activities and learning are referred to as formative assessments. Formative assessment is defined as the process used by teachers and students to recognize, diagnose, and respond to students' learning progress in order to enhance and modify teaching and activities during class time (Crowe & Bell, 1999).

Formative assessment gauges real time student progress and guides teachers in making decisions about future instruction. It also serves as practice for the student to check their understanding during the learning process. In contrast, summative assessment is intended to summarize attainment at the end of a lesson or unit, and requires grading an assignment or exam about the learning that has occurred (Boston, 2002).

Formative assessment method typically involves a form of qualitative feedback (Nicol & Macfarlane- Dick, 2006). A few examples of the formative assessment process to collect evidence of student learning are peer assessments, learning logs, and class discussions. Peer assessments help create a learning community within the classroom as students begin to see each other as resources for understanding and checking for quality work against previously determined criteria (Black & Wiliam, 1998). Also during this process, students become more aware of their personal strengths and weaknesses.

Learning logs are used for students' reflections on the material they are learning. Students record their process in the log as they go through learning something new, and add questions they may need to have clarified. This allows students to make connections to what they have learned, set goals, and reflect upon their learning process. Teachers monitor student progress toward mastery of the learning targets by analyzing student log entries and then adjust instruction to meet student needs. By reading student logs and delivering descriptive feedback on what the student is doing well and suggestions for improvement, the teacher can make the logs powerful tools for learning (Audet, Hickman, & Dobrynina, 1996).

The teacher can also initiate a discussion by presenting students with an open-ended question as a form of formative assessment. Discussions allow students to increase the breadth and depth of their understanding and expand background knowledge while discarding erroneous information (Doherty 2003). Teachers can observe and take notes on student responses to gauge where students are at in their learning.

Finally, an activity a teacher chooses to implement in their classroom is also a strategy to improve student engagement (Bonwell & Sutherland, 1996). Students are more likely to internalize, understand, and remember material learned through active engagement in the learning process (Bonwell & Eison, 1991). If students are gaining more by being active in their learning, then curricula should match this activity based learning environment. However, determining which activities are most effective may prove difficult as it requires knowing the type of activities students prefer to engage in. Certainly, specific individual activities have been determined to be effective, but until recently, efforts had not made to determine which groups of activities students prefer to engage in while learning.

Tai's (2013) conceptual framework, the Framework for the Observation of Categorization of Interest in Science (FOCIS), defines seven groups of activities teachers use to engage students in their learning: *collaborating; competing; creating and making; discovery; caretaking; teaching; performing*. Teachers that know the types of activities their students prefer may be able to increase student engagement in their classroom.

Lesson Planning For Student Engagement

Activities used to engage students in learning and the other discussed strategies for student engagement play separate roles in the lesson planning process. However, the integration of activities used to engage students with the discussed strategies for student engagement have the potential to maximize overall student engagement in the classroom.

These two components, along with objectives, assessments, materials, accommodations, and reflection, are part of classroom lesson planning and implementation procedures. Lesson planning, specifically backward design (Wiggins & McTighe, 2001), can help plan ways in which activities used to engage students and strategies for student engagement can be integrated.

Traditional lesson planning design focuses first on the content and the teaching activities leaving the desired lesson goals until the end of the planning (McTighe & Thomas, 2003). In contrast, backward design focuses first on the desired outcomes and leaves teaching activities until the end. Wiggins and McTighe (2001) argue that you can’t start planning how you’re going to teach until you know exactly what you want your students to learn. Their backward design model, Figure 1-1, has three phases: *Phase 1: identifying desired results* describes what students should know, understand, and be able to do at the end of the lesson; *Phase 2: determine acceptable evidence* describes how the teacher will decide if the student has mastered the material; *Phase 3: learning experiences* describes the procedure the teacher uses to teach toward the desired learning outcomes.

A closer examination of the backward design model reveals an opportunity to further define *Phase 3: learning experiences* in order to integrate activities used to engage students with strategies for student engagement in the lesson planning process (see Figure 1-2). This further definition maintains the overall backward design strategy of *identifying desired results* and *determining acceptable evidence* first, but adds a fourth phase and incorporates summative and formative assessment. The original *Phase 3: learning experiences* is divided into two successive phases: *Phase 3: activities used to* *engage students* describes the nature of the activity used in the classroom; *phase 4, strategies to further engage students* describes strategies within the chosen activity used to further engage students.

Another feature of this new model is the proper division and incorporation of summative and formative assessments. Summative assessment, a student evaluation at the end of instruction, remains toward the beginning of the backward design model. However, formative assessment, an evaluation of students embedded in the lesson, cannot be fully developed and understood until after the instructional activity has been chosen. Formative assessment is one of the strategies for student engagement and would be found in *Phase 4.*

In the lesson design and planning process, the activity a teacher chooses for their classroom, *Phase 3*, transcends all other strategies for student engagement, *Phase 4*. Once a teacher has fully understood the activity they will implement in their classroom, then they can begin planning for further strategies to engage students that can be embedded within the chosen the activity. A teacher can develop ways to improve student interactions, make the curriculum more relevant, pose challenging questions, allow students to explore their own questions and interests, and create formative assessments once the activity has been chosen and understood. For example, if a teacher chooses to implement a *creating and making* based activity where students are building a mousetrap racecar, teachers can plan for further strategies based off this activity. A further student engagement strategy a teacher may plan for would be to focus on improving student interactions by questioning students about their processes they are using to design and build their mousetrap racecar. Another further student engagement strategy a teacher can plan for might include making the activity more relevant by drawing similarities and differences between wheels used in real life racing and the wheels students are using on their cars. This process of choosing the activity first and then developing further strategies would prove more difficult if it was attempted in the opposite direction. Developing student engagement strategies before knowing the activity would lead to abstract goals (e.g. desire to improve student interactions) until the activity was chosen, at which these strategies could become contextualized.

The type of activity is a focal point for determining further student engagement strategies. It is also the focal point of interest for this study as the type of activity chosen is a starting point for understanding student preferences. In this study, we looked at the possible relationships between student reported preferences of the type of activities they prefer to engage in learning and their reported attitudes towards science.

Purpose of the Study

The purpose of this study is to explore relationships between student reported preferences in learning activities and their attitudes toward science. Learning activities used to engage students were organized into seven groups that established a conceptual framework called the Framework for the Observation of Categorization of Instructional Strategies (FOCIS) (Tai, 2013). The student reported attitudes towards science were drawn from the Modified Attitudes Toward Science Inventory (mATSI) (Weinburgh, & Steele, 2000). The FOCIS and mATSI variables were embedded in the same survey given to elementary, middle, and high school students across four school districts located in urban, suburban, and rural areas in two States. The research questions that will be addressed in this study are:

4. Do student reported preferences in learning activities predict student reported positive attitudes toward science at the elementary, middle, and high school grade levels?
5. Do these relationships differ across elementary, middle, and high school grade levels?
6. Do these relationships change between the Fall 2012 and Spring 2013 semesters within a single academic year for students across elementary, middle, and high school grade levels?

The research questions will be addressed using confirmatory factor analysis and structural equation modeling.

Teachers have the ability to frame their lessons and organize their classrooms to be more student-focused by knowing their students' preferences for learning (Reed, Banks, & Carlisle 2004). They can also recognize patterns where their students tend to concentrate best and alter future curriculum to maximize their students' ability to learn in their classroom. Furthermore, students are more likely to have improved attitudes in the classroom when they are permitted to learn difficult academic information or skills through their identified preferences for learning (Dunn, Beaudry, & Klavas, 2002).

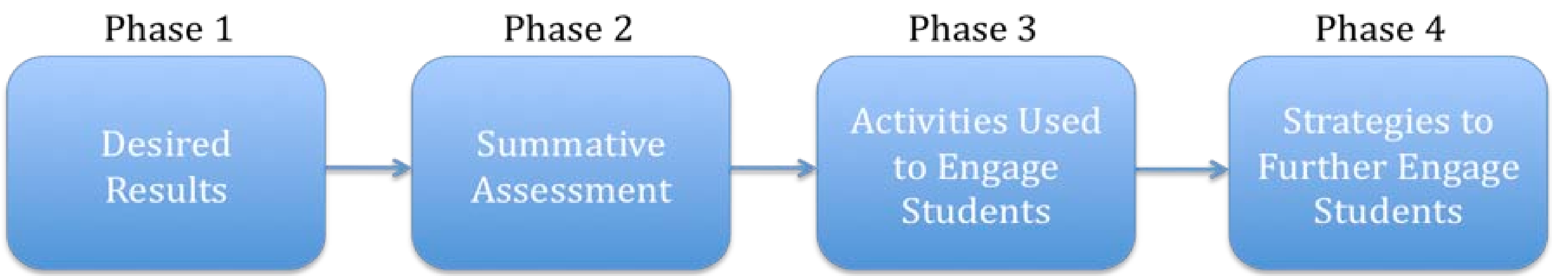
By knowing which activities students prefer are predict positive attitudes toward science, teachers can tailor their classroom to be more student-focused. In addition, teachers can improve upon types of activities student prefer that are negatively associated with attitudes toward science to possibly bring about a transformative experience where students change their attitude toward their learning science experience.

Figure 1-1

Wiggins and McTighe Backward Design Model

Figure 1-2

Backward Design Model with Student Engagement Focus



CHAPTER 2

The following section describes the groups of activities used to engage students that comprise the FOCIS framework. The FOCIS framework is then used to analyze national formal and informal science curricula. Later, attitudes toward science are defined into three separate groups, with concluding remarks on surveys used to measure attitude toward science.

Activities

Activities teachers choose to implement in their classroom to aid students in their learning have recently been organized into defined groups. An activity is defined as a task given to students for the enhancement of their learning. Tai's (2013) conceptual framework, the Framework for the Observation of Categorization of Instructional Strategies (FOCIS), defines seven groups of activities teachers use to engage students in their learning: collaborating; competing; creating and making; discovering; caretaking; teaching; performing. Teachers that know the types of activities their students prefer may be able to increase student engagement in their classroom.

Collaborating

Collaborating involves students working in groups of two or more people on a specific task toward a common goal. Students working in pairs or in small groups share ideas, discuss concepts, respond to questions, and find solutions to problems. They also capitalize on one another’s abilities by asking others in the group for information (Chiu, 2008). Students working in groups continually evaluate and monitor one another’s ideas and work, and address misunderstandings and clarify misconceptions when appropriate. Each member of the group is held accountable for their responsibilities and for the group as a whole. Collaboration-based activities often occur in a class session after students are trained on the importance of group processes, and are introduced to the lesson’s leading question, content material, and activity procedures. An example of a collaboration-based activity is a small group of students working in a chemistry or biology lab.

Teachers asking students to collaborate and work in groups allow students to learn interactively. Students can generate a broad array of possible alternative points of view or solutions to a problem by listening and working with others. Students also have a chance to work with others of different backgrounds, knowledge, experience, or skills while in groups. In addition, students who have difficulty talking in class may feel more comfortable speaking in a small group. Talking in groups can also help overcome the anonymity and passivity of a large class as more students, overall, have a chance to participate in class. Students can begin understanding how to organize work and manage group processes during collaboration. Given clear goals by the teacher, students collaborating can understand how to break down tasks into smaller units, allocate responsibilities to different group members, and learn how to make decisions as a group rather than as individuals.

Competing

Competing activities are described as two or more students or groups of students engaged in a contest where only one student or group finishes the activity as a clear winner while all others are not winners. Johnson & Johnson (1991) defines competition-based activities as one student achieving a goal while all other students fail. Competitions can be between individuals or between groups. Scores, performances, or end products are compared and judged to determine a winner. The hope of these types of activities is to use the concept of competition to generate motivation in students to have the best overall project and eliminate the tendency of just doing the minimum (Carrol, 2013). As winning can bring a feeling of satisfaction, losing in an activity can lead to greater learning as long as it leads to more reflection and critical thinking instead of disillusionment (Shindler, 2009). An example of a competition-based activity is a content trivia contest.

Competition-based activities can add excitement to the classroom, increase student participation, and be used to motivate students in their learning (Brophy, 2010). Competition motivates students to extend themselves, to exploit their real capabilities and maximize their true potential. Teachers can also use competition-based activities to teach about good sportsmanship and resiliency.

Teachers can educated their students about sportsmanship and the honesty, integrity, fairness, generosity, courtesy, respect toward others, and graceful acceptance of results that is expected in competitions (Miscisco, 1976; Allison, 1982). Teachers can also guide students between excessive seriousness and excessive playfulness. As Feezell (1986, p.10) explains sportsmanship as the balance between excessive seriousness, which misunderstands the importance of the play, and excessive amount of playfulness, which misunderstands the importance of achievement when play is competitive.

Teachers have many opportunities to teach their students how to handle defeat in a competition since most participants do not win. When failure occurs, teachers can help their students identify problems, remedy the deficiencies, reset their goals, and grow from their experiences (Rimm, 2008). These steps teacher can use in competition-based activities may help students develop positive coping strategies that bring about resiliency and a determination to work harder instead of students losing their tempers, making excuses, and quitting to avoid the risk of not winning.

Creating and Making

Creating and making activities involve students making artifacts to explain a phenomenon, display artwork, or serve a function. These activities include building, modifying, or repairing something with the use of the students' hands. Students engage raw, semi-raw materials, and component parts to produce, transform, or reconstruct material possessions (Wolf & McQuitty, 2011). An example of a creating and making based activity is students making a mousetrap racecar.

Students in creating and making activities learn to focus their engagement by manipulating material things with their own hands (Crawford, 2011). Teachers can use creating and making activities to teach their students how to work with their hands, work with specific materials, or use tools and equipment. Teachers can also use creating and making activities to teach students how to repair an object to return it to its original function, or how to engineer something new to meet a societal need.

Discovering

Discovering activities include students experimenting, problem solving, or researching a topic or question. Students explore information, concepts, knowledge, and answers to questions previously unknown. Discovery activities involving experimentation could have students following a guided procedure or be more open-ended where students develop their own procedure to come to a solution. The defining variable of these types of activities is that students are "discovering" knowledge that is new to them on their own and not being directly taught by a teacher or a peer. An example of a discovery-based lesson is answering the question: what occurs when you combine dish soap, hydrogen peroxide, and potassium iodide? Answering this question could lead students to experimentation or research.

Teachers use discovery based activities to teach research and experimentation skills. In discovery based activities, students learn research skills while exploring, experimenting, and finding answers to problems set forth by a teacher or by the students themselves. These research skills include literature search skills, various methodologies to perform research and experiments, and ways to interpret and disseminate data (Thomas, 2003).

Teaching

Teaching activities are described as a student taking the role of an educator to impart knowledge onto others. The student becomes the teacher in these activities facilitating the lesson, and ensuring the knowledge and skills they are attempting to pass on to the learners are being understood. An example of a teaching activity is a student teaching a class about his or her overall science fair experiment and its results.

Teaching based activities are used to inform students how to communicate effectively in order to pass knowledge onto others. Students learn how to organize their ideas and thoughts, plan for speeches and the use of visuals, create the right environment where those listening will understand, and present themselves in a teaching based activity (Talley, 2010; Reynolds, 2010).

Performing

Performing based activities emphasize students doing or performing a specific learned skill as a result of instruction. Students demonstrate their ability to apply their knowledge rather than imparting their knowledge onto others in teaching based activities. Performance based activities can include taking an exam as students are applying their knowledge to answer questions. Performing based activities can also include performing a skit or a play. In the skit or play, students can demonstrate their knowledge of a specific content area. The students could also showcase a learned skill in the skit or play such as the ability to use a microscope.

Teachers can use performing based activities to teach students how to execute a plan or perform at a specific moment in time. Students can display their own understanding of a topic in a performing based activity. Students can display their own ability on a multiple-choice exam, or add their own understanding and interpretation on a written exam. Also, in a skit or a play, students may add their own expression or interpretation while performing and displaying their understanding of a topic.

Caretaking

Caretaking activities address the concern for the wellbeing of something or someone. They involve actions that can be nurturing, giving, or service oriented. These types of activities include spending time with living things: helping an elderly person; raising a child; taking care of a pet; watering a plant. Caretaking activities can also involve actions that are about maintaining the upkeep of something or someplace. An example of maintaining would be changing the oil in a car.

Teachers can use caretaking activities to teach about the importance of maintaining the overall health of another person, place, or thing. In caretaking activities, students can learn how to care for someone or something as it moves through its life cycle. This would include teaching students about having an awareness of what it means to meet the changing needs of a person or object at various stages of its life. Caretaking activities also include learning about empathy (Lee, Chang, & Chen, 2007). Activities teaching empathy would involve learning how to understand other's perspectives, and learning how to distinguish between one's own perspectives and the perspectives of others (Barnett, 1987).

Combination

The seven groups of activities have been defined separately, but specific activities used in the classroom are typically described by more than one of these groups. A specific example of an activity that is described by more than one group is an experiment involving multiple students determining which color light does a plant grows best under.

Students are collaborating working in groups, and they are discovering the outcome by setting up and conducting an experiment. The activity also involves caretaking as students are attempting to grow plants. Another example of an activity that is described by more than one group is a challenge to students to build the fastest car with the use of a mousetrap as its “engine.” Students are creating and making by building a mousetrap racecar. They are also competing as each student races their car against other students. This activity also has the potential to be defined by the discovery group as students could discover through their observations which mousetrap racecar design is the fastest.

A student who has mastered the skills from all seven activity groups would have a competitive advantage over another student who had a deficiency in one or more of these areas. In other words, a student who knows how to work in groups, compete and be resilient, work and build with their hands, research and explore answers to questions, communicate information effectively to others, execute a plan, and maintain the health of themselves and others would possess a complete composite of skills that would allow them to the flourish in their field at a higher level over another student who lacked one or more of these skill sets. This notion can be used to motivate teachers to diversify their curriculum to ensure their students are learning the skill sets from all seven activity groups.

Analysis of Science Curricula

884 activities in 14 different science books and 4 modules from a week-long summer STEM camp were analyzed using the FOCIS framework. An activity was considered analyzable if it was not part of the main chapter dialog text, but was an extension or feature linking the content being described in the dialog text to a separate

activity. Visually speaking, analyzable activities were seen in an outlined box. The protocol for this analysis first involved reading through each activity to determine student procedures, goals, and objectives. Then, each activity was screened for descriptions that matched the seven FOCIS activities. If a FOCIS activity description matched the activity in a science book or summer STEM camp, it was labeled as “Yes” signifying that FOCIS activity’s presence. If a FOCIS activity description did not match the activity in a science book or summer STEM camp, it was labeled as “No” signifying that FOCIS activity’s absence. An activity could be described as possessing more than one FOCIS activity description (see Table 2-1).

All 14 science books and the summer STEM camp were found to have a presence in all 50 U.S. states, and are indicative of science curricula presented to K-12 students in formal and informal settings. The science curricula in this analysis are from McGraw Hill/Glencoe, Pearson, Holt McDougal, Project WET, and Camp Invention. Analysis focused on person-to-person activities and did not include online lab activities.

McGraw Hill/Glencoe

McGraw Hill Education is a textbook and digital learning company that provides educational content, software, and services for pre-K through postgraduate education. The company boasts itself, as of the date of this study, as having more than 11 million people using more than a thousand of their titles in all 50 U.S. states and in over 40 countries. Glencoe represents McGraw Hill’s secondary education division.

523 of the 884 activities were found and analyzed using the FOCIS framework in 7 McGraw Hill/Glencoe science books: Science: A Closer Look Grade 1 (2011), Science: A Closer Look Grade 3 (2011), Science: A Closer Look Grade 6 (2011), Integrated

iScience Grades 6-8 (2012), Glencoe Physical Science Grades 9-10 (2012), Glencoe Biology (2012), Glencoe Chemistry: Matter and Change (2013). All activities in the elementary and middle school science books were analyzed, while only the end of chapter activities were analyzed in the high school science books. Activities labeled as "labs" and embedded within the high school science book chapters were found not to be hands-on but rather asking students to interpret data presented on the page.

Analysis showed most activities having a *discovering* based component to them. More specifically, most activities had students investigating, researching, or experimenting to find an answer to a question. Furthermore, all activities presented in all three McGraw Hill/Glencoe high school science books had descriptions that matched a *discovering* based lesson. *Creating and making* activities were present in approximately 1 out of every 6 activities in the elementary and middle school science books, in 1 out of every 3 activities in high school physical science book, but in only trace amounts in the high school biology and chemistry books. *Collaborating* was suggested in a quarter of the activities in the middle school Integrated iScience book, in just over 1 out of 5 activities in the high school biology book, but in only small amounts in the remaining books. *Teaching, caretaking,* and *performing* based activities played minor roles in most of the science books, and in the cases of high school chemistry and physical science books were not present at all. There were no *competing* based activities in any of the 523 activities.

McGraw Hill/Glencoe Science: A Closer Look Grade 1

The activities and investigation labs in this book appeared in two forms. The Explore Activities appeared at the beginning of each lesson. Three or four lessons made up an entire chapter. Therefore, there were three or four Explore Activities per chapter. Explore Activities were meant to introduce new content to the learner. The other form of activities were called Quick Labs. One Quick Lab was embedded in each lesson. The Quick Labs were intended to reinforce current content being read and studied.

> *Sample Activity*: Students are introduced to magnets in lesson 4 Magnets of chapter 11 On the Move on page 381. The Explore Activity asks students what will a magnet pull. First, students make predictions by placing objects they think a magnet will pull into one pile and objects they think a magnet will not pull into another pile. Second, students investigate the effect of the magnet by placing it close to different objects to see what happens. Third, students classify the objects by dividing ones pulled by the magnet and ones not pulled by the magnet. Finally, students describe the objects pulled by the magnet.
>
> *FOCIS Analysis*: This magnet activity is solely a *discovering* based activity. Students investigate what objects move in the presence of a magnet. Then, students describe the common characteristics of the affected objects to determine what future objects will be pulled by a magnet. Students are not *performing, caretaking, creating and making, competing, teaching,* and *collaborating.*

McGraw Hill/Glencoe Science: A Closer Look Grade 3

The activities and investigation labs in this book appeared in three forms. As in Science: A Closer Look Grade 1, there were Explore Activities at the beginning of each lesson and Quick Labs embedded in each lesson. In addition, there were activities called Inquiry Skills and Investigations at the end of each chapter. These activities were used to engage students with content from the entire chapter.

> *Sample Activity*: Students are asked what a seed needs to grow in the opening activity of lesson 1 Plant Life Cycles of chapter 2 Living Things Grow and Change on page 69. The Explore Activity asks students to form a hypothesis on whether or not seeds need water to grow. Then, students are asked to place 3 seeds on a damp paper towel inside a plastic bag and 3 seeds on a dry paper towel inside another plastic bag. Once the plastic bags are sealed, students observe the seeds over the next few days and record what they see. If the original damp paper

towel appears dry, students are asked to dampen it again. Finally, students draw conclusions based on which seeds changed.

FOCIS Analysis: This seed growth investigation is a *caretaking* and *discovering* based activity. Students are *caretaking* by growing seeds and maintaining a damp paper towel within the "water" group. Students are also *discovering* by investigating whether seeds need water to grow. Students are not *performing, creating and making, competing, teaching* and *collaborating* in this activity.

McGraw Hill/Glencoe Science: A Closer Look Grade 6

The activities and investigation labs in this book appeared in the same three forms as in Science: A Closer Look Grade 3.

Sample Activity: Students build a model displaying the movement of blood through a vein. This activity is a Quick Lab in middle of lesson 4 Animal Systems of chapter 1 Classifying Living Things on page 63. The "vein-valve model" is made by students taking a paper tube and placing two paper inserts into slits made on opposite sides of the paper tube. Students pour beans down the tube to represent the flow of blood. Students pour beans from both ends and explain their results.

FOCIS Analysis: This activity is solely a *creating and making* activity. After reading about the direction of blood flow in the text, students build a model to simulate one-way valves that keep blood flowing in one direction. This activity is not a *discovering* based activity because students have already been presented with the content. Students are also not *performing, caretaking, competing, teaching*, and *collaborating.*

McGraw Hill/Glencoe Science: A Closer Look Integrated i Science Grades 6-8

The lab activities in this book appeared in four forms. Each lesson began with an Inquiry Launch Lab. Inquiry Launch Labs served as introductions to new content. Each lesson also had an Inquiry MiniLab. Inquiry MiniLabs were intended to reinforce current content being read and studied. At the end of each chapter, which were made of two to four lessons, were Inquiry Labs. Inquiry Labs were used to engage students with content from the entire chapter. The final form of lab activities were Inquiry Skill Practice labs.

These labs focused on improving skills such as making predictions, making observation, following procedures, analyzing data, and comparing and contrasting data. The 13 Inquiry Skill Practice labs appear periodically throughout the fifteen chapter book.

> *Sample Activity*: Students are asked to explore and research different kind of waves. They are also asked how can they use different waves to perform an entertainment show. This Inquiry Lab called “Check the sound! Cue the lights!” is at the end of Chapter 14 Waves, Sound, and Light on page 476. Students work in groups to research different kind of waves. Once they’ve discovered several types of waves, they decide on a concept or idea around which they will focus their show. They lay out how they will use the types of waves in the show, develop a script, and assign different roles for each group member. The students perform their entertainment show about types of waves in front of the class.
>
> *FOCIS Analysis*: This activity brings FOCIS components of *discovering, collaborating,* and *performing*. Students are working in groups as they research and discover types of waves. Then, students apply what they’ve discovered about waves into making an entertainment show. Students perform what they have learned to an audience.

The end of chapter lab activities were analyzed in three Macmillan/McGraw Hill/Glencoe high school science books: Macmillan/McGraw Hill/Glencoe Biology, Macmillan/McGraw Hill/Glencoe Chemistry, Macmillan/McGraw Hill/Glencoe Physical Science.

McGraw Hill/Glencoe Biology

> *Sample Activity*: Students are asked how the effectiveness of antibiotics can be tested. This lab activity is presented at the end of Chapter 18 Bacteria and Viruses on page 533. Students work in small groups of 2 or 3 to design an experiment to test the effectiveness of different antibiotics. Groups are given bacteria cultures, sterile nutrient agar, petri dishes, antibiotic disks, control disks, forceps, a Bunsen burner, marking pen, cotton swaps, 70% ethanol, and an autoclave disposal bag. Groups perform further research on causes of bacterial resistance. Finally, groups make a poster to display their results and inform the general public about the importance of taking all prescribed antibiotics given to you by a doctor.

FOCIS Analysis: This antibiotics lab activity involves FOCIS components of *discovering, collaborating,* and *teaching*. Students test and discover how effective the antibiotics are on bacteria cultures. Students are working in small groups during this experiment. In the final phase of the activity, students display and teach what they've discovered to others.

McGraw Hill/Glencoe Chemistry

Sample Activity: Students are asked how the positions of valence electrons affect the shape of a molecule and its covalent bonds. This lab activity is presented at the end of Chapter 8 Covalent Bonding on page 272. Students draw Lewis structures and build three-dimensional plastic models with the help of a molecular model kit. Drawings and models are used to answer the lab activity question.

FOCIS Analysis: This molecular model activity is a *discovering* and *creating and making* based activity. Students create models of molecules with the help of a molecular model kit. Students use both their molecular models and drawings of Lewis structures to explain and discover valence electron location patterns.

McGraw Hill/Glencoe Physical Science

Sample Activity: Students are asked how the behaviors of series and parallel circuits compare. This lab is presented at the end of Chapter 6 Electricity on page 192. Students are given a 6-V dry cell battery, small lights with sockets, short pieces of insulated wire, aluminum foil, paper clips, and scissors. Students work in groups and set up series and parallel circuits to answer the leading lab activity question.

FOCIS Analysis: This circuits activity is a *discovering*, *collaborating*, and *creating and making* based activity. Students working in groups create and setup a variety of circuits. Students use the variety of circuits to discover which one causes brighter light bulbs.

Pearson

Pearson is an education publishing and assessment service to corporations, schools, and directly to students. Pearson provides educational materials in all 50 U.S. states and operates in over 70 countries. All 228 activities in four Pearson science books were analyzed using the FOCIS framework: Interactive Science Grade 1 (2012), Interactive Science Grade 3 (2012), Interactive Science Grade 5 (2012), Pearson Miller & Levine Biology (2010).

The analysis of the Pearson science books showed a similar pattern seen in the McGraw Hill/Glencoe science books. There was a ubiquity of *discovering* based activities across most activities in all of the Pearson science books. *Creating and making* activities were present in approximately 10 to 15% of elementary science book activities but only 8% of high school biology activities. *Collaborating* based activities increased with grade level but only each 17% in the high school biology. *Caretaking* based activities were more of a presence in the Pearson science books. Despite only occurring in 6% of the Interactive Science Grade 5 book, the remaining books showed *caretaking* in 10 to 13% of the activities. *Teaching, performing, and competing* based activities showed little to no sign of being part of any of the activities in the Pearson science books.

The activity labs in Pearson Interactive Science books Grade 1, 3, and 5 appeared in five forms. Try It! activities were at the beginning of each chapter and were intended to prepare students for the upcoming science content. Explore It! activities were at the beginning of each lesson and were intended to introduce new content. Each chapter had three to six lessons. Thus, there were many Explore It! activities. A Design It! activity appeared once in the book as students used an engineering design process to find solutions to a presented problem. Investigate It! activities appeared at the end of each chapter and were intended to cover content studied in the chapter. The book defined these as direct inquiry labs where students were given a research question and a procedure to follow, but were not given the final outcome. Apply It! activities appeared periodically at the end of chapters. The book defined the Apply It! activities as open inquiry labs where students were challenged with developing their own experimental procedure to answer a research question.

Pearson Interactive Science Grade 1

Sample Activity: Students are asked to investigate what a cricket needs to survive. This Try It! activity is presented at the beginning of Chapter 3: Living Things and Their Environments on page 84. Students observe a cricket in a terrarium over the course of four days looking at how it behaves, what it eats, and what it drinks. They also ensure there is water in a small dish in the terrarium. Students record their observations in a table and then explain their results.

FOCIS Analysis: The cricket observation activity is a *discovering* and *caretaking* based activity. Students are finding out what are the behaviors and survival needs of crickets over the course of several days. They are also maintaining a level of water in the terrarium over this same time period.

Pearson Interactive Science Grade 3

Sample Activity: Students are asked why we see phases of the Moon. This Investigate It! activity is presented at the end of Chapter 7: Earth and Our Universe on page 179. Students make a model of the Moon phases by hanging a white stryofoam ball inside a cardboard box. They first glue black paper to the inside of the box and lid. Then, they poke one hole on each side of the box. Then, students tape a flashlight to the end of the box so it shines inward. Finally, students attach a white stryofoam ball and thread to the inside of the cardboard lid before closing it. Students look through the holes to see “Sun” light on the “Moon” from different angles to help explain why we see phases of the Moon.

FOCIS Analysis: The Moon phase model activity is a *creating and making* and *discovering* based activity. Students use their hands to build a model of the Moon phases with the inside of a cardboard box representing the night sky, a flashlight representing the Sun, and a stryofoam ball representing the Moon. Students interpret views of the Moon from different angles to explain why we see phases of the Moon.

Pearson Interactive Science Grade 5

Sample Activity: Students are asked how the speed of a meteorite affects the crater it makes upon impact. This Apply It! activity appears at the end of Chapter 9: Earth and Space on page 284. Students design an experimental procedure to answer the activity question. They are given a metal marble, flour, a meter stick, and a calculator. Students observe flour crater characteristics and sizes created from the impact of the metal marble traveling at different speeds. Students share their results with others in the class.

FOCIS Analysis: This meteorite lab is a *discovering* based activity. Students design their own experiment and run tests to find the answer to how the speed of a meteorite affects the crater. It could also be considered a *creating and making* activity as students' procedure results in a model of a crater that can be studied and compared to actual craters.

Pearson Biology

The Pearson Biology book by Miller and Levine (2010) had Quick Labs and Design Your Own Labs littered throughout its thirty-five chapters. Quick Labs were structured so that students were presented with a question and a procedure to follow, but students were not given the results or answer to the question. Design Your Own Labs were structured so that students were presented with a research question but were expected to develop their own experimental procedure to find potential answers to research questions.

Sample Activity: Students are asked to investigate where growth occur in plant roots. This Design Your Own Lab is presented in Chapter 23: Plant Structure and Function on page on page 723. Students are given a 150mL beaker, paper towels, large bean seeds, petri dish, masking tape, metric ruler, fine-tip permanent marker. Students grow the bean seeds. Once roots appear, they mark a root at two points along its length. Students observe the marks on the roots to determine where growth is occurring.

FOCIS Analysis: This plant root activity is a *caretaking* and *discovering* based activity. Students grow and care for bean seeds over several days in order to observe root growth patterns. Students research where growth occurs on the roots.

Holt McDougal

Holt McDougal is an American publishing company that specializes in secondary education textbooks. As a division of parent company Houghton Mifflin Harcourt, Holt

McDougal is part of a large network that reaches to over 60 million students in 120 countries. 47 activities in 2 Holt McDougal secondary science books were analyzed using the FOCIS framework: Modern Chemistry (2012), Physics (2012).

Analysis of the Holt McDougal science books showed very little diversity in the types of activities presented to students. 46 of the 47 activities were *discovering* based, and of those 8 of them were also described as being *creating and making*. *Collaborating*, *teaching*, *caretaking*, *performing*, and *competing* based activities showed little to no sign of being part of any of the activities in the Holt McDougal science books.

Holt McDougal Modern Chemistry

The Holt McDougal Chemistry book by Sarquis and Sarquis (2012) had twelve lab activities called Quick Labs. These lab activities appeared periodically throughout the twenty-three chapter book and were intended to provide hands-on activities to highlight the content being studied. The book also provided Online Labs that students could use to study content material, but were not analyzed in this study.

> *Sample Activity*: Students discover the meaning of limiting reactants. This Quick Lab activity is presented in Section 3: Limiting Reactants and Percentage Yield in Chapter 9: Stoichiometry on page 297. Students make a batch of cookies. Students are then given larger amounts of ingredients, but not at the same increased ratio amounts. Students determine how many cookies will they yield and determine which ingredient will result in the fewest number of cookies (i.e. the limiting reactant).
>
> *FOCIS Analysis*: This limiting reactant activity has FOCIS components of *creating and making* and *discovering*. Students are making cookies using collected ingredients. Students make a second, but larger batch of cookies. Students must investigate or discover what the limiting reactant is while determining the number of cookies made in the second batch.

Holt McDougal Physics

The Holt McDougal Physics book by Serway and Faughn (2012) had Quick Labs and additional labs that followed STEM related articles. The thirty Quick Labs appeared periodically throughout the twenty-two chapter book and were intended to provide hands-on activities highlighting the content being studied. The other five labs followed STEM related articles. They were intended to apply the content from the chapter to a real life scenarios. The book also provided Online Labs that students can use to study content material, but they were not analyzed in this study.

> *Sample Activity*: Students discover their own reaction time. This lab activity is presented in Section 3: Falling Objects of Chapter 2: Motion in One Dimension on page 58. Students determine their reaction time having another student hold a meterstick vertically between the thumb and index finger of their open hand. Without warning the student being tested, the other student releases the meterstick. The student being tested tries to catch the meterstick as quickly as possible. Students can calculate their reaction time from free fall acceleration and the distance the meterstick has fallen through their grasp.
>
> *FOCIS Analysis*: This reaction time activity is a *collaborating* and *discovering* based activity. Students work in pairs to test each other's reaction time to stop a meterstick from falling through their hands. Students discover their own reaction time and their partner's reaction time.

Project WET

A non-profit organization, the Project WET Foundation has dedicated itself to reaching out to children, parents, teachers, and community members with water education. The Project WET Curriculum and Activity Guide for K-12 students is a collection of hands-on water related activities. Project WET is present in all 50 U.S. states and in over 65 countries around the world. All 86 student activities were analyzed in the Project WET Curriculum and Activity Guide.

Analysis showed a diverse group of activities presented to students by Project WET. While *discovering* (76%) and *collaborating* (70%) components were present in the majority of activities, *creating and making* (29%) and *performing* (26%) also had strong presences in the Project WET activities. *Competing* based activities (20%), not seen in the for-profit science books, appeared in many activities. *Teaching* (7%) and *caretaking* (1%) components were only present in a few activities.

> *Sample Activity #1*: Students compete in a water Olympics to investigate two properties of water: adhesion and cohesion. The name of the activity is called H_2Olympics on page 30. Students divide into small teams and compete in five different water related events. The first event entails seeing how many pennies a team can add to a full cup of water before it overflows. In the second event, students see how many drops of water they can place on a penny before the water spills over. The third event requires students to design and make small, flat, cardboard boats that are powered by soap chips coming in contact with water. Students see which boat travels the fastest. The fourth event entails seeing how many paperclips a team can suspend on the surface of water before they sink. In the final event, students choose a brand of paper towel they think will absorb the most. To summarize the activity, students are asked to explain the role of adhesion and cohesion.
>
> *FOCIS Analysis*: The H_2Olympics activity is a *competing, collaborating, discovering,* and *creating and making* based activity. Students are competing in five different events. They are also competing on small teams. Students are observing and discovering the adhesion and cohesion properties of water during the competition. Finally, the fourth event challenges students to design and make a small cardboard boat to compete in a boat race.
>
> *Sample Activity #2*: On page 89, students are introduced to a bog. Students construct a classroom bog and a small composter to observe the rate of decomposition in anaerobic and aerobic environments. Students work in large groups to make a permeable bog by layering perlite, gravel, activated charcoal, compressed peat, and sphagnum moss. Students place buried artifacts at different layers. Students also include a small reservoir of water and plant various plants throughout the bog. Students make predictions of what will happen to the artifacts. They make observations at regular intervals to find out the results.
>
> *FOCIS Analysis*: The bog activity is a *collaborating, caretaking, discovering,* and *creating and making* based activity. Students work in groups to construct a small bog. Students care for plants over the course of the semester. They also provide

water to the bog on a regular basis. Students use this model of a bog to investigate decomposition rates of buried artifacts.

Sample Activity #3: On page 166, students participate in a whole body activity as they investigate how vegetation affects the movement of water over land surfaces. Students act out how raindrops move down a hill in the presence of vegetation. Some students are assigned the role of raindrops and try to move down the hill. Other students act as vegetation and tag and spin raindrops as they move past. The students then act out how raindrops move down a hill in the absence of vegetation. Some students are assigned the role of raindrops while others act as small rocks. Raindrop students jump over small rock students as they move down the hill.

FOCIS Analysis: The movement of water activity is a *performing, collaborating,* and *discovering* based activity. Students are role-playing the different affects vegetation and small rocks have on the movement of water. Students act out this activity as one large group

Camp Invention

Created by the National Inventors Hall of Fame and partnered with the United States Patent and Trademark Office, Camp Invention is a week-long STEM summer enrichment camp for students entering grades one through six. As a non-profit program, it currently has 1100 camps in all 50 U.S. states serving approximately 77,000 kids each summer.

At Camp Invention, students rotate through four modules a day where they work in teams to engage in investigations, experiments, and engineering challenges. The four modules in the 2012 summer camps were called *Gadget Garage, Inventeureka, Magnetropolis*, and *I Can Invent: Balloon Burst.* Analysis of Camp Invention using FOCIS as a framework took a two-step approach. First, the FOCUS Rubric was used to find descriptions of the FOCIS activities within the written curriculum. Second, eight hours of observations were done on Camp Invention over the course of one day. Each module was observed to confirm written curriculum analysis.

Analysis of Camp Invention showed most activities having a combination of *creating and making*, *performing, discovering,* and *collaborating*. Occasionally, characteristics of a *competing* based activity appeared, but did not have a strong presence. *Teaching* and *caretaking* showed little to no sign of being part of the week-long STEM curriculum of Camp Invention.

Gadget Garage

In Gadget Garage, students were introduced to a new item and how it worked each day. Students were later asked to design and build a gadget using the introduced item. For example, students were introduced to small electrical motors and then were asked to design a ride at an amusement park using the motors. In the backdrop of Gadget Garage lied a role-playing scenario of being on the set of a mock studio where students were offered the chance to talk about their gadget creation into a fake studio camera.

Instructors were encouraged to use the Creative Problem Solving (CPS) process, developed by Alex Osborn in the 1950s, to help students achieve goals and overcome obstacles and challenged. The CPS process includes three stages: the Clarification stage where students make sure they are solving the right problem, the Transformation stage where creative solutions are generated and tried out, and the Implementation stage where solutions are decided upon and are accepted for their situation.

> *FOCIS Analysis:* Gadget Garage activities were *creating and making, performing, teaching, discovering, competing,* and *collaborating* based. *Creating and making* was the main focus of the Gadget Garage module. After learning about an item, whether that be motors, circuits, alarms, or LED lights, students were asked to design and create a gadget using these items.
>
> Students were involved in many performance and acting situations in Gadget Garage. Students role-played by acting as crew members of a mock studio and pretended to film a show called Gadget Garage. Students rotated crew

member roles and positions so every student had an opportunity to play lead and supportive roles in the mock studio. Students also showcased their creations within this mock studio giving the students a chance to teach others about what they made.

Students engaged in a variety of discovery and experimental activities. They took apart items brought in from home. For example, students brought in old computers, which they took apart and discovered how they worked. Spare parts from items brought in were later used to design and build a gadget. Students also discovered and experimented with how gears, circuits, alarms, and LED lights work.

There were a couple of competitive aspects of Gadget Garage. The first day of the camp included a race to see which group could pick up their scattered materials the quickest using a selected gadget. Gadget Garage moved away from competitive situations during the week, but revisited them on the final day when team members gave feedback and voted on one gadget from their group to showcase in the final mock show Gadget Grammys Award Show.

There were many occasions for collaboration between students during Gadget Garage. Class discussions occurred during discovery and experimentation of content items. These content items included gears, circuits, alarms, and LED lights. Students also worked in groups of three during their daily challenge of building a gadget. Students collaborated and shared ideas as they decided on which gadget design they would construct.

Inventeureka

Students were exposed to various role-playing activities where they pretended to travel around the world and through time to learn about various inventions in Inventeureka. Students learned that many inventions were made to meet certain needs of society. They were asked to think of a societal need and begin creating an invention. Throughout the week, students continued to enhance their inventions, eventually meeting the needs of a particular audience member.

FOCIS Analysis: Inventeureka activities were *creating and making, performing, discovering,* and *collaborating* based. There was one brief *competing* based activity, but it was not a focus of the module. As with Gadget Garage, *creating and making* was the main focus of Inventeureka. Students were exposed to stages of inventing something new. They began the week by creating a prototype of an invention that met a societal need of their choosing. As the week progressed, new requirements and situations were added that forced students to enhance and adapt their prototypes.

There were several performance related activities in Inventeureka. Students role-played as they imagined flying around the world and through time to learn about specific inventions. Once creating and making time began, students were assigned roles to play within their team that they maintained throughout the week. Students were either “drivers” who acted as the management of the group making sure everyone was progressing, “dreamers” who generated new ideas for the group, “mechanics” who fixed things, or the “toolbox” who were in charge of inventory.

Students participated in a few experimental activities. They investigated principles of flight, experimented with photoluminescent material and ultraviolet light, and discovered what Chindogu inventions are, and were given the opportunity to make one of their own.

Students worked in groups of four or five almost the entire week. Students were encouraged to discuss topics, shared their invention ideas, and talked about how their group could enhance and adapt their invention to the changing daily requirements.

There was only one brief competitive activity in Inventeureka. On the first day, students designed, made, and tested their own paper airplane. Students competed to see which paper airplane flew the farthest. The majority of the activities in Inventeureka were non-competitive as students continued to enhance and adapt their inventions to new situations.

Magnetropolis

Students designed and built an entire city while being encouraged to use properties of magnetism and electromagnetism. Students used recycled items brought in by themselves and other student to construct their city. As a playful backdrop, instructors infused role-playing into the lesson as the class searched for the lost island of Magnetropolis via student designed boats. Once on the island, students took on roles of miners, designers, and construction workers as they built up their city.

FOCIS Analysis: Magnetropolis activities were *creating and making, performing, discovering,* and *collaborating* based with a small amount of *competing*. Students began the week designing and creating a boat out of clay and paper. Later, students built a city out of recycled materials while being encouraged to use the properties of magnets in the city design.

> There is only one competitive activity in Magnetropolis. On the first day, students designed, built, tested, and raced their own clay and paper boats. Students competed to see which clay and paper boat was the fastest across a small pool.
>
> Students were performing role-playing based activities throughout the week. Students were told to take on roles as explorers, designers, miners, and construction workers.
>
> Students learned about a few science content items and experimentation. Students explored the concept of buoyancy as they created clay and paper boats. Students also discovered how compasses work, explored magnet properties, levitated magnets, and created a nonstandard measurement system of magnet force strength.
>
> Students worked in pairs during the boat competition, but worked in larger groups as they began designing and building their city.

I Can Invent: Balloon Burst

Students spent the week using recycled materials to create an invention that burst a balloon. These inventions took the form of a cause-and-effect machine where energy was transferred in each step of the machine. These machines were called Rube Goldberg machines. Students were challenged to construct a machine that had many steps but still completed the task of bursting a balloon.

> *FOCIS Activity*: I Can Invent: Balloon Burst activity was a *creating and making, performing, discovering,* and *collaborating* based activity. *Creating and making* was also the main focus of this module. Students used recycled materials to build a machine that would burst a balloon. At the end of the week, students would display their machine by running it in front of an audience, making the activity *performing* based too.
>
> Students discovered the meaning of potential and kinetic energy through the use of capacitors, an item given to them during the week to use in their Rube Goldberg. Students' use of trial-and-error to see what design pieces worked and which ones didn't brought a *discovery* component to the activity. Students constantly tested the steps of their machine as they progress through the construction process.
>
> Collaborating was constantly taking place as students progressed through building their machine. Students shared ideas, gave feedback, and asked questions to their teammates as they added steps to their machine.

Overall Comments

Characteristics of *discovering* were present in most activities across all science curricula analyzed. This should come as no surprise as students in most disciplines are investigating, researching, and experimenting to find answers to questions. However, there were stark differences in the diversity of activities between for-profit companies (McGraw Hill/Glencoe, Pearson, Holt McDougal) and the non-profit companies (Project WET, Camp Invention). The activities from the for-profit companies showed little diversity as they mainly focused on only *discovering* based activities that did not include components from one of the other six types of activities. A few possibilities of this *discovery* based activity focus are for-profit companies following market trends, schools' and teachers' expectations, or learning and testing standards. Also, the science books from for-profit companies are written for teachers and not for students. On the other hand, activities from the two non-profit organizations showed more diversity, often having characteristics from four or more FOCIS groups. Although Project WET and Camp Invention have a large presence across the U.S., they do not represent the entire population of non-profit organizations distributing STEM curricula to K-12 students. Also, Camp Invention is an informal STEM camp with a constructivist mindset as students learn by doing. Instructors in Camp Invention have more time to plan and implement the material in a more interesting method than in the formal classroom. Overall, these non-profit results showed stark contrasts and could be used as a spring board for further research in the type of science curricula being presented to K-12 students both in formal and informal settings.

Attitudes

Value of science in society, self-concept, and *enjoyment and desire* are the three student-reported attitudes in this study explored in relation to the seven FOCIS activity groups. *Value of science in society* is a belief in the value of knowing science. *Self-concept* evokes a positive feeling toward a students' ability to do science. *Enjoyment and desire* show both positive emotions toward science and a disposition toward doing science and relate to the affective component and behavioral component of attitude theory respectively.

Attitudes have been defined in similar ways: "a favorable or unfavorable evaluative reaction toward something or someone, exhibited in ones beliefs, feelings, or intended behavior" (Myers, 1999); "a learned tendency to evaluate some object, person, or issue in a particular way" (Hockenbury & Hockenbury, 2007); "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly & Chaiken, 1993).

The three attitudes in this study share characteristics with the affective and behavioral components of the tripartite model of attitude theory: cognitive; affective; behavioral (Myers, 2012; Rosenberg & Hovland, 1960). The components of attitude were proposed by Rosenberg and Hovland (1960) in a tripartite model stating that attitude is assessed through three different reactions to an object, situation, or person. These three reactions are cognitive, affective, and behavioral. The cognitive component of attitude consists of the knowledge about the object in question. The affective component of attitude is related to a person's feelings about their self or another object, situation, or person. These feelings may be positive, negative, or neutral. For example, a student enjoys her ecology class. Behavioral component of attitude is related to the tendency or disposition to act in certain ways toward something. It is related to the impact of various situations or objects that lead to individual's behavior based on cognitive and affective components. For example, a student wants to continue studying ecology. All three components of attitude tend to be consistent with one another. A change in one attitude component will produce related changes in the other components. A change in beliefs, for example, that lowers a student's perception of science education is likely to lower the level of positive affect attached to a science lesson and reduces any behavioral tendencies that may lead to doing more science.

Value of Science in Society

The *value of science in society* shares characteristics of the affective component of attitude measured in this study. More specifically, this study follows the extrinsic *value of science in society*, described as valuing the application of science to solve society's problems, understand the world around us, help a country's development, and aid in an individual's growth.

Hartman (1967) identified three dimensions of value: systemic; extrinsic; intrinsic. The systemic dimension of value is one of definitions, structured thinking, and technicalities. All ideas in this dimension are either completely filled or do not meet any requirements. There is no middle ground in the systemic dimension. Examples of *values of science in society* in the systemic dimension include numbers, measurements, biological classifications, and Newton's Laws of Motion. Science deals in facts principles, and laws, and these alone make up the systemic dimension of value.

The extrinsic dimension of value is one of comparisons, application, and practicality. It is a type of valuation that involves function, tasks, and processes. The extrinsic dimension of value is described as valuating something as good that leads to something else that is good. Examples of values of science in the extrinsic dimension include the use of force on a lever to lift items, the application of heat to add energy to another item, and viewing science as a whole to help solve world problems.

The intrinsic dimension of value is one of the inherent uniqueness of a person or item that exists within that person or item itself. There are no needed fulfillments of a definition as in the systemic dimension. There are also no comparisons of value as in the extrinsic dimension. The intrinsic dimension addresses values that are beyond what we can see and what is directly apparent to us. An obvious example of an intrinsic value is the love and compassion one has toward another person. This type of value might be considered "priceless" as it is the only one of its kind.

Hartman identified a hierarchy between the three dimensions positioning intrinsic as having the highest quality of value and systemic having the lowest quality of value. For example, a grandfather clock that has been passed down over several generations has intrinsic value and is worth more in value to that family than a new grandfather clock of the same brand. While intrinsic value is of greater value than extrinsic value, in this study we look to the value of science as having a purpose, its helpfulness, and its application. In other words, this study only considers extrinsic value.

Self Concept

Self-concept also contributes to the affective component of attitude measured in this study. It follows one's academic *self-concept*, which is one's perception of their own academic ability. This includes their motivation, comparison to others, and ability to do school work.

Self-concept is a term used to describe how someone thinks about, perceives, and evaluates their self. It is a collection of beliefs about oneself (Leflot, Onghena, & Colpin, 2010), one's own nature, unique qualities, and typical behavior (Weiten, Dunn, & Hammer, 2012). Possessing a strong *self-concept* requires reflection of one's own self and behavior (Higgins, 1991), and is considered to become more organized, detailed, and specific as one gets older (Pastorino & Doyle-Portillo, 2013).

Self-concept is also viewed as an active, interpretive structure that is continually involved in the regulation of one's ongoing behavior (Marcus & Wulf, 1987). Its structure is influenced by intrapersonal processes, such as affect regulations and motivation, interpersonal processes, such as social perception and interaction strategies, and self-regulation processes, such as goal setting and cognitive preparation for action and reflection of one's abilities.

Academic *self-concept* refers to how someone evaluates their own academic ability (Trautwein, Lüdtke, Marsh, & Nagy, 2009). Intrapersonal, interpersonal, and self-regulation processes also influence academic self-concept. One's motivation to do school work influences the intrapersonal academic self-concept process. One's academic comparison to others influences the interpersonal academic self-concept process. One's perception of their ability to do school work influences the self-regulation academic self-concept process.

Enjoyment and Desire

Enjoyment and *desire* contribute to the affective and behavioral components of attitude respectively. *Enjoyment* is a feeling of pleasure caused by someone doing or experiencing something they like (Merriam-Webster, 2013). In other words, a person is enjoying an occurrence if this same person is simultaneously experiencing happiness or pleasure (Davis, 1982). *Enjoyment* contributes to the affective component of attitude as it is related, in this study, to a person's positive feelings toward science.

Desire is a strong feeling of wanting to have something or wishing something to happen (Merriam-Webster, 2013). It is considered to be a fundamental motivation of human behaviors and actions (Custers & Aarts, 2005). *Desire* contributes to describing the behavioral component of attitude as it is related, in this study, to the disposition of doing science.

Enjoyment and *desire* are grouped together in this study because often *enjoyment*, or a feeling of happiness that comes from an occurrence, begets a *desire* to relive the occurrence. For example, a student enjoying learning science will often lead to the student's desire to learn more science.

Students' extrinsic *value of science in society,* academic *self-concept* to do science, and *enjoyment and desire* toward science define the three attitudes in this study. Associations between these three attitudes and the seven FOCIS activity grous students prefer to engage in in their learning are examined.

Measurements of Attitude Toward Science

This study used measurements of student attitudes towards science drawn from the Modified Attitudes Toward Science Inventory (mATSI) (Weinburgh, & Steele, 2000). mATSI examines students' attitudes towards science in five areas. Three of them, *value of science in society, self-concept,* and *enjoyment and desire*, have already been discussed and are included in this study. The other two areas include students‘ uneasiness about learning science and students’ beliefs about their science teachers, and are not included in this study.

Researchers have developed other various measurements for students‘ attitudes towards science. These include the Test of Science-Related Attitudes (TOSRA) (Fraser, 1978), the Scientific Attitude Inventory (SAI II) (Moore & Foy, 1997), and the Colorado Learning Attitudes about Science Survey (CLASS).

The *Test of Science-Related Attitudes* (TOSRA) (Fraser, 1978) measures social implications of science, normality of scientists, attitude towards scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science.

The *Scientific Attitude Inventory* (SAI II) (Moore & Foy, 1997) assesses students‘ perceptions of scientists, becoming scientists, contribution of science to the society, and their interest in science.

The *Colorado Learning Attitudes about Science Survey* (CLASS) Biology, Chemistry, and Physics (Adams, Perkins, Dubson, Finkelstein, & Wieman, 2004) asks for students‘ opinions about multiple facets in learning biology, chemistry, and physics respectively: knowledge connection, social significance, problem solving, scientific thinking, and enjoyment in learning these subjects.

Figure 2-1

Framework for the Observation of Categorization of Instructional Strategies

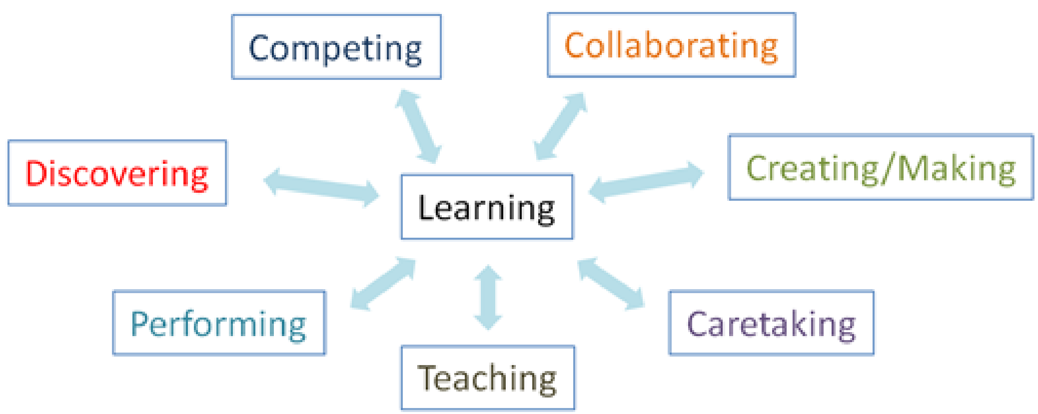


Table 2-1

FOCIS Rubric for Determining Types of Activities in Science Curricula

Activity Title:	
Chapter/Page:	
Does the activity have students…	**YES/NO**
…working in groups of two or more? (*Collaborating*)	
…researching a question, experimenting, problem solving, or answering a question? (*Discovering*)	
…participating in a contest where there is a clear winner? (*Competing*)	
…building a model, making an artifact, or designing and creating something? (*Creating and Making*)	
…attempting to impart knowledge onto others? (*Teaching*)	
…demonstrating a learned skill or ability? (*Performing*)	
…addressing the concern for the wellbeing of something or someone? (*Caretaking*)	

Table 2-2

FOCIS Activity Analysis of McGraw Hill/Glencoe Elementary and Middle School Science Books

FOCIS Groups	Grade 1	Science: A Closer Look Grade 3	Grade 6	Integrated iScience Grades 6-8
Number of Activities	80	101	128	105
Discovering	65 (81%)	87 (86%)	115 (90%)	97 (92%)
Collaborating	1 (1%)	4 (4%)	6 (5%)	25 (24%)
Creating/Making	15 (19%)	15 (15%)	22 (17%)	16 (15%)
Teaching	0 (0%)	0 (0%)	4 (3%)	5 (4%)
Caretaking	5 (6%)	5 (5%)	8 (6%)	5 (5%)
Performing	8 (10%)	7 (7%)	5 (4%)	4 (4%)
Competing	0 (0%)	0 (0%)	0 (0%)	0 (0%)

TABLE 2-3

FOCIS Component Analysis of McGraw Hill/Glencoe High School Science Books

FOCIS Groups	Biology Grades 9-12	Chemistry Grades 9-12	Physical Science Grades 9-10
Number of Activities	37	24	48
Discovering	37 (100%)	24 (100%)	48 (100%)
Collaborating	8 (22%)	2 (8%)	5 (10%)
Creating/Making	3 (8%)	1 (4%)	15 (31%)
Teaching	7 (19%)	0 (0%)	0 (0%)
Caretaking	4 (11%)	0 (0%)	0 (0%)
Performing	2 (5%)	0 (0%)	0 (0%)
Competing	0 (0%)	0 (0%)	0 (0%)

Table 2-4

FOCIS Component Analysis of Pearson Interactive Science Elementary Books

	Pearson Interactive Science		
FOCIS Groups	Grade 1	Grade 3	Grade 5
Number of Activities	47	52	66
Discovering	44 (94%)	48 (92%)	63 (95%)
Collaborating	1 (2%)	4 (8%)	8 (12%)
Creating/Making	4 (9%)	8 (15%)	9 (14%)
Teaching	0 (0%)	1 (2%)	0 (0%)
Caretaking	6 (13%)	5 (10%)	4 (6%)
Performing	0 (0%)	0 (0%)	0 (0%)
Competing	0 (0%)	0 (0%)	0 (0%)

TABLE 2-5

FOCIS Component Analysis of Various High School Science Books

FOCIS Groups	Pearson Biology	Holt McDougal Chemistry	Holt McDougal Physics
Number of Activities	63	12	35
Discovering	56 (89%)	11 (92%)	35 (100%)
Collaborating	11 (17%)	0 (0%)	2 (6%)
Creating/Making	5 (8%)	4 (33%)	4 (11%)
Teaching	1 (6%)	0 (0%)	1 (3%)
Caring	8 (13%)	0 (0%)	0 (0%)
Performing	1 (6%)	0 (0%)	0 (0%)
Competing	0 (0%)	0 (0%)	0 (0%)

TABLE 2-6

FOCIS Component Analysis of Project WET

FOCIS Groups	Project WET
Number of Activities	86
Discovering	65 (76%)
Collaborating	60 (70%)
Creating/Making	25 (29%)
Teaching	4 (7%)
Caretaking	1 (1%)
Performing	22 (26%)
Competing	17 (20%)

CHAPTER 3

Methodology

The goal of this analysis is to address the following research questions using descriptive analyses, confirmatory factor analysis, and structural equation modeling.

1. Do student reported preferences in learning activities predict student reported positive attitudes toward science at the elementary, middle, and high school grade levels?
2. Do these relationships differ across elementary, middle, and high school grade levels?
3. Do these relationships change between the Fall and Spring semesters within a single academic year for students across elementary, middle, and high school grade levels?

FOCIS Survey

The 83 question item FOCIS survey asks students about their involvement in science, preferences toward activities, attitudes toward science, career aspirations, and participation in informal activities. The survey begins with demographic questions prior to asking students how often they've participated in hands-on activities in class in the previous two weeks, have they ever attended a science camp, have they ever attended a math camp, and do they know somebody who has a job in science. The survey continues with seven questions, each pertaining to one of the seven FOCIS activity groups (*collaborating, competing, creating and making, discovering, performing, caretaking, teaching)*. The answer values for these seven questions are dichotomous, either showing an affinity toward or against the addressed FOCIS activity group. The next 28 questions continue to explore students' preferences toward activities. The format for these questions use a Likert scale of five from strongly disagree to strongly agree. There are three to five question items for each of the FOCIS activity groups. The next 17 questions also use a five-scale Likert format to ask students about their attitudes toward science. There are three to four question items for each of the five areas of attitudes (*value of science in society, self-concept, enjoyment and desire,* uneasiness about learning science, students' beliefs about their science teacher). The next to last section asks about their career aspirations. Finally, the last section asks students how often they participate in a variety of science and non-science out-of-school activities, and how interested they are about each one.

The source of the data used in this study focused on the 28 Likert scale questions regarding activities students prefer to engage in and 10 of the 17 Likert scale questions regarding attitudes toward science. The 10 question items about attitude only addressed *value of science in society, self-concept,* and *enjoyment and desire*. The other 7 question items addressed topics not included in this study: uneasiness about learning science and students' beliefs about their science teacher.

Data Collection and Matching Process

Participants of this study were elementary, middle and high school students from four school districts located in urban, suburban, and rural areas. Students ranged from third to twelfth grade. They were given the FOCIS survey once in the Fall of 2012 and a second time in the Spring of 2013 creating six groups analyzed in this study: Elementary Fall 2012; Elementary Spring 2013; Middle School Fall 2012; Middle School Spring 2013; High School Fall 2012; High School Spring 2013.

In the Fall of 2012, 7382 students were surveyed. In the Spring of 2013, a similar number of students were surveyed, but only 5178 students were matched mechanically using Excel and SPSS. The Fall 2012 to Spring 2013 student mechanical matching process took several steps. First, names were split from one field into several fields (last, first, middle) using excel and then imported into SPSS for ease of sorting and searching by name. Then, a separate "ID file" was made that contained all the students and all their demographic info. This file included the fields Case ID through race with additional fields: a "new name" field and a "data period" field that allowed us to keep track of when the data was from: 1 = Fall 12, 2 = Spring 13. This acted as the base file used for matching.

In general, matching was done by sorting and filtering the various variables in SPSS over several rounds. The first round focused on using last name and first name to isolate matches. Date-of-birth, grade, and school were then used to confirm or deny matches. Later rounds included searching for matches using zip code, grade, and school, and then confirmed or denied with last and first name. When a match was found the entire name that was most likely correct from the two data periods, it was entered into the "new name" field for both periods. Picking or creating the "correct" name was mostly objective but occasionally the scanner had issues with certain letters. For example, first and last names sometimes got switched. Original data were always preserved to ensure they could be checked for validity and referenced for subsequent rounds of data collection and matching. The “new name” field also acted as a check mark to acknowledge that a match was made. After the initial round of matching, matched and unmatched data were split into "matched" and "unmatched" files. Matches from subsequent rounds were added to the matched file. 5178 student participant files were found to be matched and were used in this study as the sample size. 1977 of the 5178 were elementary students, 1831 were middle school students, and 1370 were high school students.

Analytic Approach

Analytic approaches used in this study include descriptive analyses, confirmatory factor analysis, and structural equation modeling.

Descriptive Analyses

Descriptive analyses were run on all variables and for background information including grade distribution, gender, and English as a Second Language. These analyses were used to check for central tendency and assumptions regarding confirmatory factor analysis and structural equation modeling. These assumptions included univariate outliers, univariate normality, and multivariate outliers.

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was first used to test whether the data from the observed measures of the survey were consistent with hypothesized model of the FOCIS framework. CFA was also used to confirm the data from the observed measures were consistent with the hypothesized model on the three attitudes. Each of the seven FOCIS activity groups and the three attitudes toward science in their respective CFA models were considered latent constructs and were each defined by three to five observed variables. These observed variables were question items of five point Likert scale values. In the analysis, negative statements were coded reversely to ensure consistency with other observed variables. STATA 13 statistical software was used to construct the CFA FOCIS and attitude models.

A Chi Squared analysis was run on the models. Chi Squared indicated the difference between the observed measures and the hypothesized covariance matrices. Due to Chi Squared sensitive nature to sample size, in this case of a large sample size (n = 5178) may have led to Type II error as it may have failed to find a model that fits, other measures of fit were used.

Comparative Fit Index (CFI) was used to measure fit for each hypothesized model. CFI measures model fit by comparing the hypothesized model with a baseline model. A baseline model works as having all observed variables uncorrelated. CFI values close to 1 indicate a very good fit. CFI values should be equal to or greater than 0.90 to accept the hypothesized model. Root Mean Square Error of Approximation (RMSEA) was also used to measure fit for each of the hypothesized models. RMSEA measures model fit by comparing the hypothesized model with a perfect saturated model. A saturated model perfectly reproduces all of the variances, covariances, and means of the observed variables. RMSEA values less than 0.06 indicate a good fit. RMSEA values greater than 0.10 indicate a poor fit. Finally, Standardized Root Mean Square Residuals (SRMR) was also used to measure model fit for each of the hypothesized models. SRMR measures the standardized difference between the observed correlation and the predicted correlation. SRMR shows a value of zero indicating a perfect fit. A value less than 0.08 is considered a good fit (Hu & Bentler, 1999).

FOCIS CFA Models

Each of the seven FOCIS activity typologies were considered latent constructs and were each defined by three to five observed variables in the hypothesized CFA models. A FOCIS CFA model was run for each grade and time: Elementary Fall 2012; Elementary Spring 2013; Middle School Fall 2012; Middle School Spring 2013; High School Fall 2012; High School Spring 2013. *Figure 3-1* displays the hypothesized model of the seven latent constructs and their observed variables. The hypothesized model is constructed by correlating all the seven latent constructs together. The following describes the latent constructs and their observed variables.

The *collaborating* latent construct was defined by four observed variables. Feelgrp: I like an activity that involves being in a group. Wrkothers: Working with others is more fun than working alone. Partteam: I like being part of a team. Lrnothers: I learn better when I am working with others.

The *competing* construct was defined by four observed variables. Feelcmpt: I like an activity that involves being in a competition. Exctcmpt: I get excited when I hear there will be a competition. Cmptothr: I enjoy competing against other people. Reverse coded Focusown: I like to focus on my own goals, rather than competing with others.

The *creating and making* construct was defined by four observed variables. Feelmkbd: I like an activity that involves making or building things. Likemake: I like doing projects where I make things. Resrcfull: Whenever I can, I make things I need. Likebld: I like building things.

The *discovering* construct was defined by five observed variables. Feeldisc: I like an activity that involves discovering and learning new things. Figrhow: I like figuring out how things work. Tkapart: I like taking things apart to see what is inside. Figrdiff: I like trying different ways to figure things out. Probsolv: I like solving problems.

The *performing* construct was defined by four observed variables. Feelpres: I like an activity that involves presenting in front of lots of people. Perform: Performing in front of people is fun. Presppl: I like telling people about my work. Presclas: I like presenting my work to my class.

The *caretaking* construct was defined by three observed variables. Feelanml: I like an activity that involves taking care of animals. Havepet: Having a pet is a big responsibility, but something I like to do. Plntaqua: I like to take care of things like plants and aquariums.

The *teaching* construct was defined by four observed variables. Feeltutr: I like an activity that involves helping people learn things. Hlpothrs: Helping others learn things is fun. Tchothrs: I like teaching things to others. Dpendme: I feel good when people depend on me.

Attitudes CFA Models

CFA models were run to confirm the data from the observed measures were consistent with the hypothesized model on the three attitudes. An attitude CFA model was run for each grade and time: Elementary Fall 2012; Elementary Spring 2013; Middle School Fall 2012; Middle School Spring 2013; High School Fall 2012; High School Spring 2013. In these CFA models, the three attitudes were considered latent constructs and were defined by three to four observed variables. *Figure 3-9* displays the hypothesized model of the three attitude latent constructs and their observed variables. The hypothesized model was constructed by correlating all the three attitude latent constructs together.

The *value of science in society* construct was defined by four observed variables. Scipbslv: Science is useful in helping to solve the problems of everyday life. Scistudy: Most people should study some science. Scihlpfl: Science is helpful in understanding today's world. Sciimprt: Science is of great importance to a country's development.

The *self-concept* construct was defined by three observed variables. Scieasy: Science is easy for me. Sciustnd: I usually understand what we are talking about in science. Scichlng: I like the challenge of science assignments.

The *enjoyment and desire* construct is defined by three observed variables. Item 19B: Science is something I enjoy very much. Item 20L: Science is one of my favorite subjects. Item 20M: I have a real desire to learn science.

Structural Equation Modeling

The first question of this study seeks to examine whether students who reported preferences in learning activities predicted student reported positive attitudes toward science. A structural equation modeling (SEM) technique was used that allowed a set of relationships between student reported preferences in learning activities and student reported positive attitudes toward science to be examined. The seven FOCIS latent constructs were considered predictors, or in SEM terminology, exogenous variables. The three attitudes were considered the outcomes, or endogenous variables, regressed on the FOCIS exogenous variables. *Figure 3-13* shows the full model displaying each FOCIS exogenous variable attempts to predict each of the three attitude outcomes variables. As with the CFA models, SEM models were explored for each grade and time combination: Elementary Fall 2012; Elementary Spring 2013; Middle School Fall 2012; Middle School Spring 2013; High School Fall 2012; High School Spring 2013. Also as with the CFA models, the STATA 13 statistical software was used to construct these SEM models.

Variable Selection Procedure in SEM Models

The variable selection procedure was intended to select the best subset of predictors to create models in their simplest form. Backward elimination (Myers, 1990) was used as the variable selection procedure that created models for each grade and time. The procedure remained the same for each model selecting predictors that were statistically significant and stable. The first step included running the full model with all three attitude endogenous variables regressed on the seven FOCIS exogenous variables. Model fit indices, CFI, RMSEA, and SRMR, were used to confirm model fit. The second step removed the predictor pathway that possessed the highest *p*-value greater than an alpha critical value of .05. Models were then refit and ran again under reduced conditions. Model fit indices of reduced models were compared to determine better model fit. Predictor pathways remained removed if model fit indices improved or remained the same. Predictor pathways previously removed were reinserted into the model if the model fit indices worsened. The procedure continued removing other predictor pathways one-by-one that possessed higher *p*-value greater than an alpha critical value of .05 and did not worsen model fit indices until all *p*-value greater than an alpha critical were analyzed.

Addressing Collinearity in Variable Selection Procedure. A concern during the variable selection procedure was collinearity. Collinearity occurs when there is a high correlation between two or more variables, and could lead to incorrectly determining a predictor variable as being significant. A regression model with correlated predictors can indicate how well all of predictors predict the outcome variable, but it may not give valid results about any individual predictor, or about which predictors are redundant with respect to others. In our backward elimination procedure, we were concerned an elimination of one predictor would lead to another predictor, previously not significant, becoming significant. In this example, collinearity existed. The variables selection procedure in this study emphasized predictor variables that remained statistically significant throughout the backward elimination process. In more specific terms, variables in the final reduced models remained significant starting with the full model and remained significant in subsequent reduced models or in different all tested combinations of predictors.

Once final reduced models were determined, gender (sex) and English as a Second Language (englang) were entered into these models as controls. Each of these covariates were directly observed variables used as predictors of the three attitudes. Males were coded as 1 and Females were coded as 2 in the gender observed variables. A positive response to English as a Second Language was coded as 1 and a negative response was coded as 2.

Comparing Models

In order to answer the second and third research questions of this study, final SEM models were compared. Comparisons included looking at differences between FOCIS activity groups in their significance at predicting attitudes toward science across time (Fall 2012 to Spring 2013 and grade levels. Model fit indices (Chi Squared, CFI, RMSEA, and SRMR) and R-squared values were used also used to compare between models. The first analysis used the SEM in *Figure 12* on students from the elementary grade levels (Grades 3, 4, 5) from the Fall 2012. The second and third analysis was run on students from middle (Grades 6, 7, 8) and high school (Grades 9, 10, 11, 12) respectively in the Fall 2012. Three more separate analyses were run on the elementary, middle school, and high school grade levels from the Spring 2013.

Missing Values

Problems of missing data are often magnified in SEM (Ullman, 2006) due to the large number of observed variables employed in the models. Therefore, missing data imputation is particularly important in SEM models. All predictor, control, and outcome variables were examined for missing values prior to any CFA or SEM analysis. The missing data percentages based on the study predictor variables are reported in Table 3-1. Missing-data analysis was used to determine whether data were not missing at random, missing at random, or missing completely at random. Recommendations by Enders (2010) was consulted in order to determine an appropriate missing data procedure based on the nature of the missing data.

Specific to the FOCIS activity predictor variables, mean comparisons of grade level, gender, and English as a second language did not differ based on the three attitude outcome variables. Therefore, it was determined that there was no bias in the data. However, some predictor variables indicated high percentages of missing values. Missing values were converted to systems-missing, then maximum likelihood with missing values were run under CFA and SEM models.

Figure 3-1

FOCIS CFA Model

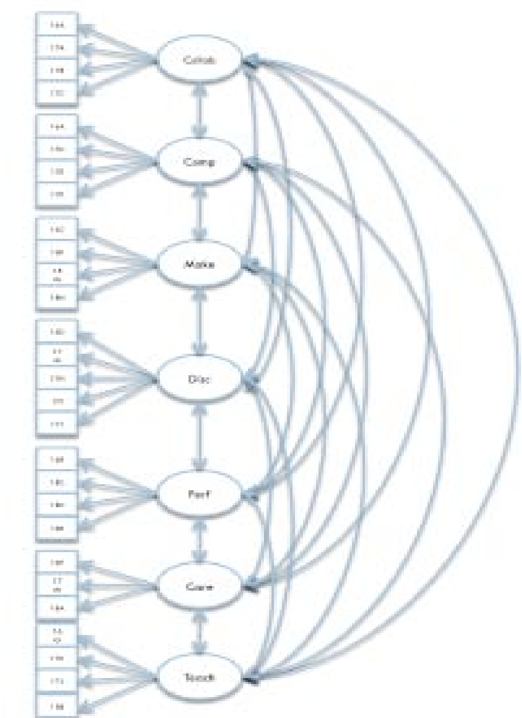


Figure 3-2

Collaborating Portion of FOCIS CFA Model

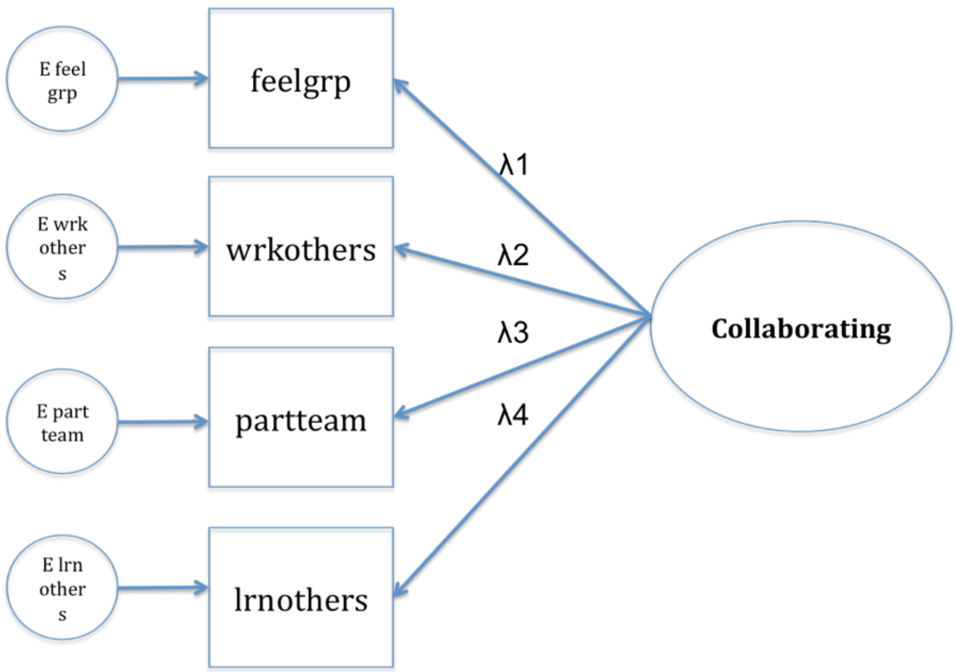


Figure 3-3

Competing Portion of FOCIS CFA Model

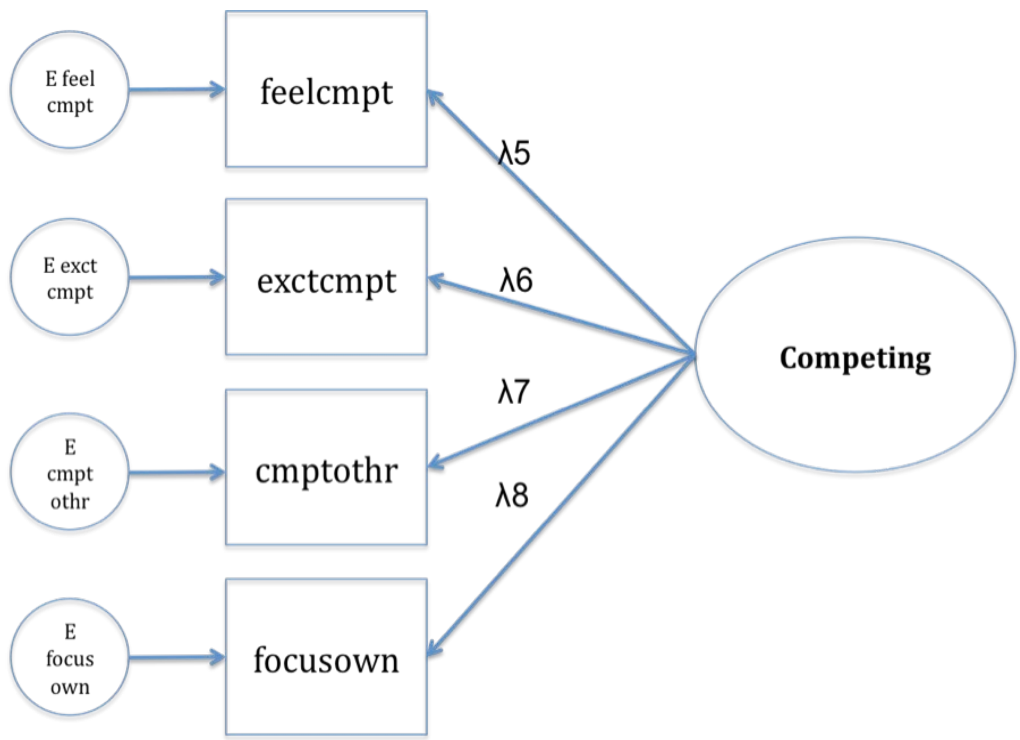


Figure 3-4

Creating and Making Portion of the FOCIS CFA Model

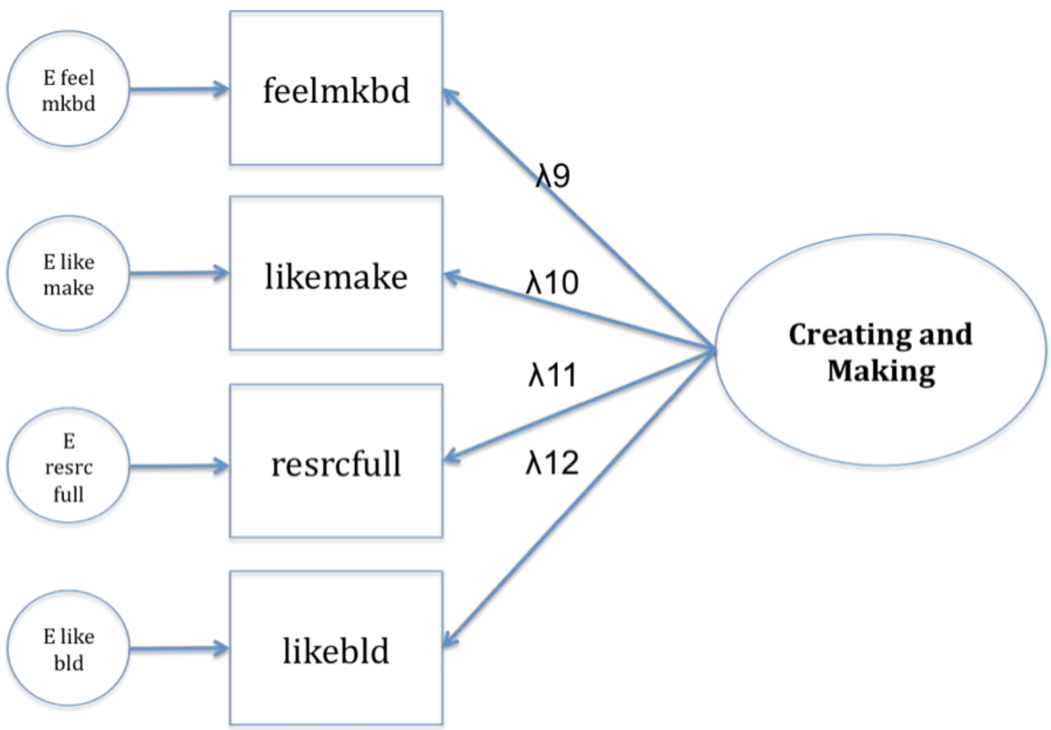


Figure 3-5

Discovering Portion of the FOCIS CFA Model

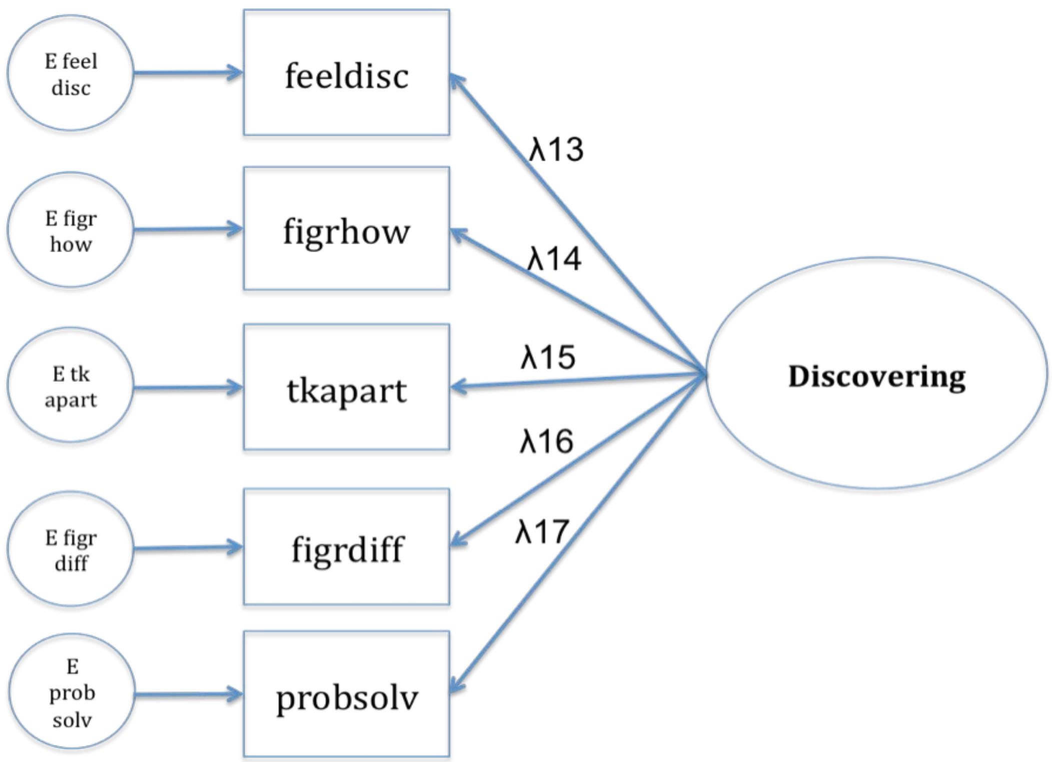


Figure 3-6

Performing Portion of the FOCIS CFA Model

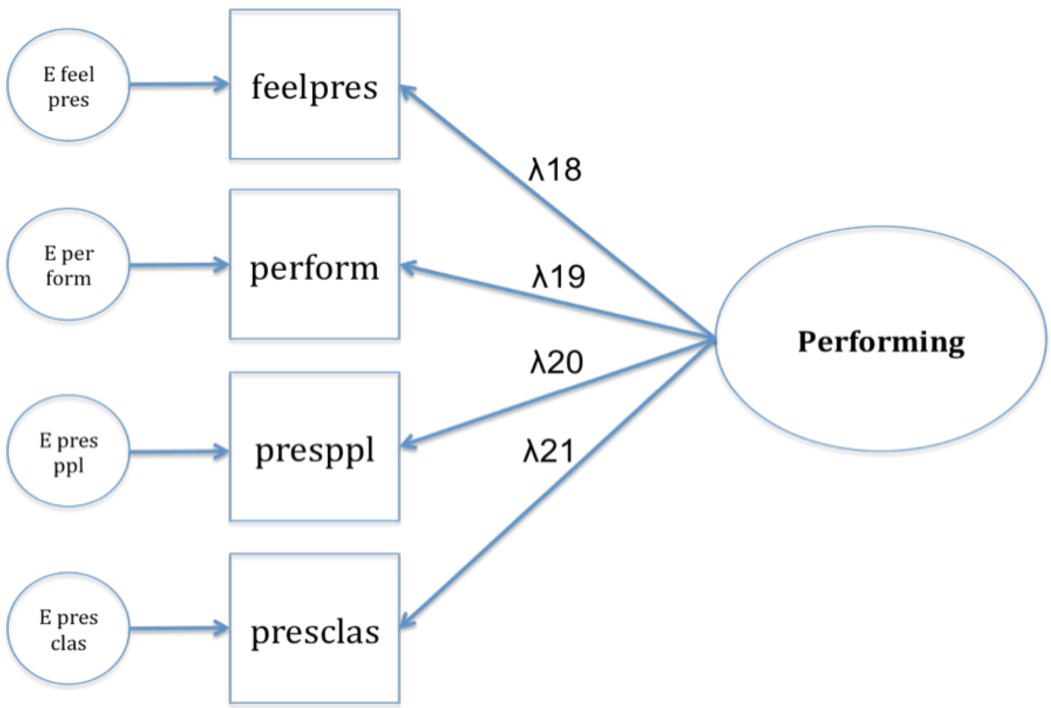


Figure 3-7

Caretaking Portion of the FOCIS CFA Model

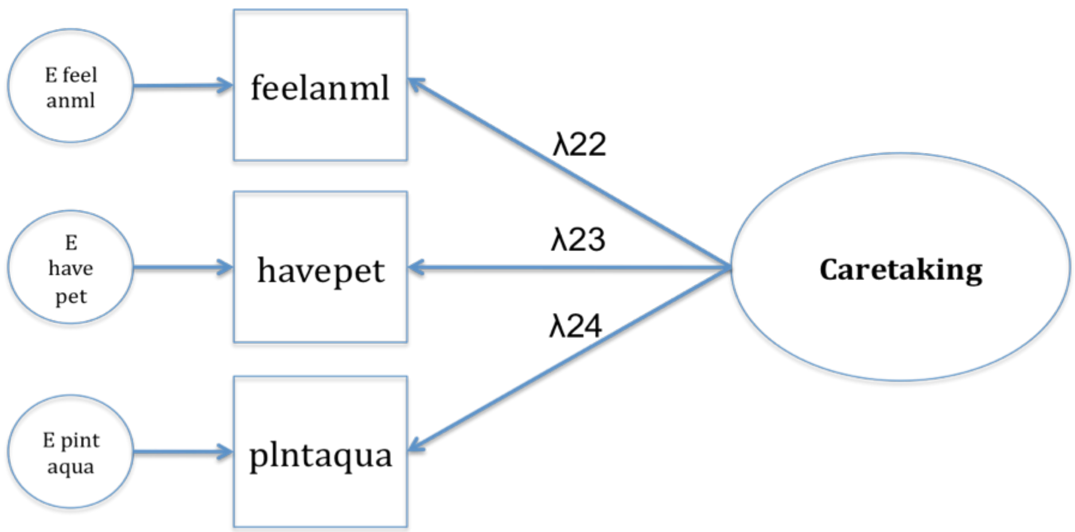


Figure 3-8

Teaching Portion of the FOCIS CFA Model

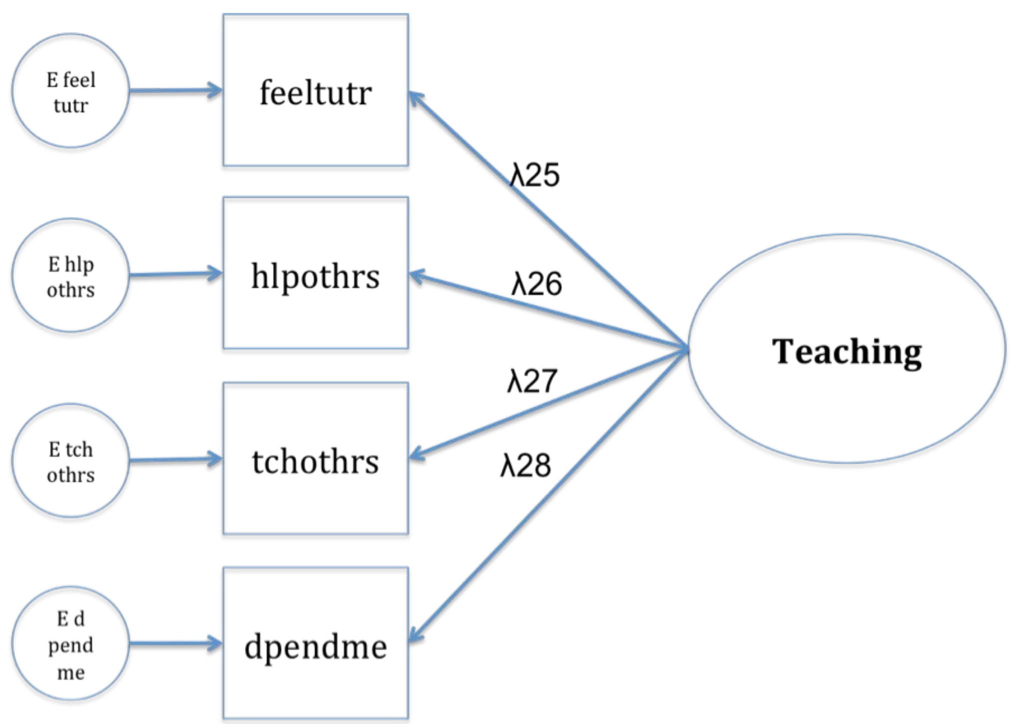


Figure 3-9

Attitude CFA Model

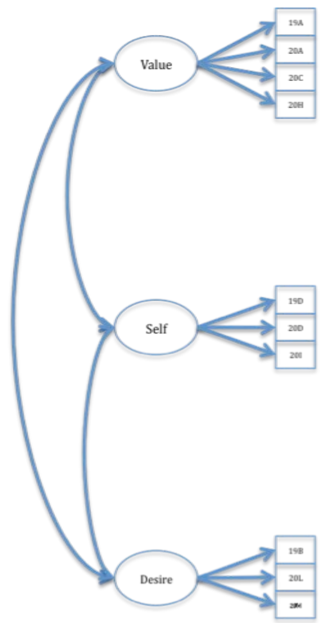


Figure 3-10

CFA Model of Value of Science in Society

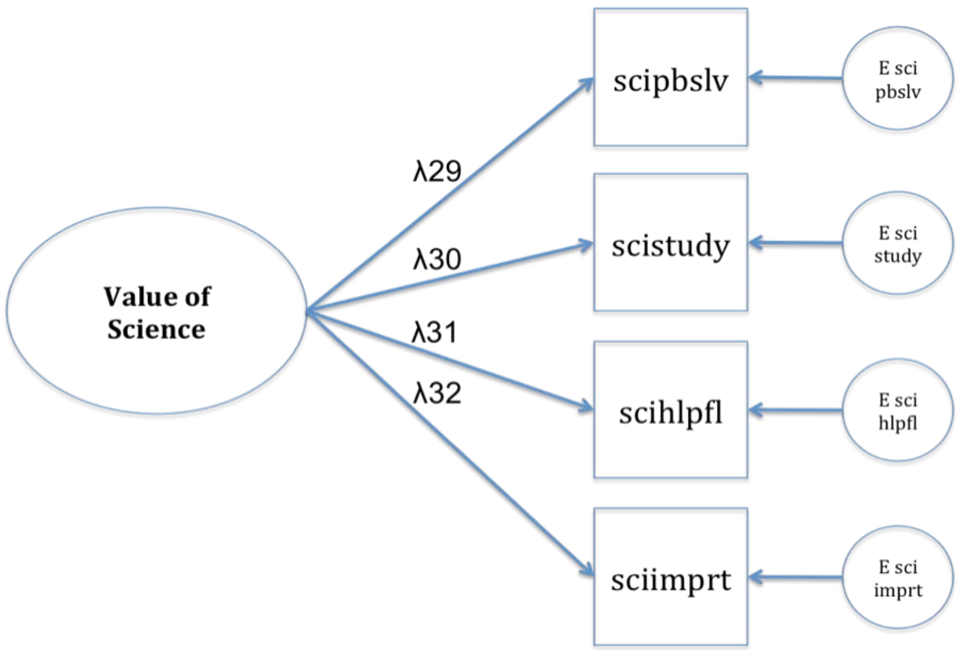


Figure 3-11

CFA Model of Self-Concept

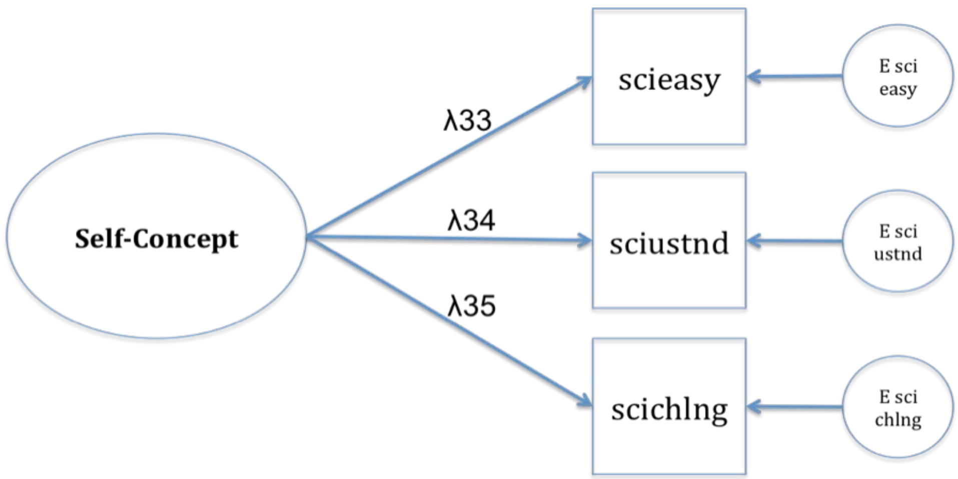


Figure 3-12

CFA Model of Enjoyment and Desire

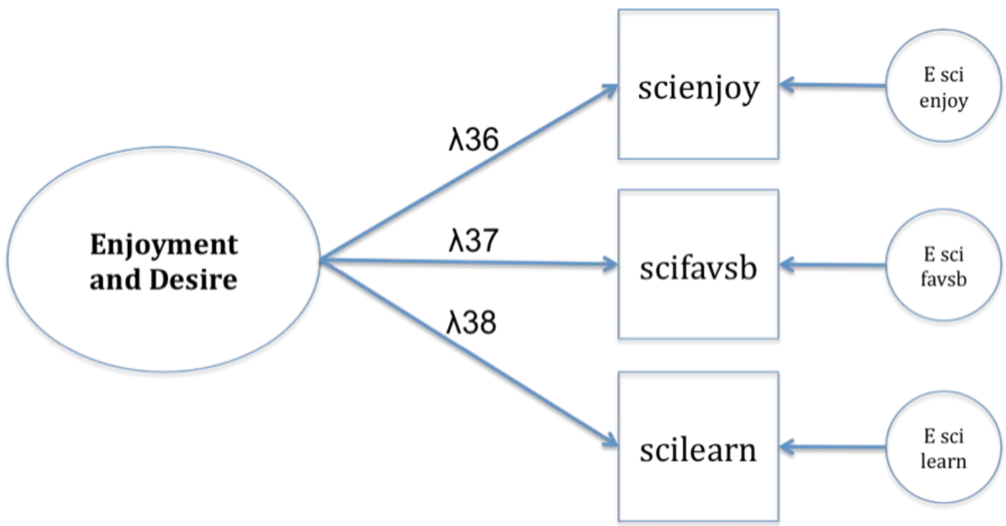


Figure 3-13

Full Structural Equation Model

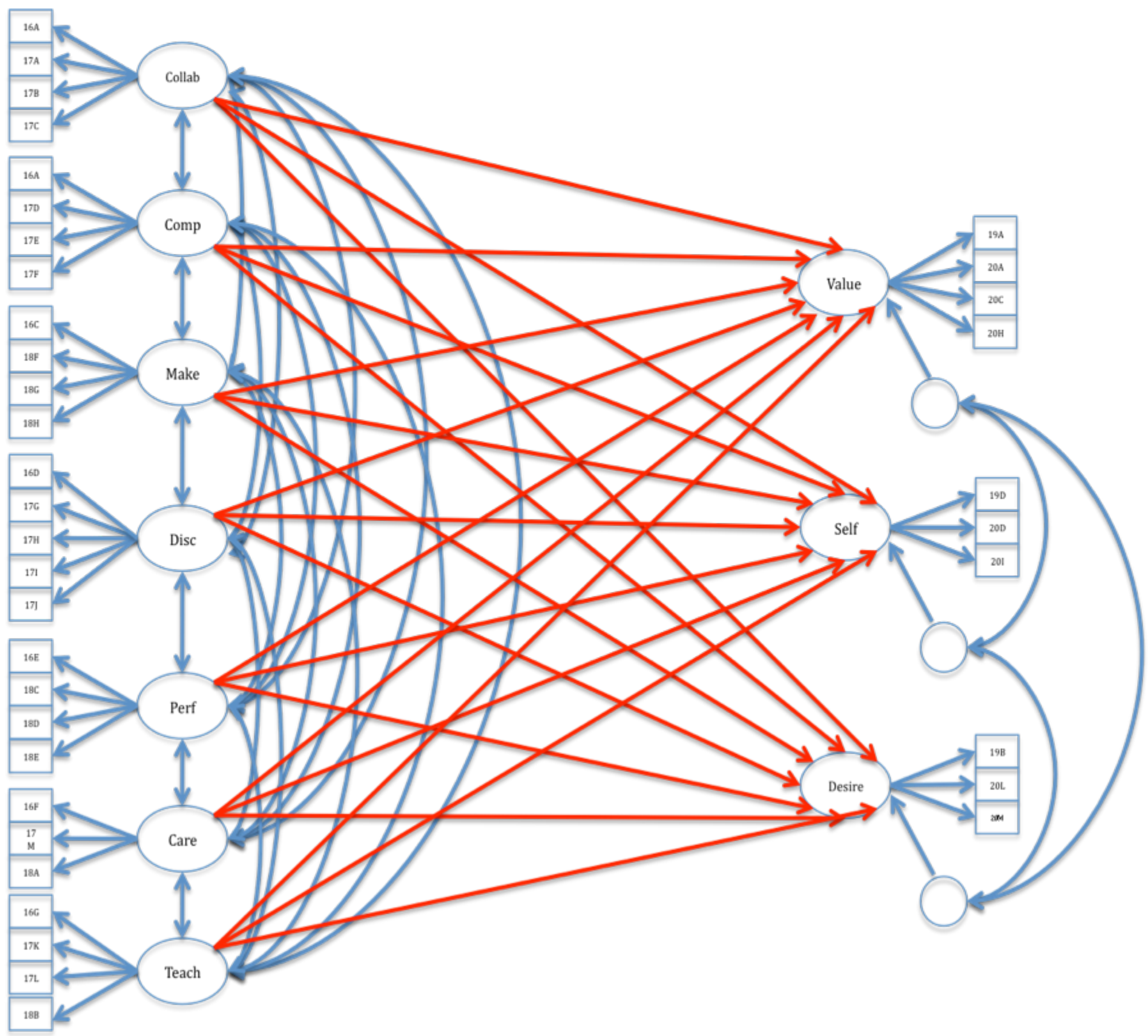


Table 3-1: Missing Value Percentages for FOCIS and Attitudes Question Items

FOCIS				***Attitudes***	
feelgrp	*1.3*	*tkapart*	*2.1*	*scipbslv*	*1.9*
wrkothers	*1.3*	*figrdiff*	*2.4*	*scistudy*	*1.8*
partteam	*1.7*	*probsolv*	*2.1*	*scihlpfl*	*2.3*
lrnothers	*2*	*feelpres*	*2.2*	*sciimprt*	*2.6*
feelcmpt	*1.5*	*perform*	*1.7*	*scieasy*	*2.6*
exctcmpt	*1.9*	*presppl*	*1.7*	*sciustnd*	*2.3*
cmptothr	*1.9*	*presclas*	*2.0*	*scichlng*	*2.6*
focusown	*1.7*	*feelanml*	*2.7*	*scienjoy*	*2.2*
feelmkbd	*1.6*	*havepet*	*2.2*	*scifavsb*	*2.6*
likemake	*2.0*	*plntaqua*	*1.5*	*scilearn*	*2.7*
resrcfull	*2.0*	*feeltutr*	*2.2*		
likebld	*2.3*	*hlpothrs*	*2.7*		
feeldisc	*1.9*	*tchothrs*	*2.7*		
figrhow	*2.0*	*dpendme*	*1.7*		

CHAPTER 4

Results

Analyses of relationships between student reported preferences in learning activities and their reported positive attitudes toward science are divided into the following sections: descriptive analyses, confirmatory factor analysis, and structural equation modeling analysis. Descriptive analyses included background information including grade distribution, gender, and English as a Second Language, reported variable means for each question item, and univariate outliers, univariate normality, and multivariate outlier assumptions. Confirmatory factor analysis (CFA) was used to test whether the data from the observed measures of the survey were consistent with hypothesized model of the FOCIS framework. Also, CFA was used to confirm the data from the observed measures were consistent with the hypothesized model on the three attitudes. Finally, structural equation modeling (SEM) examined whether students who reported preferences in learning activities predicted positive attitudes toward science.

Descriptive Analysis

The sample analyzed in this dissertation is comprised of data from the FOCIS survey on student reported preferences in learning activities and student reported attitudes toward science. In the Fall of 2012, 7382 students from grades 3-12 were surveyed. A similar number of students were surveyed in the Spring of 2013. However, a matching procedure reduced the sample sized used for this study to 5178 students. 1977 elementary students, grades 3-5, were surveyed. 1831 middle school students, grades 6-8, were surveyed. 1370 high school students, grades 9-12, were surveyed. At the elementary grade level, 48.66% reported being male and 51.09% reported female. Also at the elementary grade level, 21.29% reported speaking another language at home other than English. At the middle school grade level, 51.67% reported being male and 47.95% reported female. Also at the middle school level, 18.84% reported speaking another language at home other than English. Finally, at the high school grade level, 49.12% reported being male and 50.51% reported female, while 11.9% reported speaking another language at home other than English.

Variables

Variables *collaborating, competing, creating and making, discovering, performing, caretaking, teaching*, *value of science in society, self-concept,* and *enjoyment and desire* were reported as latent constructs and defined by three to five continuous observed variables in the analysis ranging from 0 to 5. Students were asked how they feel or agree with item question statements. A response “0” signified a very negative or strongly disagree response. A “3” signified a neutral response. A “5” signified a very positive or strongly agree response.

FOCIS Variables

The *collaborating* latent construct was defined by four continuous observed variables. Feelgrp: I like an activity that involves being in a group. Wrkothers: Working with others is more fun than working alone. Partteam: I like being part of a team. Lrnothers: I learn better when I am working with others. Table 4-1 displays mean and standard deviation values for these four continuous observed variables. There did not appear to be a trend when comparing mean values of these observed across grade and time.

The *competing* latent construct was defined by four continuous observed variables. Feelcmpt: I like an activity that involves being in a competition. Exctcmpt: I get excited when I hear there will be a competition. Cmptothr: I enjoy competing against other people. Reverse coded Focusown: I like to focus on my own goals, rather than competing with others. Table 4-2 displays mean and standard deviation values for the these four continuous observed variables. There did not appear to be a consistent trend when comparing mean values of these observed across grade and time.

The *creating and making* latent construct was defined by four continuous observed variables. Feelmkbd: I like an activity that involves making or building things. Likemake: I like doing projects where I make things. Resrcfull: Whenever I can, I make things I need. Likebld: I like building things. Table 4-3 displays mean and standard deviation values for the these four continuous observed variables. Elementary students reported having higher mean values than middle school students for all four *creating and making* observed variables. Also, middle school students reported having higher mean values than high school students for all four *creating and making* observed variables.

The *discovering* latent construct was defined by five continuous observed variables. Feeldisc: I like an activity that involves discovering and learning new things. Figrhow: I like figuring out how things work. Tkapart: I like taking things apart to see what is inside. Figrdiff: I like trying different ways to figure things out. Probsolv: I like solving problems. Table 4-4 displays mean and standard deviation values for the these five continuous observed variables. Similar to *creating and making*, *discovering* reported mean values were highest for elementary students and lowest for high school students on four of the five observed variables.

The *performing* latent construct was defined by four continuous observed variables. Feelpres: I like an activity that involves presenting in front of lots of people. Perform: Performing in front of people is fun. Presppl: I like telling people about my work. Presclas: I like presenting my work to my class. Table 4-5 displays mean and standard deviation values for the these four continuous observed variables. There did not appear to be a consistent trend when comparing mean values of these observed across grade and time.

The *caretaking* latent construct was defined by three continuous observed variables.. Feelanml: I like an activity that involves taking care of animals. Havepet: Having a pet is a big responsibility, but something I like to do. Plntaqua: I like to take care of things like plants and aquariums. Table 4-6 displays mean and standard deviation values for the these three continuous observed variables. *Caretaking* reported mean values were highest for elementary students and lowest for high school students on all three observed variables.

The *teaching* latent construct was defined by four continuous observed variables. Feeltutr: I like an activity that involves helping people learn things. Hlpothrs: Helping others learn things is fun. Tchothrs: I like teaching things to others. Dpendme: I feel good when people depend on me. Table 4-7 displays mean and standard deviation values for the these four continuous observed variables. *Teaching* reported mean values were highest for elementary students and lowest for high school students on all three observed variables.

Attitude Variables

The *value of science in society* latent construct was defined by four continuous observed variables. Scipbslv: Science is useful in helping to solve the problems of everyday life. Scistudy: Most people should study some science. Scihlpfl: Science is helpful in understanding today's world. Sciimprt: Science is of great importance to a country's development. Table 4-8 displays mean and standard deviation values for the these four continuous observed variables. *Value of science in society* reported mean values were highest for elementary students and lowest for high school students on all three observed variables.

The *self-concept* latent construct was defined by three continuous observed variables.. Scieasy: Science is easy for me. Sciustnd: I usually understand what we are talking about in science. Scichlng: I like the challenge of science assignments. Table 4-8 displays mean and standard deviation values for the these three continuous observed variables. *Self-concept* reported mean values were also highest for elementary students and lowest for high school students on all three observed variables.

The *enjoyment and desire* latent construct was defined by three continuous observed variables. Item 19B: Science is something I enjoy very much. Item 20L: Science is one of my favorite subjects. Item 20M: I have a real desire to learn science.

Table 4-9 displays mean and standard deviation values for the these three continuous observed variables. *Enjoyment and desire* reported mean values were also highest for elementary students and lowest for high school students on all three observed variables.

Assumptions

Assumption tests were run prior to analyzing the data through the CFA and SEM models. All variables were first examined for univariate outliers by running descriptives and then analyzing the standardized values. Standardized values above 3.29 and below -3.29 were scanned for. There were no values showing such values and thus no values were removed from the data. Then, all variables were checked for univariate normality by running descriptives of skewness and kurtosis. Skewness values above 2 and below -2, and kurtosis values above 7 and below -7 were scanned for. All values showed values with those ranges. Finally, the data was checked for multivariate outliers. A multivariate outliers is considered a value that is associated with a Mahalanobis (Ullman, 2006) distance. This was determined as greater than the Chi Square critical value associated with 38 degrees of freedom (i.e. the number of variables) and *p-value* of 0.001. In this case, the Chi Square critical threshold was 70.703. 51 cases (0.98% of sample) were determined multivariate outliers are were removed from the data.

Confirmatory Factor Analysis

CFA was used to test whether the data from the observed measures of the survey were consistent with hypothesized model of the FOCIS framework. Also, CFA was used to confirm the data from the observed measures were consistent with the hypothesized model on the three attitudes. Although Chi Squared values indicate the difference between the observed measures and the hypothesized covariance matrices, due to Chi Squared sensitivity to large sample sizes, Chi Squared values were not reported. However, other measures of model fit were used and reported: RMSEA, CFI, SRMR. Root Mean Square Error of Approximation (RMSEA) values less than 0.06 indicate a good fit. RMSEA values between 0.06 and 0.10 are still acceptable, but greater than 0.10 indicate a poor fit. Comparative Fit Index (CFI) values should be equal to or greater than 0.90 to accept the hypothesized model. Standardized Root Mean Square Residuals (SRMR) values less than 0.08 is considered a good fit (Hu & Bentler, 1999).

FOCIS CFA Models

Six CFA models were run to confirm the observed measures of the survey were consistent with hypothesized model of the FOCIS framework (*collaborating, competing, creating and making, discovering, performing, caretaking, teaching*) at the elementary level in the Fall 2012 and Spring 2013, at the middle school level in the Fall 2012 and Spring 2013, and at the high school level in the Fall 2012 and Spring 2013. All models showed the hypothesized models, created from the FOCIS framework, matched the observed variables for all reported fit indices. Table 4-11 displays the model fit indices from all CFA models related to the FOCIS framework.

Attitude CFA Models

Six CFA models were run to confirm the observed measures of the survey were consistent with hypothesized model of the three attitudes (*value of science in society, self-*

concept, and *enjoyment and desire*) at the elementary level in the Fall 2012 and Spring 2013, at the middle school level in the Fall 2012 and Spring 2013, and at the high school level in the Fall 2012 and Spring 2013. All models showed the hypothesized models, created from the FOCIS framework, matched the observed variables for all reported fit indices. Table 4-12 displays the model fit indices from all CFA models related to the three attitudes.

Structural Equation Modeling

SEM technique was used to explore a set of relationships between student reported preferences in learning activities (FOCIS) and student reported positive attitudes toward science to be examined (three attitudes). The seven FOCIS latent constructs were assigned as predictor variables, or exogenous variables. The three attitudes latent constructs were considered the outcomes, or endogenous variables, regressed on the FOCIS exogenous variables. A model was run and examined using backward elimination (Myers, 1990) for each grade and time period. The model fit indices, *p*-values at the structural level (between latent constructs), and evidence of collinearity were used to determine model goodness of fit and variable selection for all models. R-squared and standardized coefficient values were also reported. The following sections describe the variable selection process and the results from the SEM models.

Elementary Fall 2012 SEM Model

The following illustrates the variable selection process for the elementary grade level in the Fall 2012 beginning with the full model and continuing until the final model was determined.

Full Model

The full model included all three attitude endogenous variables regressed on all seven FOCIS exogenous variables. Fit indices showed good model fit values (RMSEA 0.036, CFI 0.932, SRMR 0.050). It should be noted that model fit indices did not change for RMSEA and SRMR as the model was reduced. CFI only decreased to a value of 0.930, a 0.002 reduction, in the final reduced model. Table 4-13 displays full model *p*-values and standardized coefficient values. *Discovering* (*p*<0.001), *collaborating* (*p*=0.002)*, and caretaking* (*p*=0.003) were significant in predicting *value of science in society*. *Discovering* (*p*<0.000)*, teaching* (p=0.037)*, performing* (*p*<0.001), and *caretaking* (p=0.033) were significant in predicting *self-concept*. *Discovering* (*p*<0.001), *performing* (*p*=0.042), and *caretaking* (*p*=0.011) were significant in predicting *enjoyment and desire*. *Creating and making* (*p*=0.886) on predicting *value of science in society*, *collaborating* (*p*=0.562) on predicting *self-concept*, and *collaborating* (*p*=0.194) on predicting *enjoyment and desire* showed the highest *p*-values and were removed from the full model creating a reduced model, labeled as Elementary Fall Reduced Model 2 (EFRM2), signifying the grade, the time, a reduced model, and a number determining what model overall in the variable selection process.

Second Model

Performing (*p*=0.839) on predicting *value of science in society*, *competition* (*p*=0.079) on predicting *self-concept*, and *teaching* (*p*=0.373) on predicting *enjoyment and desire* showed the highest *p*-values and were removed from the model EFRM2 creating a reduced model labeled as EFRM3. Table 4-14 displays the output from running EFRM2.

Third Model

Teaching (*p*=0.302) on predicting *value of science in society*, and *caretaking* (*p*=0.064) on predicting *self-concept* showed the highest *p*-values and were removed from the model EFRM3 creating a reduced model labeled as EFRM4. Table 4-15 displays the output from running EFRM3. No exogenous variables were removed predicting *enjoyment and desire* due to all variables showing significance.

Fourth Model

Competing (*p*=0.053) on predicting *value of science in society* and *caretaking* (*p*=0.114) on predicting *enjoyment and desire* were removed from the model EFRM4 creating another reduced model labeled as EFRM5. No exogenous variables were removed predicting *self-concept* and *enjoyment and desire* due to all variables showing significance. Table 4-16 displays the output from running EFRM4.

Fifth Model

In model EFRM5, the remaining exogenous variables showed significance in predicting the endogenous variables. *Discovering* (*p*<0.001), *collaborating* (*p*<0.001), and *caretaking* (*p*=0.02) significantly predicted *value of science in society*. *Discovering* (*p*<0.001), *creating and making* (*p*=0.008), *teaching* (*p*=0.003), and *performing* (*p*<0.001) significantly predicted *self-concept*. *Discovering* (*p*<0.001), *competing* (*p*=0.021), *creating and making* (*p*=0.005), and *performing* (*p*=0.028) significantly predicted *enjoyment and desire*. Table 4-17 displays the output from running EFRM5. However, *creating and making* in predicting *self-concept* was not significant in the full model. In turn, collinearity between creating *and making* and *teaching* was explored and R-squared values were compared. *Teaching* was removed from model EFRM5 to form a new reduced model EFRM6C, with the “C” representing *creating and making*.

Sixth Model with Creating and Making

In the model EFRM6C, all exogenous variables remained significant from model EFRM5. R-squared value for *self-concept* was 0.342, meaning 34.2% of the *self-concept* variance could be explained by the exogenous variables *discovering, creating and making,* and *performing.* Then for comparison, *creating and making* was switched with *teaching* on predicting *self-concept* to create a model labeled EFRM6T, with the “T” representing *teaching*.

Sixth Model with Teaching

In the model EFRM6T, the R-squared value for *self-concept* was higher than in the EFRM6C model at 0.378, meaning that 37.8% of the *self-concept* variance could be explained by the exogenous variables *discovering, teaching,* and *performing.* Thus, *teaching* was kept in the model over *creating and making*. Also, *creating and making* in predicting *enjoyment and desire* became not significant (*p*=0.073) and was removed to create a new reduced model EFRM7.

Seventh Model

In model EFRM7, the remaining exogenous variables showed significance in predicting the endogenous variables. *Discovering* ($p<0.001$), *collaborating* ($p<0.001$), and *caretaking* ($p=0.046$) significantly predicted *value of science in society*. *Discovering* ($p<0.001$), *teaching* ($p<0.001$), and *performing* ($p<0.001$) significantly predicted *self-concept*. *Discovering* ($p<0.001$), *competing* ($p=0.036$), and *performing* ($p=0.027$) significantly predicted *enjoyment and desire*. Table 4-20 displays the output from running EFRM7. *Competing* was not significant in predicting *enjoyment and desire* in the full model and was removed to create a reduced model EFRM8.

Eighth Model

Caretaking ($p=0.056$) on predicting *value of science in society*, and *performing* ($p=0.107$) on predicting *enjoyment and desire* were removed from the model EFRM8 creating a reduced model labeled as EFRM9. Table 4-21 displays the output from running EFRM8.

Final Model

Discovering ($p<0.001$) and *collaborating* ($p<0.001$) significantly predicted *value of science in society*, *discovering* ($p<0.001$), *teaching* ($p<0.001$), and *performing* ($p<0.001$) significantly predicted *self-concept*, and *discovering* ($p<0.001$) significantly predicted *enjoyment and desire* in the final model, EFRM9. Table 4-22 displays the output from EFRM9. Goodness of fit indices show the model fit the data (RMSEA 0.038, CFI 0.930, SRMR 0.050).

In interpreting *value of science in society*, when controlling for *discovering, value of science in society* increased by a standard deviation of 0.112 for every one standard deviation increase in *collaborating*. When controlling for *collaborating, value of science in society* increased by a standard deviation of 0.614 for every one standard deviation increase in *discovering.* The R-squared value of *value of science in society* was 0.436, meaning 43.6% of the *value of science in society* variance could be explained by *discovering* and *collaborating*.

In interpreting *self-concept,* when controlling for *teaching* and *performing, self-concept* increased by a standard deviation of 0.567 for every one standard deviation increase in *discovering*. When controlling for *discovering* and *performing, self-concept* decreased by a standard deviation of 0.139 for every one standard deviation increase in teaching. The R-squared value of *self-concept* was 0.377, meaning 37.7% of the *self-concept* variance could be explained by *discovering*, *teaching*, and *performing*.

In interpreting *enjoyment and desire, enjoyment and desire* increased by a standard deviation of 0.548 for every one standard deviation increase in *discovering*. The R-squared value of *enjoyment and desire* was 0.300, meaning 30% of the *enjoyment and desire* variance could be explained by *discovering.*

Adding Gender and English as a Second Language

Gender (p=0.630 on *value*, p=0.944 on *self*, p=0.973 on *enjoy*) and English as a Second Language ((p=0.529 on *value*, p=0.365 on *self*, p=0.740 on *enjoy*) were shown to be not significant when predicting the three attitudes and holding the other variables constant in the final reduced model.

Elementary Spring 2013 SEM Model

The final reduced model for elementary students in the Spring of 2013 showed *discovering* (p<0.001) significantly predicting *value of science in society*, *collaborating* (p<0.001), *discovering* (p<0.001), *competing* (p<0.001), and *performing* (p<0.001) significantly predicting *self-concept*, and *discovering* (p<0.001) and *caretaking* (p<0.001) significantly predicting *enjoyment and desire.* Table 4-22 displays the output from this model. The model also showed it fit the data in the goodness of fit indices (RMSEA 0.041, CFI 0.930, SRMR 0.053).

In this model, *value of science in society* increased by a standard deviation of 0.594 for every one standard deviation increase in *discovering*. The R-squared value of *value of science in society* was 0.353, meaning 35.3% of the *value of science in society* variance could be explained by *discovering*.

In interpreting s*elf-concept,* when controlling for *discovering, competing, and performing*, *self-concept* decreased by a standard deviation of 0.139 for every one standard deviation increase in *collaborating*. When controlling for *collaborating*, *competing,* and *performing*, *self-concept* increased by a standard deviation of 0.465 for every one standard deviation increase in *discovering.* When controlling for *collaborating*, *discovering,* and *performing*, *self-concept* increased by a standard deviation of 0.131 for every one standard deviation increase in *competing*. Finally, when controlling for *collaborating, discovering,* and *competing, self-concept* increased by a standard deviation of 0.178 for every one standard deviation increase in *performing*. The R-squared value for *self-concept* was 0.351, meaning 35.1% of the *self-concept* variance could be explained by *collaborating, discovering, competing*, and *performing*.

In interpreting *enjoyment and desire,* when controlling for *caretaking*, *enjoyment and desire* increased by a standard deviation of 0.421 for every one standard deviation increase in *discovering*. When controlling for *discovering, enjoyment and desire* increased by a standard deviation of 0.087 for every one standard deviation increase in *caretaking.* The R-squared value of *enjoyment and desire* was 0.216, meaning 21.6% of the *enjoyment and desire* variance could be explained by *discovering* and *caretaking.*

Gender and English as a Second Language to Elem Spring 2013 Model

Gender (p=0.569 on *value*, p=0.694 on *self*, p=0.600 on *enjoy*) and English as a Second Language (p=0.312 on *value*, p=0.179 on *self*, p=0.575 on *enjoy*) were shown to be not significant when predicting the three attitudes and holding the other variables constant in the final reduced model.

Middle School Fall 2012 SEM Model

The final middle school fall 2012 reduced model showed *discovering* (p<0.001), *collaborating* (p<0.001) significantly predicting *value of science in society*, *discovering* (p<0.001), *collaborating* (p<0.001), *competing* (p<0.001), and *performing* (p<0.001) significantly predicting *self-concept*, and *discovering* (p<0.001), *performing* (p=0.011), and *caretaking* (p=0.024) significantly predicting *enjoyment and desire.* Table 4-23 displays the results from this model. The model also showed it fit the data in the goodness of fit indices (RMSEA 0.048, CFI 0.924, SRMR 0.062).

The standardized coefficient values showed *value of science in society* increasing by a standard deviation of 0.609 for every one standard deviation increase in *discovering* when controlling for *collaborating*. When controlling for *discovering*, *value of science in society* increased by a standard deviation of 0.078 for every one standard deviation increase in *collaborating.* 38.3% of the *value of science in society* variance could be explained by *discovering* and *collaborating.*

Self-concept increased by a standard deviation of 0.472 for every one standard deviation increase in *discovering*, when controlling for *collaborating, competing,* and *performing*. *Self-concept* decreased by a standard deviation of 0.082 for every one standard deviation increase in *collaborating* when controlling for *discovering, competing,* and *performing. Self-concept* increased by a standard deviation of 0.117 for every one standard deviation increase in *competing* when controlling for *discovering, collaborating,* and *performing. Self-concept* also increased by a standard deviation of 0.154 for every one standard deviation increase in *performing* when controlling for *discovering, collaborating,* and *competing.* 34.8% of the *self-concept* variance could be explained by *discovering, collaborating, competing,* and *performing.*

Enjoyment and desire increased by a standard deviation of 0.503 for every one standard deviation increase in *discovering* when controlling for *performing* and *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.055 for every one standard deviation increase in *performing* when controlling for *discovering* and *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.043 for every one standard deviation increase in *caretaking* when controlling for *discovering* and *performing*. 29.4% of the *enjoyment and desire* variance could be explained by *discovering* and *performing.*

Gender and English as a Second Language in Middle School Fall 2012 Model

Gender (*p*=0.394 on *value*, *p*=0.141 on *self*, *p*=0.102 on *enjoy*) and English as a Second Language ((*p*=0.874 on *value*, *p*=0.237 on *self*, *p*=0.154 on *enjoy*) were shown to be not significant when predicting the three attitudes and holding the other variables constant in the final reduced model.

Middle School Spring 2013 SEM Model

The final middle school Spring 2013 SEM model resulted in *discovering* (*p*<0.001), *performing* (*p*=0.001), and *caretaking* (*p*<0.001) significantly predicting *value of science in society*. The model also showed *discovering* (*p*<0.001), *performing* (*p*<0.001), and *caretaking* (*p*=0.011) significantly predicting *self-concept*. Finally, *discovering* (*p*<0.001), *competing* (*p*<0.001), *teaching* (*p*<0.001), *performing* (*p*<0.001), and *caretaking* (*p*=0.011) significantly predicted *enjoyment and desire*. Table 4-24 displays the results from this model. The model also showed it fit the data in the goodness of fit indices (RMSEA 0.051, CFI 0.928, SRMR 0.061).

The standardized coefficient values showed *value of science in society* increasing by a standard deviation of 0.507 for every one standard deviation increase in *discovering* when controlling for *performing* and *caretaking*. When controlling for *discovering* and *caretaking*, *value of science in society* increased by a standard deviation of 0.086 for every one standard deviation increase in *performing*. *Value of science in society* increased by a standard deviation of 0.124 for every one standard deviation increase in *caretaking* when controlling for *discovering* and *performing.* 35.9% of the *value of science in society* variance could be explained by *discovering, performing,* and *caretaking.*

Self-concept increased by a standard deviation of 0.428 for every one standard deviation increase in *discovering*, when controlling for *performing* and *caretaking*. *Self-concept* increased by a standard deviation of 0.229 for every one standard deviation increase in *performing* when controlling for *discovering* and *caretaking. Self-concept* increased by a standard deviation of 0.070 for every one standard deviation increase in *caretaking* when controlling for *discovering* and *performing.* 34.1% of the *self-concept* variance could be explained by *discovering, performing,* and *caretaking.*

Enjoyment and desire increased by a standard deviation of 0.467 for every one standard deviation increase in *discovering* when controlling for *competing, teaching, performing,* and *caretaking*. *Enjoyment and desire* decreased by a standard deviation of 0.076 for every one standard deviation increase in *competing* when controlling for *discovering, teaching, performing,* and *caretaking*. *Enjoyment and desire* decreased by a standard deviation of 0.075 for every one standard deviation increase in *teaching* when controlling for *discovering, competing, performing,* and *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.155 for every one standard deviation increase in *performing* when controlling for *competing, teaching, performing,* and *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.099 for every one standard deviation increase in *caretaking* when controlling for *discovering, competing, teaching,* and *performing*. 27.7% of the *enjoyment and desire* variance could be explained by *discovering, competing, teaching, performing,* and *caretaking.*

Gender and English as a Second Language in Middle School Spring 2013 Model

Gender (p=0.637 on *value*, p=0.494 on *self*, p=0.838 on *enjoy*) and English as a Second Language ((p=0.998 on *value*, p=0.904 on *self*, p=0.692 on *enjoy*) were shown to be not significant when predicting the three attitudes and holding the other variables constant in the final reduced model.

High School Fall 2012 SEM Model

The final high school Fall 2012 SEM model resulted in *discovering* (p<0.001) and *caretaking* (p<0.001) significantly predicting *value of science in society*. The model also showed *discovering* (p<0.001), *competing* (p<0.001), and *caretaking* (p=0.002) significantly predicting *self-concept*. Finally, *discovering* (p<0.001) and *caretaking* (p<0.001) significantly predicted *enjoyment and desire*. Table 4-25 displays the results from this model. The model also showed it fit the data in the goodness of fit indices (RMSEA 0.049, CFI 0.927, SRMR 0.058).

The standardized coefficient values showed *value of science in society* increasing by a standard deviation of 0.520 for every one standard deviation increase in *discovering* when controlling for *caretaking*. When controlling for *discovering*, *value of science in society* increased by a standard deviation of 0.149 for every one standard deviation increase in *caretaking*. 32.5% of the *value of science in society* variance could be explained by *discovering* and *caretaking.*

Self-concept increased by a standard deviation of 0.457 for every one standard deviation increase in *discovering*, when controlling for *competing* and *caretaking*. *Self-concept* increased by a standard deviation of 0.145 for every one standard deviation increase in *competing* when controlling for *discovering* and *caretaking. Self-concept* increased by a standard deviation of 0.095 for every one standard deviation increase in *caretaking* when controlling for *discovering* and *competing. 29.6*% of the *self-concept* variance could be explained by *discovering, competing,* and *caretaking.*

Enjoyment and desire increased by a standard deviation of 0.428 for every one standard deviation increase in *discovering* when controlling for *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.171 for every one standard deviation increase in *caretaking* when controlling for *discovering*. 24.3% of the *enjoyment and desire* variance could be explained by *discovering, performing*, and *caretaking.*

Gender and English as a Second Language in High School Fall 2012 Model

Gender (*p*=0.005 on *value*, *p*=0.001 on *self*, *p*=0.008 on *enjoy*) significantly predicted all three attitudes when controlling for the respectable predictor variables in the model. The model also showed it fit the data in the goodness of fit indices (RMSEA 0.049, CFI 0.924, SRMR 0.057). Standardized coefficient values were negative for all three attitudes, meaning males had a more positive attitude toward science in all three areas. In interpreting the gender standardized coefficient values, high school males reported in the Fall 2012 of having a standard deviation of 0.080 more than females in their attitudes toward *value of science in society*. High school males also reported in the Fall 2012 of having a standard deviation of 0.097 more than females in their attitudes toward *self-concept*. Also, high school males also reported in the Fall 2012 of having a standard deviation of 0.075 more than females in their attitudes toward *enjoyment and desire*. Table 4-26 displays the results from this model. English as a Second Language (*p*=0.387 on *value*, *p*=0.892 on *self*, *p*=0.380 on *enjoy*) was shown to be not significant when predicting the three attitudes and holding the other variables constant in the high school Fall 2012 final model.

High School Spring 2013 SEM Model

The final high school Spring 2013 SEM model resulted in *discovering* (p<0.001), *creating* (p<0.001), *performing* (p=0.001), and *caretaking* (p<0.001) significantly predicting *value of science in society*. The model also showed *discovering* (p<0.001), *collaborating* (p=0.020), *competing* (p<0.001), *performing* (p<0.001), and *caretaking* (p=0.002) significantly predicting *self-concept*. Finally, the model showed *discovering* (p<0.001), *performing* (p=0.001), and *caretaking* (p<0.001) significantly predicting *enjoyment and desire.* Table 4-27 displays the results from this model. The model also showed it fit the data in the goodness of fit indices (RMSEA 0.054, CFI 0.922, SRMR 0.058).

The standardized coefficient values showed *value of science in society* increasing by a standard deviation of 0.522 for every one standard deviation increase in *discovering* when controlling for *creating and making*, *performing,* and *caretaking*. *Value of science in society* decreased by a standard deviation of 0.128 for every one standard deviation increase in *creating and making* when controlling for *discovering,* performing, and *caretaking*. *Value of science in society* increased by a standard deviation of 0.097 for every one standard deviation increase in *performing* when controlling for *discovering, creating and making*, and *caretaking*. *Value of science in society* increased by a standard deviation of 0.196 for every one standard deviation increase in *caretaking* when controlling for *discovering, creating and making*, and *performing*. 30.6% of the *value of science in society* variance could be explained in this model.

Self-concept increased by a standard deviation of 0.383 for every one standard deviation increase in *discovering* when controlling for *collaborating, competing,* *performing,* and *caretaking*. *Self-concept* decreased by a standard deviation of 0.047 for every one standard deviation increase in *collaborating* when controlling for *discovering, competing, performing,* and *caretaking*. *Self-concept* increased by a standard deviation of 0.099 for every one standard deviation increase in *competing* when controlling for *discovering, collaborating, performing,* and *caretaking*. *Self-concept* increased by a standard deviation of 0.158 for every one standard deviation increase in *performing* when controlling for *discovering, collaborating, competing,* and *caretaking*. Finally, *self-concept* increased by a standard deviation of 0.095 for every one standard deviation increase in *caretaking* when controlling for *discovering, collaborating, competing,* and *performing*. 29.6% of the *self-concept* variance could be explained in this model.

Enjoyment and desire increased by a standard deviation of 0.374 for every one standard deviation increase in *discovering* when controlling for *performing* and *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.097 for every one standard deviation increase in *performing* when controlling for *discovering* and *caretaking*. *Enjoyment and desire* increased by a standard deviation of 0.097 for every one standard deviation increase in *caretaking* when controlling for *discovering* and *performing*. 25.1% of the *enjoyment and desire* variance could be explained in this model.

Gender and English as a Second Language in High School Spring 2013 Model

Gender (p=0.004 on *value*, p=0.025 on *self*, p=0.005 on *enjoy*) significantly predicted all three attitudes when controlling for the respectable predictor variables in the model. The model also showed it fit the data in the goodness of fit indices (RMSEA

0.055, CFI 0.918, SRMR 0.057). Standardized coefficient values were negative for all three attitudes, meaning high school males in the Spring 2013 had a more positive attitude toward science in all three areas. In interpreting the gender standardized coefficient values, high school males reported in the Spring 2013 of having a standard deviation of 0.077 more than females toward *value of science in society*. High school males also reported in the Spring 2013 of having a standard deviation of 0.062 more than females in their attitudes toward *self-concept*. Also, high school males also reported in the Spring 2013 of having a standard deviation of 0.075 more than females in their attitudes toward *enjoyment and desire*. Table 4-28 displays the results from this model. English as a Second Language (p=0.998 on *value*, p=0.288 on *self*, p=0.471 on *enjoy*) was shown to be not significant when predicting the three attitudes and holding the other variables constant in the high school Spring 2013 final model.

Summary

Once the CFA models confirmed the observed measures of the survey were consistent with the FOCIS and three attitudes hypothesized models, SEM models fixed the FOCIS activities as predicting the three attitudes as outcomes. In other words, SEM models examined if students reported preferences in learning activities (FOCIS) predicted student reported positive attitudes toward science (three attitudes) at the elementary, middle, and high school grade levels.

Results showed those students who reported having a preference for *discovering* types of activities significantly predicted a positive *value of science in society, self-concept,* and *enjoyment and desire* attitudes toward science at the elementary, middle school, and high school grade levels in the Fall 2012 and in the Spring 2013. The highest standardized coefficient value of *discovering* predicting *value of science in society* was 0.614 reported in the elementary grade level in the Fall 2012. The lowest standardized coefficient value of *discovering* predicting *value of science in society* was 0.507 reported in the middle school grade level in the Spring 2013. A closer examination of *discovering* predicting *value of science in society* from Fall 2012 to Spring 2013 within the same grade level show standardized coefficient values decreasing at the elementary and middle school levels, and having similar values at the high school level.

The highest standardized coefficient value of *discovering* predicting *self-concept* was 0.567 reported in the elementary grade level in the Fall 2012. The lowest standardized coefficient value of *discovering* predicting *self-concept* was 0.384 reported in the high school grade level in the Spring 2013. A closer examination of *discovering* predicting *self-concept* from Fall 2012 to Spring 2013 within the same grade level show standardized coefficient values decreasing at the elementary, middle school, and high school levels.

The highest standardized coefficient value of *discovering* predicting *enjoyment and desire* was 0.548 reported in the elementary grade level in the Fall 2012. The lowest standardized coefficient value of *discovering* predicting *enjoyment and desire* was 0.374 reported in the high school grade level in the Spring 2013. A closer examination of *discovering* predicting *enjoyment and desire* from Fall 2012 to Spring 2013 within the same grade level show standardized coefficient values decreasing at the elementary, middle school, and high school levels.

SEM results also showed students who reported having a preference for *performing* types of activities significantly predicted a positive *self-concept* attitude toward science at the elementary and middle school grade levels in the Fall 2012 and in the Spring 2013. *Performing* also significantly predicted *self-concept* at the high school grade level in the Spring 2013 but did not show significance in the Fall 2012. Further evidence of *performing* having a presence in the data was at the middle school grade level on predicting *enjoyment and desire*. Students who reported having a preference for *performing* types of activities significantly predicted a positive *enjoyment and desire* attitude toward science at the middle school grade level in the Fall 2012 and in the Spring 2013.

Caretaking also showed stable significance in predicting an attitude across time, Fall 2012 to Spring 2013, at the middle school and high school grade levels. Students who reported having a preference for *caretaking* types of activities significantly predicted a positive *enjoyment and desire* attitude toward science at the middle school and high school grade levels in the Fall 2012 and in the Spring 2013. Also, students who reported having a preference for *caretaking* types of activities significantly predicted a positive *self-concept* attitude toward science at the middle school grade levels in the Spring of 2013 and in the high school grade levels in the Fall 2012 and in the Spring 2013.

Students who reported having a preference for *competing* types of activities significantly predicted a positive *self-concept* attitude toward science at the high school grade levels in the Fall 2012 and in the Spring 2013. All other predictors either did not show significance in predicting one of the attitudes or was not stable by showing significance in only one time frame (i.e. in the Fall 2012 or in the Spring 2013) but not showing significance in the other time frame.

Finally, small gender differences were present in high school students. Both in the Fall 2012 and Spring 2013, male high school students reported having a slightly more positive *value of science in society, self-concept,* and *enjoyment and desire* attitudes toward science than female high school student.

Table 4-1

Mean and Standard Deviation Values of the *Collaborating* Observed Variables Across Grade and Time

	Elem Fall 2012		**Elem Spring 2013**		**Middle Fall 2012**		**Middle Spring 2013**		**High Fall 2012**		**High Spring 2013**	
Obs. Variable	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
feelgrp	3.843541	1.215341	3.862157	1.159021	4.033461	1.00136	4.069934	1.014528	3.974721	1.074993	3.931668	1.081477
wrkothrs	3.898043	1.393998	3.888548	1.33681	4.083379	1.185655	4.079846	1.169263	3.995542	1.165799	3.916115	1.183601
partteam	4.213693	1.202393	4.194473	1.136847	4.188462	1.063761	4.199449	1.035159	4.074294	1.07647	4.060258	1.071919
lrnothrs	3.626819	1.470331	3.532341	1.42848	3.739923	1.269816	3.736726	1.272214	3.536858	1.302275	3.598234	1.21255

Table 4-2

Mean and Standard Deviation Values of the *Competing* Observed Variables Across Grade and Time

Obs. Variable	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
feelcmpt	3.419555	1.470331	3.404992	1.454199	3.508502	1.277522	3.545154	1.312852	3.519345	1.214058	3.556458	1.206344
exctcmpt	3.380655	1.604715	3.327329	1.5417	3.318107	1.415199	3.303433	1.418071	3.175373	1.32866	3.239114	1.324278
cmptothr	3.342188	1.630254	3.335219	1.573873	3.456546	1.415199	3.496411	1.417477	3.411896	1.344026	3.423616	1.3064
focusown	2.442427	1.564329	2.496926	1.50004	2.661538	1.341909	2.634986	1.284787	2.440149	1.90061	2.494118	1.184879

Table 4-3

Mean and Standard Deviation Values of the *Creating and Making* Observed Variables Across Grade and Time

	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
Obs. Variable	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
feelmkbd	4.361989	1.058881	4.303836	1.052735	4.077558	1.11429	4.029785	1.130158	3.81487	1.143337	3.73692	1.185918
likemake	4.561039	0.9466205	4.460825	1.014598	4.056938	1.192977	3.974501	1.182425	3.722057	1.211838	3.60089	1.228007
resrcful	3.721961	1.394667	3.687082	1.316485	3.35848	1.313131	3.311222	1.312336	3.183445	1.285648	3.086795	1.264807
likebld	4.37794	1.145701	4.339691	1.119277	3.964128	1.291921	3.877968	1.310398	3.566292	1.332863	3.475167	1.342751

Table 4-4

Mean and Standard Deviation Values of the *Discovering* Observed Variables Across Grade and Time

	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
Obs. Variable	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
feeldisc	4.315405	1.047836	4.229826	1.059926	3.957072	1.065232	4.003857	1.044483	4.050558	0.9867282	3.966102	1.005311
figrhow	4.153365	1.215958	4.166752	1.148135	3.859108	1.190068	3.792244	1.198921	3.818792	1.111999	3.736183	1.118876
tkapart	3.950366	1.384381	3.908205	1.359943	3.734289	1.350354	3.658347	1.332081	3.494784	1.348201	3.473762	3.473762
figrdiff	4.053018	1.221233	3.914227	1.232624	3.612707	1.219772	3.60586	1.212941	3.58806	1.173713	3.481536	1.169974
probsolv	3.843455	1.354076	3.704254	1.334811	3.30418	1.322259	3.364947	1.262422	3.342027	1.275598	3.318787	1.222053

Table 4-5

Mean and Standard Deviation Values of the *Performing* Observed Variables Across Grade and Time

	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
Obs. Variable	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
feelpres	2.942197	1.535702	2.904053	1.50206	2.428571	1.410265	2.496674	1.385485	2.470149	1.342088	2.518409	1.324626
perform	3.164511	1.634211	3.188912	1.56595	2.767199	1.513618	2.874862	1.484121	2.807463	1.392481	2.814074	1.401136
presppl	3.149586	1.531267	3.186118	1.45272	3.064942	1.323362	3.139227	1.287546	3.182563	1.27509	3.193165	1.225436
presclas	3.232486	1.610558	3.143445	1.57019	2.555556	1.460518	2.644358	1.450592	2.540299	1.358959	2.598816	1.358255

Table 4-6

Mean and Standard Deviation Values of the *Caretaking* Obsrved Variables Across Grade and Time

Obs. Variable	Elem Fall 2012 Mean	Elem Fall 2012 Std. Dev	Elem Spring 2013 Mean	Elem Spring 2013 Std. Dev	Middle Fall 2012 Mean	Middle Fall 2012 Std. Dev	Middle Spring 2013 Mean	Middle Spring 2013 Std. Dev	High Fall 2012 Mean	High Fall 2012 Std. Dev	High Spring 2013 Mean	High Spring 2013 Std. Dev
feelanml	4.54478	0.91817	4.5	0.93331	4.177606	1.043431	4.113636	1.075029	3.723261	1.267868	3.698822	1.250444
havepet	4.558005	0.9862075	4.511783	0.9878112	4.268427	1.103107	4.161415	1.135428	3.821029	1.266399	3.819867	1.235368
plntaqua	3.989712	1.32045	3.930506	1.287534	3.49174	1.350008	3.489256	1.332227	3.043219	1.35758	3.11037	1.354386

Table 4-7

Mean and Standard Deviation Values of the *Teaching* Observed Variables Across Grade and Time

Obs. Variable	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
feeltutr	4.024763	1.16028	3.905593	1.182224	3.641406	1.1307	3.591487	1.114345	3.612639	1.134938	3.547128	1.107516
hlpothrs	3.827278	1.357054	3.717224	1.321022	3.65651	1.287986	3.304783	1.265742	3.284753	1.243836	3.22929	1.191793
tchothrs	3.71421	1.420997	3.630817	1.378349	3.214483	1.349529	3.225305	1.28125	3.227782	1.280977	3.168764	1.222481
dpendme	4.230769	1.188323	4.136573	1.207816	3.748348	1.206501	3.726519	1.196925	3.599553	1.124344	3.584444	1.117909

Table 4-8

Mean and Standard Deviation Values of the *Value of Science* Observed Variables Across Grade and Time

Obs. Variable	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
	Mean	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
scipbslv	3.781686	1.340921	3.651973	1.305352	3.440265	1.250467	3.43519	1.275001	3.381913	1.253221	3.352897	1.275265
scistudy	3.94476	1.254556	3.709463	1.235556	3.465155	1.186953	3.427464	1.195096	3.413125	1.22326	3.344725	1.197286
scihlpfl	4.108628	1.185433	3.997432	1.186379	3.676846	1.214707	3.646896	1.23547	3.617053	1.174814	3.578987	1.186906
sciimprt	4.06873	1.20889	3.903876	1.203262	3.613208	1.208752	3.609783	1.206229	3.626028	1.199742	3.581845	1.210834

Table 4-9

Mean and Standard Deviation Values of the *Self-Concept* Obsrved Variables Across Grade and Time

Obs. Variable	Elem Fall 2012		Elem Spring 2013		Middle Fall 2012		Middle Spring 2013		High Fall 2012		High Spring 2013	
	Mean	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
scieasy	3.751832	1.372553	3.718621	1.332342	3.317478	1.380104	3.450774	1.371224	3.40478	1.249397	3.401189	1.262369
sciustnd	4.044179	1.221502	4.016958	1.172618	3.687361	1.211809	3.743079	1.223226	3.609738	1.147213	3.504095	1.180987
scichlng	3.617167	1.477025	3.438115	1.501183	3.095768	1.389881	3.116861	1.372953	2.948276	1.319662	2.947839	1.255665

Table 4-10

Mean and Standard Deviation Values of the *Enjoyment and Desire* Observed Variables Across Grade and Time

	Elem Fall 2012		**Elem Spring 2013**		**Middle Fall 2012**		**Middle Spring 2013**		**High Fall 2012**		**High Spring 2013**	
Obs. Variable	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
scienjoy	3.913202	1.32783	3.639815	1.401296	3.252078	1.397714	3.299448	1.394076	3.124907	1.324047	3.072862	1.321429
scifavsb	3.730284	1.500594	3.508781	1.533072	3.148498	1.523211	3.173503	1.525289	3.022455	1.43141	3.00297	1.419454
scilearn	3.721406	1.418858	3.511088	1.438185	3.083749	1.396117	3.085366	1.434241	2.914543	1.391286	2.920328	1.376424

Table 4-11

FOCIS CFA Model Values

FOCIS CFA		**RMSEA**	**CFI**	**SRMR**
Fall 2012	Elementary	0.045	0.926	0.054
	Middle School	0.057	0.920	0.064
	High School	0.055	0.933	0.059
Spring 2013	Elementary	0.048	0.934	0.056
	Middle School	0.060	0.928	0.068
	High School	0.063	0.922	0.061

Table 4-12

Attitude CFA Model Values

Attitudes CFA		RMSEA	CFI	SRMR
Fall 2012	Elementary	0.049	0.977	0.025
	Middle School	0.078	0.966	0.031
	High School	0.097	0.948	0.037
Spring 2013	Elementary	0.059	0.973	0.027
	Middle School	0.096	0.956	0.032
	High School	0.110	0.942	0.038

Table 4-13

Elementary Fall 2012 SEM Full Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.434
	Discovering	0.5564571	0.0579882	9.6	0.000	
	Collaborating	0.1016546	0.033011	3.08	0.002	
	Competing	-0.0316966	0.0287356	-1.10	0.270	
	Creating	-0.0064058	0.0447363	-0.14	0.886	
	Teaching	0.0105592	0.0500039	0.21	0.833	
	Performing	0.0096575	0.0365974	0.26	0.792	
	Caretaking	0.1147969	0.0380617	3.02	0.003	
Self-Concept						0.369
	Discovering	0.4427769	0.0612406	7.23	0.000	
	Collaborating	-0.0203035	0.0349817	-0.58	0.562	
	Competing	0.0538914	0.0304897	1.77	0.077	
	Creating	0.078498	0.046532	1.69	0.092	
	Teaching	-0.1088579	0.0521267	-2.09	0.037	
	Performing	0.2140954	0.038409	5.57	0.000	
	Caretaking	0.0855089	0.0400791	2.13	0.033	
Enjoyment and Desire						0.293
	Discovering	0.445131	0.0558464	7.97	0.000	
	Collaborating	0.0414551	0.0318866	1.30	0.194	
	Competing	0.0423335	0.0277524	-1.53	0.127	
	Creating	0.0704645	0.0425207	1.66	0.097	
	Teaching	-0.0627395	0.0475576	-1.32	0.187	
	Performing	0.0718113	0.035282	2.04	0.042	
	Caretaking	0.0926776	0.0365415	2.54	0.011	

Table 4-14

Elementary Fall 2012 SEM Reduced Model 2 Results

Structural		**Coefficient (Stand)**	**Std Error**	**z**	***P*-value**	**R^2**
Value of Science in Society						0.431
	Discovering	0.551306	0.043298	12.73	0.000	
	Collaborating	0.0898577	0.0283699	3.17	0.002	
	Competing	-0.0286915	0.0286841	-1.00	0.317	
	Teaching	0.0202578	0.0467202	0.43	0.665	
	Performing	0.0073657	0.0362773	0.20	0.839	
	Caretaking	0.1128631	0.0365703	3.09	0.002	
Self-Concept						0.361
	Discovering	0.4366598	0.0584524	7.47	0.000	
	Competing	0.0533658	0.0303745	1.76	0.079	
	Creating	0.0856	0.0416912	2.05	0.040	
	Teaching	-0.1178906	0.047998	-2.46	0.014	
	Performing	0.2156295	0.0381208	5.66	0.000	
	Caretaking	0.0819898	0.0395164	2.07	0.038	
Enjoyment and Desire						0.289
	Discovering	0.4473457	0.0523904	8.54	0.000	
	Competing	-0.0372196	0.0276519	-1.35	0.178	
	Creating	0.0679971	0.0364622	1.86	0.062	
	Teaching	-0.0388491	0.0436146	-0.89	0.373	
	Performing	0.0667083	0.0350249	1.9	0.057	
	Caretaking	0.0942298	0.035989	2.62	0.009	

Table 4-15

Elementary Fall 2012 SEM Reduced Model 3 Results

Structural		**Coefficient (Stand)**	**Std Error**	**z**	***P*-value**	**R^2**
Value of Science in Society						0.430
	Discovering	0.5459093	0.0397568	13.73	0.000	
	Collaborating	0.0880806	0.0282119	3.12	0.002	
	Competing	-0.0433515	0.0244025	-1.78	0.076	
	Teaching	0.0408423	0.0395375	1.03	0.302	
	Caretaking	0.1071342	0.0362626	2.95	0.003	
Self-Concept						0.360
	Discovering	0.4277198	0.0545073	7.85	0.000	
	Creating	0.0937551	0.0412947	2.27	0.023	
	Teaching	-0.1053127	0.0387421	-2.72	0.007	
	Performing	0.2322569	0.0324614	7.15	0.000	
	Caretaking	0.0721733	0.0389706	1.85	0.064	
Enjoyment and Desire						0.288
	Discovering	0.4207278	0.0404821	10.39	0.000	
	Competing	-0.0595047	0.0223434	-2.66	0.008	
	Creating	0.0799979	0.0346286	2.31	0.021	
	Performing	0.0634152	0.0289062	2.19	0.028	
	Caretaking	0.0820196	0.0344002	2.38	0.017	

Table 4-16

Elementary Fall 2012 SEM Reduced Model 4 Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.437
	Discovering	0.5857439	0.0305753	19.16	0.000	
	Collaborating	0.0996558	0.026109	3.82	0.000	
	Competing	-0.0472076	0.0244102	-1.93	0.053	
	Caretaking	0.0852449	0.0334459	2.55	0.011	
Self-Concept						0.362
	Discovering	0.4504631	0.0543316	8.29	0.000	
	Creating	0.1100808	0.0407154	2.7	0.007	
	Teaching	-0.0962664	0.0374953	-2.57	0.010	
	Performing	0.2252407	0.032337	6.97	0.000	
Enjoyment and Desire						0.288
	Discovering	0.4369779	0.0397434	10.99	0.000	
	Competing	-0.0596056	0.0223453	-2.67	0.008	
	Creating	0.0882749	0.0343662	2.57	0.01	
	Performing	0.0582529	0.0285498	2.04	0.041	
	Caretaking	0.0454771	0.0288048	1.58	0.114	

Table 4-17

Elementary Fall 2012 SEM Reduced Model 5 Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.433
	Discovering	0.5833917	0.0292127	19.97	0.000	
	Collaborating	0.0981334	0.0261348	3.75	0.000	
	Caretaking	0.072853	0.0313966	2.32	0.020	
Self-Concept						0.365
	Discovering	0.45424077	0.0539498	8.42	0.000	
	Creating	0.1083544	0.040655	2.67	0.008	
	Teaching	-0.1093202	0.0370738	-2.95	0.003	
	Performing	0.2365029	0.0318686	7.42	0.000	
Enjoyment and Desire						0.289
	Discovering	0.4489817	0.037902	11.85	0.000	
	Competing	-0.0486351	0.0211478	-2.30	0.021	
	Creating	0.0969777	0.0342876	2.83	0.005	
	Performing	0.0627836	0.0285731	2.20	0.028	

Table 4-18

Elementary Fall 2012 SEM Reduced Model 6C Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.432
	Discovering	0.5789421	0.0292386	19.80	0.000	
	Collaborating	0.102665	0.0261795	3.90	0.000	
	Caretaking	0.077397	0.0313966	2.46	0.014	
Self-Concept						0.342
	Discovering	0.3582831	0.0433722	8.26	0.000	
	Creating	0.1402665	0.0389883	3.60	0.000	
	Performing	0.2119229	0.0306492	6.91	0.000	
Enjoyment and Desire						0.289
	Discovering	0.4475794	0.0379836	11.78	0.000	
	Competing	-0.0545243	0.0211027	-2.58	0.01	
	Creating	0.097751	0.0343518	2.85	0.004	
	Performing	0.0655857	0.0285731	2.30	0.022	

Table 4-19

Elementary Fall 2012 SEM Reduced Model 6T Results

Structural		**Coefficient (Stand)**	**Std Error**	**z**	***P*-value**	**R^2**
Value of Science in Society						0.433
	Discovering	0.5847421	0.0291819	20.04	0.000	
	Collaborating	0.102665	0.0259409	3.97	0.000	
	Caretaking	0.0649967	0.031103	2.09	0.037	
Self-Concept						0.378
	Discovering	0.5513433	0.040252	13.70	0.000	
	Teaching	-0.1375061	0.0364131	-3.78	0.000	
	Performing	0.2460833	0.0320846	7.67	0.000	
Enjoyment and Desire						0.291
	Discovering	0.4790042	0.0362093	13.23	0.000	
	Competing	-0.0469699	0.0211518	-2.22	0.026	
	Creating	0.0555288	0.0309624	1.79	0.073	
	Performing	0.0633218	0.028665	2.21	0.027	

Table 4-20

Elementary Fall 2012 SEM Reduced Model 7 Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.433
	Discovering	0.584343	0.0291897	20.02	0.000	
	Collaborating	0.1071369	0.0257634	4.16	0.000	
	Caretaking	0.0617148	0.0309921	1.99	0.046	
Self-Concept						0.376
	Discovering	0.5451935	0.039946	13.65	0.000	
	Teaching	-0.1279491	0.035716	-3.58	0.000	
	Performing	0.2438284	0.0320588	7.61	0.000	
Enjoyment and Desire						0.296
	Discovering	0.5192803	0.0282661	18.37	0.000	
	Competing	-0.0444143	0.0211537	-2.10	0.036	
	Performing	0.0637564	0.0288586	2.21	0.027	

Table 4-21

Elementary Fall 2012 SEM Reduced Model 8 Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.433
	Discovering	0.5860592	0.0291507	20.10	0.000	
	Collaborating	0.1065485	0.0257453	4.14	0.000	
	Caretaking	0.059119	0.0309434	1.91	0.056	
Self-Concept						0.376
	Discovering	0.5500264	0.0399756	13.76	0.000	
	Teaching	-0.1361404	0.0356817	-3.82	0.000	
	Performing	0.2454107	0.032073	7.65	0.000	
Enjoyment and Desire						0.296
	Discovering	0.5212805	0.0282794	18.43	0.000	
	Performing	0.0439981	0.0273291	1.61	0.107	

Table 4-22

Elementary Fall 2012 SEM Final Model

Structural		**Coefficient (Stand)**	**Std Error**	**z**	***P*-value**	**R^2**
Value of Science in Society						0.436
	Discovering	0.613895	0.0212662	27.93	0.000	
	Collaborating	0.1120652	0.025587	4.38	0.000	
Self-Concept						0.377
	Discovering	0.5672949	0.0289213	14.6	0.000	
	Teaching	-0.1392013	0.035805	-3.89	0.000	
	Performing	0.2225177	0.0288672	7.71	0.000	
Enjoyment and Desire						0.300
	Discovering	0.548004	0.0227729	24.06	0.000	

Table 4-23

Middle School Fall 2012 SEM Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.383
	Discovering	0.6091367	0.0199953	30.46	0.000	
	Collaborating	0.077811	0.0203431	3.82	0.000	
Self-Concept						0.348
	Discovering	0.4723241	0.0257981	18.31	0.000	
	Collaborating	-0.0821327	0.0189635	-4.33	0.000	
	Competing	0.117295	0.0196672	5.96	0.000	
	Performing	0.1538723	0.0252248	6.10	0.000	
Enjoyment and Desire						0.294
	Discovering	0.5029008	0.0244751	20.55	0.000	
	Performing	0.0552147	0.0217687	2.54	0.011	
	Caretaking	0.043086	0.0190247	2.26	0.024	

Table 4-24

Middle School Spring 2013 SEM Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.359
	Discovering	0.5077519	0.0248401	20.44	0.000	
	Performing	0.0858822	0.0251174	3.42	0.001	
	Caretaking	0.124478	0.0265052	4.70	0.000	
Self-Concept						0.341
	Discovering	0.4282208	0.0268778	15.93	0.000	
	Performing	0.2293359	0.0258128	8.88	0.000	
	Caretaking	0.0702322	0.0276952	2.54	0.011	
Enjoyment and Desire						0.277
	Discovering	0.4665413	0.0244751	17.22	0.000	
	Competing	-0.0757259	0.0165917	-4.56	0.000	
	Teaching	-0.0747375	0.0212345	-3.52	0.000	
	Performing	0.1558966	0.0266756	5.84	0.000	
	Caretaking	0.0988688	0.0278727	3.55	0.000	

Table 4-25

High School Fall 2012 SEM Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.325
	Discovering	0.52033	0.0248122	20.97	0.000	
	Caretaking	0.1493371	0.0288706	5.17	0.000	
Self-Concept						0.296
	Discovering	0.4570175	0.028912	15.81	0.000	
	Competing	0.1457554	0.0218212	6.68	0.000	
	Caretaking	0.0949259	0.031302	3.03	0.002	
Enjoyment and Desire						0.243
	Discovering	0.4280468	0.0260241	16.45	0.000	
	Caretaking	0.1714126	0.0287585	5.96	0.000	

Table 4-26

High School Fall 2012 with Gender SEM Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.320
male = 1, female = 2	Gender	-0.0796061	0.0285238	-2.79	0.005	
	Discovering	0.5100924	0.0255016	20.00	0.000	
	Caretaking	0.1494003	0.0295099	5.06	0.000	
Self-Concept						0.304
male = 1, female = 2	Gender	-0.0974728	0.0306657	-3.18	0.001	
	Discovering	0.4614498	0.0294892	15.81	0.000	
	Competing	0.1315371	0.02213	5.94	0.000	
	Caretaking	0.0997199	0.031957	3.12	0.002	
Enjoyment and Desire						0.237
male = 1, female = 2	Gender	-0.0754679	0.0285962	-2.64	0.008	
	Discovering	0.4207993	0.0260241	15.73	0.000	
	Caretaking	0.1635721	0.0295251	5.54	0.000	

Table 4-27

High School Spring 2013 SEM Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.306
	Discovering	0.5218179	0.0396209	13.17	0.000	
	Creating	-0.1281475	0.0357272	-3.59	0.000	
	Performing	0.0974605	0.0288714	3.38	0.001	
	Caretaking	0.1960838	0.0284605	6.89	0.000	
Self-Concept						0.296
	Discovering	0.383533	0.0303692	12.63	0.000	
	Collaborating	-0.0474248	0.0203427	-2.33	0.020	
	Competing	0.0995393	0.0218292	4.56	0.000	
	Performing	0.1584471	0.0307466	5.15	0.000	
	Caretaking	0.0949259	0.031302	3.03	0.002	
Enjoyment and Desire						0.251
	Discovering	0.3743902	0.0285471	13.11	0.000	
	Performing	0.0971963	0.0283329	3.43	0.001	
	Caretaking	0.2004241	0.0276624	7.25	0.000	

Table 4-28

High School Spring 2013 with Gender SEM Model Results

Structural		Coefficient (Stand)	Std Error	z	*P*-value	R^2
Value of Science in Society						0.322
male = 1, female = 2	Gender	-0.0777659	0.0267722	-2.90	0.004	
	Discovering	0.5263907	0.0423028	12.44	0.000	
	Creating	-0.13139	0.0386351	-3.40	0.001	
	Performing	0.1073297	0.0308753	3.65	0.000	
	Caretaking	0.2024782	0.0302273	5.91	0.000	
Self-Concept						0.298
male = 1, female = 2	Gender	-0.06279	0.027953	-2.25	0.025	
	Discovering	0.383533	0.0319695	12.43	0.000	
	Collaborating	-0.0554248	0.020762	-2.67	0.008	
	Competing	0.0985742	0.022478	4.39	0.000	
	Performing	0.1635433	0.0325418	5.03	0.000	
	Caretaking	0.1564671	0.031308	5.00	0.002	
Enjoyment and Desire						0.251
male = 1, female = 2	Gender	-0.0752851	0.026522	-2.84	0.005	
	Discovering	0.3696709	0.0303522	13.11	0.000	
	Performing	0.1190941	0.0301704	3.95	0.000	
	Caretaking	0.1856336	0.0293869	6.32	0.000	

CHAPTER 5

Discussion and Conclusion

This section first discusses reasons for *discovering*, *performing,* and *caretaking* having a large presence in predicting positive attitudes toward science. Later, a perspective on the three attitudes toward science is used to make suggestions on improving teacher education.

Discovering

The alignment between the questions items used in the FOCIS survey to define the *discovering* construct and definitions of science processing and reasoning skills used in understanding what science is and why it is important can be used as a way of interpreting the presence of the *discovering* construct significantly predicting positive attitudes toward science. The *discovering* construct question items, such as asking students how they feel about activities involving discovering and learning new things, trying different ways to figuring things out, and solving problems, are similar to scientific processing and reasoning skills, which include skills involved in inquiry, discovering, researching and experimentation (Zimmerman, 2007) and contribute to understanding what science is and why it is important.

The first question item in the FOCIS survey defining the *discovering* construct asked students, on a five-point Likert scale, how much they liked the statement “I like an activity that involves discovering and learning new things." Discovery is the act of finding or learning something for the first time, or something seen or learned for the first time (Merriam-Webster, 2014). This question asked if students had the desire to acquire new knowledge.

The second question item in the FOCIS survey defining the *discovering* construct asked students, on a five-point Likert scale, how much they liked the statement "I like figuring out how things work." This question addresses a student's willingness and a desire toward knowing how a process functions. In relating the second question to the first question, the act of figuring how something works will lead the student to the formation of new knowledge.

The third question item in the FOCIS survey defining the *discovering* construct asked students, on a five-point Likert scale, how much they liked the statement "I like taking things apart to see what is inside." This question takes a more tactile approach to figuring things out by taking objects apart, but the question still addresses a student's curiosity and willingness to deconstruct something and a student doing so will also lead them to the formation of new knowledge.

The fourth question item in the FOCIS survey defining the *discovering* construct asked students, on a five-point Likert scale, how much they liked the statement "I like trying different ways to figure things out." This question addresses a student's methodology for answering questions and solving problems. This may involve trial and error, reaffirming initial results from a different approach, or interpreting results from a different perspective.

The final question item in the FOCIS defining the *discovering* construct asked students, on a five-point Likert scale, how much they liked the statement “I like solving problems.” At the basic core, this question links enjoyment with solving problems.

The aggregate meaning of these question items, a desire to acquire new knowledge, a willingness to know how a process or an object functions, even if it means physically taking it apart, a method of understanding something through multiple approaches, and an overall enjoyment in solving problems draw similarities to definitions describing science processing and reasoning skills.

Science processing and reasoning skills involve in observing, hypothesizing, classifying, researching and experimentation, collecting and interpreting, and predicting (Zimmerman, 2007). Observing is determining the properties of an object or event through the use of senses. Hypothesizing is proposing an explanation based on observational data. Classifying is grouping objects or events according to their properties. Experimentation is investigating and testing hypotheses through a procedure to determine a result. Collecting and interpreting data is a gathering of forms of data to make meaningful information that can lead to inferences and predictions. Predicting is the use of data to state a claim that describes an anticipated consequence. These science processing skills are used in acquiring new knowledge, in understanding how something works and functions, in using multiple approaches and methods to understand something, and in solving problems. The science processing skills in solving problems contribute to our understanding of what science is and why it’s important.

Science is the effort to understand the natural world around us and how the natural world works, with observable physical evidence as the basis of that understanding (Academic Press Dictionary of Science and Technology, 1992). Science is done through the observation of natural phenomena, and through experimentation that tries to simulate natural processes under controlled conditions. It is through these observations of natural events and conditions that may lead to a discovery of facts about them and a formulation of laws and principles based on these facts. The importance of science lies in collecting information to test new ideas or to disprove old ideas. In the latter scenario, science can overturn or slightly change some previously accepted idea. The former scenario provides our society with something previously not explained. However, either scenario is often referred to as a discovery. New discoveries could improve people's lives, could impact a country's economic development, or could simply quench or curiosity for wanting to know more about the natural world around us. In order to make these discoveries and to solve problems, scientists use science processing and reasoning skills.

The connection between the question items in the FOCIS survey describing the *discovering* construct and the science processing and reasoning skills used in understanding what science is and why it is important is that the question items closely matches what a scientist does. Due to the question items closely matching what scientists do and their value to society, it is reasonable to use this as an argument for why we saw students who reported having a preference for *discovering* types of activities significantly predicted a positive *value of science in society and self-concept, and enjoyment and desire* attitudes toward science at the elementary, middle school, and high school grade levels in the Fall 2012 and in the Spring 2013.

*Discover*ing activities in school also simulate what scientists do as students experiment, problem solve, or research a topic or a question in search of knowledge previously unknown by the student, and was a reason why the science curricula analysis using the FOCIS framework showed a high percentage of activities characterized as *discovering*. The science curricula analysis showed 730 of 798 (91.5%) activities found in the 14 for-profit science books having characteristics of a *discovering* based activity.

Performing

Conceptually, there is a connection between *performing* and *self-concept*, which can be used to explain the presence of *performing* significantly predicting *self-concept*. In reviewing the FOCIS *performing* based activities, we are reminded that students are displaying a certain developed skill in these types of activities. More specifically, students emphasize doing or performing a specific learned skill as a result of instruction or developed on their own accord. They demonstrate their ability to do a task or display their knowledge of a topic, which could involve performing or presenting in front of an audience.

Students who reported having a preference for *performing* types of activities improve their *self-concept* attitude toward science at the elementary and middle school grade levels, and even later in high school. That is to say, the act of performing is an act of displaying a skill, and is leading students who report they prefer performing as a type of activity to reflect on their own academic ability and behavior in science. Students who report they prefer performing are also improving how they perceive and evaluate themselves in doing science.

Caretaking

Caretaking was not reported as significantly predicting a positive attitude toward science at elementary grade levels. *Caretaking* did significantly predict *enjoyment and desire* attitude at the middle school and high school grade levels in Fall 2012 and Spring 2013 and *self-concept* attitude at the middle school grade level in the Spring 2013 and at the high school grade level in Fall 2012 and Spring 2013. Since this data was not longitudinal data, meaning the data did not represent the same students over time, we cannot say that *caretaking* emerged to be a significant predictor of attitude over time. However, the data did represent separate groups of students at different grade levels and was treated as such in interpreting why *caretaking* had a presence in middle and high school but not in the elementary student groups.

Social Cognitive Career Theory (Bandura, 1986; Lent, 1994) is highlighted and drawn from in order to give one possible reason to the presence of *caretaking* in middle school and high school. Social Cognitive Career Theory (SCCT) emphasizes personal agency, choice, and self-direction in the learning process. This theory helps to elucidate the complex interplay between an individual's self-efficacy, goals, and outcome expectations, or expected costs and benefits of performing in a certain way to achieve a particular task and make future choices. The SCCT interest development model (Lent et al, 1994), in particular, provides a useful lens for understanding how student expectations, identity formation, and beliefs in their ability to succeed prior to and during a learning experience could influence their ability to flourish and make future career choice in a particular area. For students preferring *caretaking* activities in science, this could mean that the combination of students' initial expectations toward science, how they see themselves in science, and their belief in their ability to accomplish tasks in science could influence their engagement, success, and career choices. Furthermore, students who report a preference toward *caretaking* activities may find associations between these activities and *caretaking* related careers, such as in health care, medical, environmental, or biological related fields, which in turn influenced their future career choices. As to why middle school and high school students reported *caretaking* significantly predicting attitude toward science, and not elementary students, may be due to adolescence maturing and developing their own identity (Erikson, 1963; Santrock, 2007). Adolescents emerge from a childhood time of learning family, social, and cultural norms to a period of relative freedom from societal expectations and a feeling of wanting to experiment with different personalities and roles. Everything that was established about their self in childhood is re-evaluated in adolescence according to Erikson. Some of the components of the self-concept, self worth, and childhood personality may be retained or rejected in the adolescent's search for identity. Adolescents have to internalize a set of affirmations regarding their own strengths, weaknesses, values, and career choice (Santrock, 2007). Middle school and high school students may be beginning to form an identity that is associated with *caretaking* and *caretaking* related career fields. In turn, this identity formation toward *caretaking* related career fields could help explain the presence of *caretaking* predicting positive attitudes toward science at the middle school and high school grade levels.

Attitudes Toward Science

Science teachers and educators are charged with the responsibility of engaging their students, exposing them to science content and processing skills, and assessing them on these materials. In addition to science teachers’ responsibility of educating their students to become more science literate, policy makers are concerned about meeting future employment demands in areas of science and engineering (Carnevale, 2010). Not meeting these needs will result in loss of national economic and innovation opportunities. In the recent ASPIRES study (2013), which explored what influences the likelihood of students aged 10 to 14 to aspire to a science-related career, researchers found that although the majority of students reported they were learning interesting things in science (approx 70%), less than 18% of students reported they aspired to enter a science-related career.

Applying a different perspective of the variables from this study could possibly lead to the improvement of teachers' understanding of educating their students to become more science literate and possibly increase the number of individuals moving into science fields. This perspective would mean viewing the three attitudes toward science in this study, *value of science in society, self-concept,* and *enjoyment and desire,* as goals science teachers should have for their students instead of a symptom of teaching. Using these goals, along the data from this study and the literature on student engagement, could provide teachers with a different perspective on educating their students and creating a more meaningful education experience.

Value of Science in Society

Students grasping the *value of science in society* is having them understand the impact science processing and reasoning skills can have in their lives, what the processes of doing science has lead to, and what future discoveries are possible through the use of science. Teachers making the process of science (observing, hypothesizing, classifying, researching and experimentation, collecting and interpreting, predicting) relevant to their students' personal lives in constructing their own knowledge about the world around them can possibly benefit their understanding of their own environment and help them understand the process of science itself. Teachers can also use past examples of discoveries as evidence that new scientific knowledge may lead to new applications. Teachers can address how the process of doing science and the development of new technologies may lead to new scientific discoveries, with its application having the potential of solving a major societal or world problem.

These three aspects of teaching *value of science in society* are not independent of each other nor should they be taught in that fashion. Teachers can integrate these to show connections between past discoveries, the students themselves, and what students can do in the future by developing science processing skills and being science literate. *Discovering* based activities simulate science processing skills by exploring information, concepts, knowledge, and answers to questions previously unknown.

Enjoyment and Desire

Although it is important for students to understand what science is and have an appreciation for it, it is also important for students to enjoy doing science so engagement and retention remains in learning science. Teachers need to nurture their students' sophisticated thinking capabilities through increased student engagement instead of implementing a lecture-oriented, teacher-centric instruction system that ends up blunting or even destroying what the students already possess. The concern of the latter is that a lecture-based class could turn students into passive learners removing the joy of learning science in school. This includes the low bar of being an entertainer as a teacher, only using a pedagogy that involves demonstrations. Increasing student engagement and having them remain active in their learning increases students' enjoyment and positive attitude toward school (Cothran & Ennis, 2000). Earlier mentioned strategies on how to improve student engagement in learning, such as improving teacher-student interactions, making curriculum more relevant, posing challenging questions, allowing students to explore their own questions and interests, setting high academic standards through assessment, and engaging them in hands-on activities have the potential to increasing enjoyment and desire to learn. As a juxtaposition to a lecture based, teacher centric classroom is a constructivist learning environment where students experience learning by doing (Kolb, 1984). Constructivism is the learner constructing their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. Upon the learner encountering something new, they have to interpret it with their previous ideas, conceptions, and experiences, which may lead to either a change in what they initially believed or a reaffirmation disregarding new information. Constructivism in the classroom focuses on encouraging students to use active techniques (i.e. *discovering* based activities) to create more knowledge and then to reflect on what they are doing and how their understanding is changing. This technique constantly allows the students to assess their own learning in the activity while simultaneously helping teachers gauge where their students are at in their development and understanding of science content knowledge. In turn, students have more ownership of their learning and are engaged leading to more enjoyment in their learning.

Self-Concept

As it is important for students to enjoy doing science and understanding what science is and having an appreciation for it, it is also important for students to have a strong self-concept toward doing science. That is to say, it is important to develop students' academic self-concept in doing science as it influences students' motivation and their continued ability to do science related work. Self-concept involves students' perceptions of their own academic ability to do work. It is how a student thinks about, perceives, and evaluates their self. It is a collection of beliefs about oneself (Leflot, Onghena, & Colpin, 2010), one's own nature, unique qualities, and typical behavior (Weiten, Dunn, & Hammer, 2012).

As a teacher, charged with their students' learning, improving students' self-concept in doing science is to address any possible psychological barriers that may exist by building upon students' own experiences in science. Barriers could include a student not having the confidence in doing science, or not identifying, imagining, or seeing themselves doing science. To address these barriers, a teacher needs to know where the student is at in their learning and where to set the initial bar in goal setting. Setting the bar too low could make the task too easy and possibly leading the student to disengage. Setting the bar too high could make the task too hard and possibly leading the student to reaffirm their initial notion of not being able to do science. However, if a teacher has knowledge of where her students are at in their learning she can then proceed through the lesson giving feedback and support to her students as they take on more challenging tasks and build and improve their self-concept.

Integration

The data from this study showed all standardized coefficient values of *discovering* predicting *value of science in society, self-concept,* and *enjoyment and desire* attitude toward science to decrease from Fall 2012 to Spring 2013. Although the data was not longitudinal data, initially reported (i.e. Fall 2012) standardized coefficient values of *discovering* predicting *value of science in society, self-concept,* and *enjoyment and desire* attitudes toward science decreased with each older group grade level. This is a cause for concern because students who initially reported at the beginning of the year their preference toward *discovering* based activities, activities similar to science processing and reasoning skills, as predicting positive attitudes toward science are later predicting positive attitudes toward science with a lesser effect. A misinterpretation of the data would be to advise teachers to only implement *discovering, performing, caretaking,* and at the high school level *competing*. A quick frequency analysis of these predictors showed students happy about *discovering* and *caretaking* based activities, but were unhappy about *performing* based activities. Students show neutral to happy about being in a *competing* based activities.

Using this study, recommendations to teachers ought to be focused on integrating student goals of obtaining a *value of science in society,* improving their *self-concept* in doing science, and possessing an *enjoyment and desire* to do science through activities that students prefer doing in their learning. While integrating these goals and activities into the classroom, teachers can provide meaningful experiences for their students as students see the purpose in doing science, improve upon their ability in doing science, and enjoy doing science.

Limitations

This study looked a large sample of student reported preferences of activities in learning and their reported attitudes toward science. The macro level of this study did not allow for the understanding of what type of science activities teachers were using in their classrooms. We were unaware how often teachers were implementing science activities and what kind of pedagogy was being used in engaging students. More micro level observations and analyses of classrooms in the schools surveyed in this study may lead to a richer understanding of teachers' pedagogy styles, students' preferences for learning activities, and students' attitudes toward science.

The variable selection procedure used in the SEM emphasized predictors that showed little to no collinearity. Further analysis is needed to understand the relationships in the data between *creating and making*, *teaching,* and *collaborating*.

Table 5-1

Frequency Analysis of *Discovering, Performing, Caretaking, Competing*

We want to know how you feel about…

… discovering and learning new things.	**Elementary**	**Middle School**	**High School**
Unhappy	3.45%	2.81%	1.64%
2	3.03%	6.16%	5.20%
Neutral	14.31%	23.61%	20.82%
4	16.97%	27.35%	31.15%
Happy	62.25%	40.07%	41.19%

…presenting in front of lots of people.	**Elementary**	**Middle School**	**High School**
Unhappy	28.01%	37.58%	33.36%
2	12.30%	18.74%	20.22%
Neutral	21.76%	19.73%	22.69%
4	13.35%	11.15%	13.51%
Happy	24.59%	12.80%	10.22%

…taking care of animals.	**Elementary**	**Middle School**	**High School**
Unhappy	2.44%	2.43%	7.70%
2	2.07%	5.74%	8.98%
Neutral	8.90%	15.33%	24.83%
4	11.76%	24.66%	20.27%
Happy	74.83%	51.85%	38.22%

…being in a competition.	**Elementary**	**Middle School**	**High School**
Unhappy	17.54%	9.60%	8.04%
2	8.28	11.08%	11.09%
Neutral	23.85%	27.37%	27.75%
4	15.36%	22.76%	27.16%
Happy	34.97%	29.18%	25.97%

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