Effect of Task Specific Self-Regulation Prompts on Science Content Knowledge and Transfer

By

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Abstract

A goal of the Next Generation Science Standards (NGSS) is to teach students to be self-regulated in planning, monitoring, and evaluating problems they will solve and questions they will answer. Self-regulating learners use metacognitive monitoring to help them choose their strategies (Winne, 2018). The problem is that not all students learn to be metacognitive and practice self-regulation on their own. Middle school students find it very difficult to distinguish between what they know and what they do not know (Zepeda, Richey, Ronevich & Nokes-Malach, 2015). By helping students in middle school, to practice the self-regulating strategies (SRS) of planning, monitoring and evaluating, we can prepare our students for the rigors of high school and future assessments from the College Board, which expects science students who are college-ready to practice metacognition (Lombardi, Conley, Seburn & Downs, 2013).

The purpose of this study was to determine the effectiveness of using metacognitive and self-regulating strategies on improved strategy use and content mastery in middle school science. Science and special education teachers taught self-regulating and metacognitive strategies to 181 students and used prompts to encourage the use of SRS. The results of the study showed the successful effect of prompts on development and use of SRS and illustrates through Structural Equation Modeling (SEM) the effect of SRS on science learning.

Consistent use of SRS has been identified in high achieving learners (Zimmerman & Martinez Pons, 1986) however, in an article designed for science and special education teachers, I described how the design of instruction and prompting of SRS in science content improved the use of these skills for other level learners as well. I designed a professional development plan for teams of teachers to explicitly teach SRS. By preparing the strategies instruction together they can consistently use the same metacognitive and self-regulating language across several core

content areas since self-regulation is context dependent (Bransford, Brown & Cocking, 2000,Winne, 2010).

Dedication

I could not have done this without the support of my beloved husband and best friend, Kurt, thank you for believing in me, making all those delicious dinners and for the hours of editing.

To my darling sons, Peter, Luke, and Thomas your belief in me and your senses of humor carried many a difficult day.

For my Mom and Dad, who listened to every setback with compassion and cheered every success. And my sisters and brothers who all seemed to just know I would finish this, your confidence in me is gratifying.

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Chapter 1: Introduction to the Study

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Problem of Practice

In today's world of readily available information one must be self-directed and, in fact, as a 21st century skill this quality is essential (Kereluik, Mishra, Fahnoe, and Terry, 2013). A self-directed learner chooses what they will learn and how they will do it using metacognition and self-regulation strategies. Self-regulated students are problem solvers who reflect, evaluate, monitor, and discipline themselves in their studies. Self-regulating learners use metacognitive monitoring to help them choose their strategies (Winne, 2018). A student must know what they already know and what they need to know to plan how they will learn something new. Understanding how you learn and knowing your learning strengths and weaknesses is metacognition (Bransford, Brown & Cocking, 2000).

The problem is that not all students learn to be metacognitive and practice self-regulation on their own. Students may learn by watching and listening to adults around them model these practices (Newman, 2002; Zimmerman (2002). Middle school students find it very difficult to distinguish between what they know and what they do not know (Zepeda et al, 2015). Although teachers know that self-regulating skills are important, those in the secondary grades argue that they have little time to teach these skills and are sometimes unaware of the processes novice learners go through to learn their material (Joseph, 2010). Teaching students to practice metacognition will enable them to more effectively use self-regulating skills so they will spend less time practicing a problem and focus on what is going well or not with the problem, allowing less practice and still yielding improved problem solving (Zepeda, Richey, Ronevich & Nokes-Malach, 2015).

Specifically in science, the Next Generation Science Standards (NGSS), adopted by New Jersey since 2016, expect students to be self-directed (Lee, Miller, and Januszyk, 2014). One NGSS goal is to teach students to be self-regulated in planning, monitoring, and evaluating problems they will solve and questions they will answer (NGSS, 2013). By helping students in middle school to practice these self-regulating skills of planning, monitoring, and evaluating, during which they use metacognition, we can prepare them for the rigors of high school and future assessments from the College Board, which expect science students who are college-ready to practice metacognition (Lombardi, Conley, Seburn & Downs, 2013).

The motivation for this study is the mission of my school district, West Windsor-Plainsboro Regional School District, and the goals of The Next Generation Science Standards (NGSS). In a letter to our townships, David Aderhold, the Superintendent of Schools, wrote that it is the mission of the school district to develop self-directed learners (2015). Educators of sixth to eighth graders recognize this need for students to be self-regulated and teach students at a point in their growth where we can bring about significant advances in these skills. If we teach middle school students to become more metacognitive and to use self-regulation strategies (SRS) of planning, monitoring, and evaluating their progress (Zimmerman, 2002), then their ability to self-direct their actions will improve.

Teaching students to be reflective thinkers will help improve their mastery of content and save instructional time in the long run (Joseph, 2010). Therefore, teachers need to explicitly teach SRS and encourage their use through instructional strategies such as prompts. My study had two interrelated research questions. How will using embedded self-regulating prompts affect science learning over the short-term and long-term? How will using self-regulation and metacognitive prompts change students' use of self-regulation strategies and metacognition?

Outline of Alternative Format

As a change agent, I have created three products to communicate the findings in my study "Effect of Task Specific Self-Regulation Prompts on Science Content Knowledge and Transfer" to reach the broadest audience I can. I hope to inspire a variety of content teachers to adopt these changes so this naturally leads me to several different products. I have written a scholarly journal article targeted to the self-regulating strategies research community specifically in middle school science, and a practitioner's article targeted to middle school science teachers, both general and special education,, and finally a professional development plan targeted to middle school teachers of all content in my district.

As middle school teachers have enriched their curriculum with deeper content, some of us may have strayed from teaching the broader skills students need to learn. These self-regulating skills and the accompanying metacognition that goes with them are content specific (Winne, 2010). The skills need to be linked to the content so motivating teachers to include these skills would mean that I would need to present them to different teacher groups. The following describes each product in more detail.

As part of my research analysis, I tested to see if teaching and then prompting self-regulating strategies (SRS) would improve the knowledge and use of these strategies and if that knowledge and use effects science learning. In addition to analyzing students' prompt responses as they develop over time, I used a Structural Equation Model (SEM) a type of path analysis that attempts to show a cause and effect. I used this quantitative approach since there is a good deal of qualitative analysis in research that shows the positive effects of self-regulating strategies on learning. And yet these skills elude so many despite our understanding that most can develop them. There is much to be learned about effectively teaching students to use these strategies and how they help them learn and be successful throughout school K-12, college and beyond, a true lifelong learners' skill. This research shows through a SEM the effect of four specific SRS on science learning and the successful effect of prompts on development and use of SRS for middle school students. Consequently, it is important for all findings to be shared so I will submit my article to the *Research in Science Education* or the *Journal of Research in Science Teaching.*

The second part of my portfolio is an article written for NSTA's Science Scope magazine which is directed to middle school science and special education teachers. A Next Generation Science Standard goal is to teach students to be self-directed in planning, monitoring, and evaluating problems they will solve and questions they will answer. My objective for the article was to motivate teachers to teach these skills by describing how to design instruction of SRS and embed these strategies into the science content and use prompts to support their use. I addressed some of the challenges teachers face due to an increasing need to teach many levels of students by describing the scaffolds used for special education students and others and sharing those students' successes in developing SRS. I hope to further encourage teachers that these strategies teach students to be reflective thinkers, which will help improve their mastery of content and save instructional time in the long run (Joseph, 2010).

This third part of the portfolio is a professional development plan (PD) to take teachers through experiences to design and implement SRS in their practice in middle school. The PD would inspire teachers to include these SRS in their content, help them create the educational environment needed for students to develop these skills, and illustrate how they can be embedded in curriculum. A universal reflection by the science teachers in my intervention was that it would be best for all of the core content teachers to use these skills consistently. The plan encourages teams of teachers to focus on some of the many skills by embedding them in their content. By preparing these strategies instruction together they can consistently use the same metacognitive and self-regulating language across several core content areas. Since self-regulation is context dependent (Winne, 2010), as students are taught strategies in Science, they may not use these in Social Studies. Therefore, it is best to teach the strategies in all classes and as some of the strategies would be used in all classes, this could reduce the need to re-teach those but rather to build upon them. The plan includes an intense summer session as well as a follow-up throughout the year with the different teams or PLCs teaching the skills. The summer session would allow the teachers the freedom to create their strategies' lessons with each other without all of the other things that pull teachers in so many directions. And the yearlong PLC meetings will enable them to share experiences as they build on their initial lessons as building these skills with middle school students is dynamic process as teachers respond to what the students are learning.

These three artifacts allow me to reach a broader audience of educators. Each product is focused on three different groups and content, the scholarly journal article will allow me to contribute to the stream of research on effective teaching methods in science for self-regulating strategies for middle school students to help them become lifelong learners. The practitioner article for *Science Scope* will bring my research in a very practical way directly to middle school science and special education teachers by demonstrating how the teachers differentiated for their students. The professional development plan will allow me to reach potentially 100 middle school teachers across core content areas in West Windsor-Plainsboro Regional School District.

Chapter 2: Research Article

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May 2019

Introduction

Schools are increasingly seeking to teach students 21st Century Skills such as self-directed learning. Self-directed students are problem solvers who reflect, evaluate, monitor, and discipline themselves in their studies. To be self-directed one must self-regulate your learning which is important in today's world of readily available information (Fahnoe & Mishra, 2013) where students often must manage their own work (Darling-Hammond, 2008). Educators of sixth to eighth graders recognize this need for students to be self-regulated and teach students at a point in their growth where we can bring about significant advances in these skills.

Self-regulating learners use metacognitive monitoring to help them choose their strategies (Winne, 2018). Understanding how you learn and knowing your learning strengths and weaknesses is metacognition (Bransford, Brown & Cocking, 2000). Winne (2018) describes the relationship between metacognition and self-regulation as an iterative process, that is, as you are metacognitive you use better strategies which then improves your metacognition improving future strategy choice. As you use SRS your metacognition improves which refines your choice of SRS based on what you need to learn. Efklides (2008) recognized this iterative process and describe additional layers noting that metacognition is a nonconscious process. If we teach middle school students to become more metacognitive and to use the self-regulation strategies of planning, monitoring and evaluating their progress (Zimmerman, 2002; Schunk, 2005), then their ability to self-direct their actions should improve.

The Next Generation Science Standards, (NGSS) expects students to be self-directed (Lee, Miller, and Januszyk, 2014) and, in fact, as a 21st century skill, this quality is essential (Kereluik, Mishra, Fahnoe, & Terry, 2013). One NGSS goal is to teach students to be self-regulated in planning, monitoring, and evaluating problems they will solve and questions they will answer. NGSS standards have been adopted by New Jersey since 2016. By helping students in middle school, to practice these self-regulating skills (SRS) of planning, monitoring and evaluating, we can prepare our students for the rigors of high school and future assessments from the College Board, which expects science students who are college-ready to practice metacognition (Lombardi, Conley, Seburn & Downs, 2013). The question then is how do we best support students in developing self-regulating skills in science.

Perry (1998) found that successful development of self-regulated learning requires a specific environment. She observed elementary reading classrooms however not as much work has been done in the middle school science classroom so we can learn from this. An environment where students can make appropriate choices and expand their developing abilities by attempting challenging tasks that are complex and open ended gives them opportunities to evaluate their own and others' work. Effective teachers of self-regulated learning (SRL) also provide just enough support including providing content knowledge and teaching self-regulating strategies to ensure student independence for academically effective forms of learning (Perry, 1998).

The problem is that not all students learn to be metacognitive and practice self-regulation on their own (Bolhuis, 2003). Although teachers know that these self-regulating skills are important, those in the secondary grades argue that they have little time to teach these skills and are sometimes unaware of the processes novice learners are going through to learn their material (Joseph, 2010). Teaching students to practice metacognition will enable them to more effectively use SRS so they will spend less time practicing a problem and focus on what is going well or not with the problem, allowing less practice and still yielding improved problem solving (Zepeda, Richey, Ronevich & Nokes-Malach, 2015). Teaching students to be reflective thinkers will help improve their mastery of content and save instructional time in the long run (Joseph, 2010).

Therefore, teachers need to explicitly teach these skills and encourage their use through prompts. This study has two interrelated research questions. How will using embedded self-regulating prompts affect science learning over the short-term and long-term? How will developing self-regulation and metacognitive prompts affect students' science learning in middle school classrooms?

Literature Review

The literature review focuses on empirical studies of self-regulation strategies taught primarily in science education to middle school students. I searched for peer reviewed articles published since 2000 about self-regulation and metacognition in middle school science for both general education and special education. I included studies that showed the use of prompts to encourage student use of self-regulation. However some studies outside of middle school or in non-science content areas were reviewed to include guidance where there was none in middle school science. I begin with briefly discussing research on self-directed learning, what it is, and why it is important. Following that, I examine research to show the relationship between self-direction, metacognition, and self-regulation. Finally, the review ends by reviewing research illustrating the techniques used to teach self-regulation and metacognitive strategies with a focus on those used in middle school science including special education students.

Self-directed or self-regulated learning

Self-directed learning is a skill necessary to be successful both in school and in the job environment (Zimmerman & Martinez-Pons, 1986). Though self-directed learning is identified as a 21st Century skill by the Partnership for 21st Century Skills in 2007, it may be that it is only a 21st Century skill because schools have traditionally failed to teach them (Kereluik, Mishra, Fahnoe & Terry, 2013). Specifically in science, the move to the NGSS has placed more importance in self-directed learning with respect to learning content. Three NGSS Science and Engineering Practices, developing and using models, planning and carrying out investigations, and designing solutions require students to be self-directed.

Self-directed learning is more generally defined as self-regulated behavior. The concepts of self-directed and self-regulated learning are similar. Self-directed learners determine what they want to learn, what they need to know, what resources they will use (people and otherwise), and then evaluate their learning (Knowles, 1975). The difference between the two concepts is the choice of what to learn. The student determines what they will learn about and how they will go about it when being self-directed (Merriam & Bierema, 2014). Whereas, a self-regulated learner is given the learning challenge and takes the responsibility to plan for the learning, monitor their own understanding and behavior, evaluate whether they have achieved the goal and what they did to achieve it or not, and make appropriate adjustments (Schunk & Zimmerman, 2007). In the K-12 setting there is specific content students are asked to learn. As a result, this study uses the term self-regulation for this research with middle school students. Self-regulation strategies can be divided into three phases: planning, action, and reflection (Schunk & Zimmerman, 1998). In the planning phase, goals are established. The action phase requires self-monitoring of cognitive processes, knowledge acquisition, and controlling impulses. The reflection phase is self-evaluation of both what was learned and whether the goal was attained (Garner, 2009).

The relationship between self-regulation and metacognition is not entirely clear. Winne (2018) says self-regulating learners use metacognitive monitoring to help them choose their strategies. Schraw and Dennison (1994) in their metacognition assessment included self-regulation strategies as part of metacognition. In order for students to evaluate their understanding, they need to be metacognitive. Some, usually higher-level learners, can become self-regulated on their own, but many students need to be taught these skills metacognitively (Greene & Azevedo, 2007; Zepeda et al, 2015). We can teach self-regulation skills and then use prompts to remind students to be metacognitive and self-regulate their learning (Davis, 2003; Kitsantas & English, 2013).

Metacognition in Self-Regulated and Self-Directed Learning

Thinking about your thinking is being metacognitive. Flavell (1979) described metacognition as the knowledge of what one knows and the actions taken in connection with that knowledge. An individual who is aware of the areas where he has adequate knowledge as well as those areas where there are gaps in his understanding, can study, and ultimately, learn more efficiently. Both self-direction and self-regulation are actions one takes as a result of being metacognitive.

Evidence of self-regulation

Metacognitive strategies taught at a young age are retained and can be subsequently developed. Metacognitive strategies refers to knowing what is needed and then using those strategies is self-regulating. In a survey of 486 3rd and 4th grade former Reading Recovery students and their non-Reading Recovery classmates, those students who had successfully completed Reading Recovery in the first grade were still using the metacognitive strategies, that is self-regulating, they had been taught two and three years later (Schmitt, 2003). When teachers make explicit choices for the learning environment and instruction, it positively affects the development of self-regulated learning in students from kindergarten to third grade (Perry, VandeKamp, Mercer & Nordby, 2002). In their study of five Kindergarten through third grade classrooms the authors found 3 classrooms that effectively supported and used self-regulated learning. They identified specific things the teachers in those classes did to encourage self-regulation in students so young. They offered choices, gave them opportunities to control the challenges so they could independently complete tasks, gave opportunities to evaluate their own and other's work, and supported their students with just enough scaffolding to enable them to continue independently. These studies show that teaching metacognitive strategies to elementary students enables them to self-regulate their learning. This in turn improves performance and students retain these strategies later in their schooling.

In middle school, students are expected to be more independent about their learning and there is an increased expectation that students exhibit self-regulation and take more personal responsibility (Zimmerman, 2002). Middle school students are at the perfect developmental level to be taught skills necessary for success in the 21st Century including teaching self-direction (Kay, 2009). Although some children make the transition from elementary school to middle school smoothly, helping children develop self-regulating strategies in sixth grade is critical because many children find the middle school transition difficult, resulting in risky behavior, lower self worth, and feeling disengaged from school (Williford, Jacobson & Pianta, 2011). Although self-regulation can be taught and learned in elementary school, some middle school students do not self-regulate. Perhaps this is because the higher achievers have learned the self-regulating strategies they were taught and the other students have not learned to be self-regulating yet. There remains the need to teach self-regulation to middle school students.

Although middle school may be fertile ground for teaching self-regulation strategies, few studies have focused on middle school students. We can learn from high school studies such as when Zimmerman and Martinez-Pons (1986) examined the correlation between higher achieving students and the use of self-regulation strategies. In a study of 40 male and female tenth graders from high achievement tracks and 40 male and female students from lower achievement tracks in a suburban high school, the authors developed and used a structured interview to measure self-regulating strategies and to determine if these strategies had any relationship to academic achievement (Zimmerman & Martinez-Pons, 1986). The students were identified as higher or lower achievement tracks based on a statewide achievement test. The interviews included 13 categories of questions on self-regulated learning including goal setting, environmental structuring, self-evaluating, strategies of organizing and transforming, seeking and selecting information, and seeking social assistance. As expected, the high achieving students used the self-regulation strategies frequently (Zimmerman & Martinez-Pons, 1986). However, what this study does not address is the extent to which, or how, lower achieving students can be taught the strategies that the high-achieving students have developed.

Encouraging self-regulation strategy use

Teachers can help students who are not high achievers to use self-regulating strategies by teaching the strategies and explicitly encouraging students to use them (Ifenthaler, 2012; Jimenez, Browder & Courtade, 2009). Several studies focus on specific techniques for supporting students in developing self-regulation in middle school including: prompting self-regulating behaviors, creating an encouraging environment for self-regulating strategy use, and explaining to students why self-regulating strategies are being taught (Hughes, 2011; Perry, Vandekamp, Mercer & Nordby, 2002. Other studies describe using prompts to encourage self-monitoring and reflection that are not content specific (Davis, 2003) or prompts that are content specific (Peters & Kitsantas, 2010) and gradually fading prompts as students begin to initiate the strategies on their own (Kitsantas & English, 2013). Techniques can include prompts that are further scaffolded to cue students to make a plan with subsequent prompts to set goals, self-question, self-monitor and evaluate (Hughes, 2011).

Davis (2003) used general prompts to encourage self-regulating strategy use. She made a distinction between generic prompts to "stop and think", and directed prompts, hints indicating potentially productive directions for reflection. Students in the generic prompt condition developed more coherent understandings as they worked on a complex science project (Davis, 2003; Ifenthaler 2012). Students reflected unproductively more often in response to directed prompts as compared to the generic prompts. Students with some autonomy who received generic prompts developed more coherent understandings than their similarly autonomous peers who receive directed prompts (Davis, 2003; Ifenthaler 2012). Given these findings, the present study used generic prompts to encourage self-regulating strategy use.

Bulu and Pedersen (2010) found that encouraging self-direction in science through continuous prompts resulted in significant change in content knowledge for middle school students in science exploration classes. In their study of 332 6th grade students, the authors investigated four situations, domain specific continuous and faded prompts and domain general continuous and faded prompts. Domain general prompts could be “What information do you need to find in order to solve this problem?” whereas a domain specific prompt would identify a problem and ask “What information do you need to help….survive, think about habitat, food, etc. They found that for science content, the domain specific continuous prompt led to more student success. However, they found that the domain general prompts when faded helped students “transfer problem solving skills”. There is some evidence that continuous teacher support for using self-regulation strategies is necessary (Zepeda et al, 2015). This may be specific to the individual learners, which will require ongoing evaluation by the teacher of the student's developing self-regulation skills (Bulu & Pedersen, 2010). However, some researchers found that when supports are gradually faded away, those students perform better when no supports are provided compared to students who had continuous support and are now presented with none (McNeill, Lizotte, Krajcik & Marx, 2006). Since the goal of this study was to teach self-regulation strategies to students such that they transfer the use of these skills even when the prompts have been faded, it used both domain specific and general prompts. After the initial unit, the prompts were partially faded during the subsequent science unit and students again were assessed on their use of metacognition and self-regulated strategy use.

In addition to training and prompts to plan, monitor, and evaluate, researchers found that a learning environment that encouraged self-efficacy, student autonomy, and control over how students would learn, improved science inquiry skills (Yoon, 2009). As the students became more self-efficacious and goal oriented, they used more self-regulating strategies to control their learning. However, although autonomy was encouraged, the researchers found that a fully non-scaffolded approach was not as effective as when the inquiry was scaffolded to focus these 8th grade students to prepare for self-directed investigations (Yoon, 2009). All teachers in this study provided a more autonomous environment as students designed their own investigation, but teachers scaffolded the investigations by prompting for writing hypotheses, identifying variables, and using their evidence in their reasoning for support, or not, of their claim. This study will use similar scaffolds for the student designed investigations along with training and prompts for self-regulation.

Measuring the use of self-regulation strategies

There are several tools that measure self-regulation and metacognition skills, however, only a few have been developed for elementary and middle school students. Perry (1998) argued that you need to observe elementary age students to determine their SRS, in fact, Schraw and Dennison (1994) found a differece between teacher evaluation of a student's metacognitive ability and how students reported themselves. Greene and Azevedo (2007) used audio recordings of students by encouraging them to think aloud. All of these methods would be too time consuming to conduct with 200 students. There are two self-report instruments that have been adapted for middle school students though: the Junior Metacognitive Awareness Index (JrMAI) and the Middle School Learning Strategy Scale (MSLS).

The Junior Metacognitive Awareness Inventory (JrMAI) was designed for elementary and middle school students based on Schraw and Dennison's (1994) Metacognitive Awareness Inventory for older learners. Using exploratory factor analysis, the authors found that 15 items loaded on one factor, with only 2 items loading on a second factor, and one item loading nearly equally on both, so they subsequently recommended that the all items be used as one.. The two constructs were highly correlated despite a careful delineation between regulation of cognition and knowledge of cognition so the researchers postulated that for other samples this could affect the factor structure. Overall though this survey was found to correlate to several other measures of metacognition for older learners, providing evidence of construct validity.

The Middle School Learning Strategy Scale (MSLS) was developed out of a need for a middle school tool similar in use to the Motivated Strategies for Learning Questionnaire for adults (Pintrich, Smith, Garcia & McKeachie, 1993). It was designed to measure a middle schooler's use of self-regulated learning strategies. The MSLS scale is structured into three categories: cognitive, metacognitive, and behavioral (Liu, 2009). The scale was tested on 238 middle school students from 3 schools near Princeton, NJ. A factor analysis grouped the items into 3 scales, cognitive, behavioral, and metacognitive and also showed that the inventory was reliable.

This study uses both the Jr.MAI, as a measure of metacognitive strategies, and the MSLS, as a measure of self-regulation strategies. Using both instruments allowed for the measurement of the impact of the intervention on domain general and specific thinking. Additionally, as stated earlier, the study examined the degree to which each of these strategies is linked to science content learning. Therefore, the study blends the strengths of previous research by drawing on domain specific and general prompts to understand how this influences students' learning strategies and their learning of science content.

Methods

Study Design

This is a mixed methods study of the effectiveness of using self-regulating strategies on science content mastery. The teachers taught self-regulating and metacognitive strategies, using prompts embedded within the Human Body System (HBS) unit. All students took the HBS pre and post-assessments, the Junior Metacognitive Awareness Inventory (JrMAI), and the Middle School Learning Strategies Questionnaire (MSLS). My hypothesis was that metacognition and self-regulating strategy instruction would improve the students' use of those skills and improve content mastery. I conducted a quantitative analysis comparing the pre and post assessments and survey results as well as a qualitative analysis of selected students prompt replies. To determine if the three teachers have used the prompts similarly, I interviewed them three times throughout the unit to assess the fidelity of the intervention.

Sample size and missing data

The sample consisted of 7th grade general and special education students chosen as a convenience since all three science teachers at the school were very willing to participate in this research. There were 210 students, who had agreed to participate, in the 12 classes taught by the three teachers. There were three measures administered immediately before and after the intervention. Students who did not complete all six of the pre and post assessment and surveys were excluded as these each represented at least 10% of the data. Those students missed the tests/surveys due to being absent on the day of administration or had moved out of the district. It was assumed that these cases were missing completely at random. These further reduced the sample to 181 students. All but one analyses included here have no missing data. The one model on a larger data set of 204 is included here for comparison only. Two of the classes contain in-class resource students with Individual Education Plans (IEP). The only students in 7th grade who were excluded from the study were special education students in self-contained classes, which were not taught by the three general education science teachers.

Within this middle school the 7th grade 2016-2017 demographic was 21.2% White, 3.8% Black, 4.3% Hispanic, 70.4% Asian and 0.3% Other. The participants in Free and Reduced Lunch was 6.1% of entire middle school population of Community Middle School.

Intervention Description

All 7th grade students participated in the Human Body Systems unit, which is approximately 2½ months long and was begun in January 2018. This unit addresses two Performance Expectations of the Next Generation Science Standards, MS-LS1-3, the body is a system of interacting subsystems, and MS-LS1-7, food is rearranged through chemical reactions forming new molecules that release energy as this matter moves through an organism.

The 7th grade science teachers taught specific self-regulation skills to 7th grade science students during the HBS Unit. The population of students within each science teachers' room were composed of 25% from each of the other teachers' students. The teachers would therefore be sharing the responsibilities of developing the self-regulating strategies, prompting the students, and creating a partially autonomous environment for the students. Usually those students who needed the most help with self-regulating strategies remained with their science teachers but there was an evenly spread mix of high, mid, and low scoring students in each classroom. The teachers taught planning, monitoring, evaluating, and designing a graphic organizer. They prompted for these strategies throughout the unit, see prompts in Appendix A. The unit was designed to cycle through five human body systems so skills were practiced and prompted for five times throughout.

The students had two opportunities each system to plan and execute their research and their system task. All students were given research questions and were charged with creating a graphic organizer for that research. They were given several days to answer the questions including a system introduction day, in-classroom research day, a library research day, and a wrap-up day. They needed to plan how they would answer the research questions and cite their sources within the time frame. The Planning prompt was issued the second day. Upon completion of that research they were each given their task, i.e.; podcast, screencast, written section, and they had another three or four days to accomplish this. The monitoring prompt was administered sometime during the second day or third day of their task time frame. These opportunities for choice and challenge allowed students some autonomy of action and decision making so we can see how they choose to use strategies, i.e.; how they self-regulate.

Over the course of the unit all students were responsible for conducting a student-designed investigation at least twice. The students received a scaffold in the form of a template that lists the requirements they needed to include such as identifying the problem, creating a hypothesis, identifying the materials needed, choosing the independent, dependent and control variables, and reporting the data using tables and/or graphs. Those students who designed the investigation for a particular system were also required to conduct a podcast with their lab group. The needed to take pictures during their investigation, write questions where some modeling was provided, and then conduct interviews for the podcast, and finally the audio podcast and captioned photos had to uploaded into the groups Wiki document for that system. Each of these efforts required learning opportunities such as how to podcast and to caption the photos, and planning opportunities such as organize with their group members when they would conduct their interview.

The teachers, including the researcher, met several times a week to plan together when and how instruction was delivered and allowed for a regular check on fidelity of implementation. The teachers remained in sync by using a shared google slides presentation that began each day, which used the same language and delivered consistent instruction on the strategies. They called these slides the “Things to Remember” and it guided every day’s instruction.

To provide the proper environmental conditions for developing SRS (Perry et al, 2002), the unit included challenging tasks such as researching how a particular HBS works in relation to the other systems. The teachers challenged the students with guiding questions and followed that with independently controlled time to research the answers in the classroom and library using texts and online databases. The teachers supported the students by providing texts with a variety of reading levels and online databases that allowed student control of the level of rigor and reading level. The teachers also provided a variety of planning and organizing techniques and prompted students to monitor and evaluate their work. Students could choose to work independently or with others as there was flexible seating both in the classrooms and library. Throughout the unit, teachers provided support to students by carefully orchestrating instruction to provide students with the science knowledge and strategy knowledge they needed to operate independently.

Measures

a. *Pre and Post Assessments of HBS Unit*: The pretest was identical to the posttest with open-ended questions which addressed the NGSS Performance Expectations, MS-LS1-3 and MS-LS1-7 and corresponding Disciplinary Core Ideas, that is, evidence for the interactions between human body systems and how food is rearranged to provide energy for the body (NGSS, 2013). The first two questions of this assessment were based on previous assessments used in this grade and have been repeatedly reviewed by the science teachers, speaking to the content validity of the times. All remaining questions were designed specifically for this study. Assessment questions in Part Two required students to interpret three articles with data to help them answer the question “Given these pieces of evidence, can you determine whether eating right before swimming could be dangerous in terms of your ability to raise your heart rate and breathe in oxygen?”. Part Three required students to describe their designed investigation to answer that same question.The questions on the assessment were reviewed for consistency with the Unit’s Enduring Understandings, the NGSS Performance Expectations Assessment

Boundaries by two faculty experts, and all science teachers. The assessments contained subjective questions and were graded with a rubric by the author after establishing interrater agreement with four colleagues.

b. *Middle School Learning Strategies (MSLS) Survey*

This Survey includes 47 items for students to self-report their learning strategies, for example “I relate new things to things I already know” on a 4 point Likert Scale from 1 (Hardly ever), 2 (Sometimes), 3 (Often), and 4 (Almost Always) (Liu, 2009). The author administered the survey to 238 students in 6th, 7th, and 8th grade and Cronbach’s alpha for scores on the MSLS scale was .90. A factor analysis grouped the items into 3 scales: cognitive, behavioral, and metacognitive was found reliable. Cronbach’s alpha was .80 for scores on the cognitive strategies scale, .75 for scores on the behavioral strategies scale, and .70 for scores on the metacognitive strategies scale.

c. *Junior Metacognition Assessment Inventory (JrMAI)* This inventory includes 18 items for students to self-report their use of metacognitive skills. For example “I know when I understand something” (Sperling, Howard, Miller, & Murphy, 2002). Students answer using a 5 point Likert Scale from Never, Seldom, Sometimes, Often, to Always. The authors based their survey on the MAI (Schraw & Dennison, 1994). They changed items to have appropriate language for younger students. Two hundred 6th through 9th grade students completed their survey. The internal consistency of this inventory for middle school students was .82. This survey has been found to correlate with similar measures of metacognition for older learners, suggesting it has strong construct validity (Fortunato, Hecht, Tittle & Alvarez, 1991).

d. Planning, monitoring and evaluating prompts: I examined prompt responses across systems one, three, and five. Within each iteration of the system I looked for any development of responses, especially indications that the students are developing their self-regulating skills such as improvement in planning, effectiveness of monitoring and evaluation of their goals. Specifically I reviewed whether they improved in planning by achieving their goals on time, I reviewed their monitoring to see if they improved being on time without rushing, and I reviewed their evaluating as they reflected on whether they would use the same graphic organizer or not and whether to improve their plan or simply adhere better to it.

Data Collection

At the beginning of the school year, students completed two questionnaires, the Jr. MAI and the Middle School Learning Strategies adapted from Liu (2009). Aware that the metacognition and self-regulating questionnaires could motivate students to use self-regulating strategies, I separated these questionnaires from the intervention to come. There were five iterations of cycles where students planned to research the questions on their graphic organizers and planned tasks such as screencasts and student designed investigations. Teachers were interviewed following the first and last system regarding their use of the prompts. At the end of this first unit, students repeated the JrMAI, MSLS, and HBS assessment. I collected and analyzed students' prompt responses, comparing the early to middle and then later responses looking for potential changes in depth and elaboration. Throughout the subsequent unit, prompts could be administered by partially fading them out. At the close of that unit, students again took the Jr.MAI and MSLS surveys one last time to check for retention of the strategies.

Data Analysis

The quantitative analysis was conducted by comparing the pre and post assessments and survey results using a repeated measure *t* test across all participating students. I also used a paired *t* test for the Prompting data to test for significant change in being on time or less rushed as the students developed from System 1 to System 5.

Table 1

Data and Analysis by Research Question

Research Question	Data Sources	Analysis
How will using embedded self-regulating prompts affect science learning for short-term and long-term?	HBS assessment	Use a repeated measure T-Test to compare pre and post assessment. Use Structural Equation Modeling to look at impact of self-regulation on science learning.
	Teacher Interviews	Qualitatively analyze for the consistency of delivery of prompts during focus unit and the fading of prompts in subsequent unit.
	Student prompt responses	Quantitatively analyze for improvements in the use of self-regulating strategies
How will using self-regulation and metacognitive prompts change students' use of self-regulation strategies and metacognition?	Jr.MAI MSLS	Compare pre-assessment responses to post assessment responses. Using confirmatory factor analysis in Structural Equation Modeling
	Student prompt responses	Quantitatively analyze for improvements in the use of self-regulating strategies in first, third and fifth prompt responses.
	Teacher Interviews	Qualitatively analyze for the consistency of delivery of prompts during focus unit and the fading of prompts in subsequent units.

In Table 2 I describe those items included in each of the indicator variables. The variables with the prefix SCI refer to items on the science assessment, in particular, knowledge of the relationship between human body systems, interpretation of data to answer a question, and finally effective design of an investigation to answer a question. These items were analyzed using rubrics designed for each question.

REGCOGPOST and KNOWCOGPOST together represent the 18 items on the JrMAI and all loaded onto the ImprovedMetacognition latent variable. The items assigned to each of these variables were based on the original research (Sperling et al). The 47 items from the MSLS, were assigned to variables based on the classification of those items from Liu (2009). There was one additional indicator, SCIREGPOST, included on the same latent variable. This indicator represents the three planning, monitoring, and evaluating questions from the science assessment. These four indicator variables were loaded onto the SRS latent variable.

Table 2

Description of Latent and Indicator Variables

Latent Variable	Indicators	Indicator description
ScienceLearning	SCIKNOWPOST	First two questions in the science assessment how one body system supports another
	SCICLAIMPOST	3 different articles from which to draw 3 claims
	SCIEVIPOST	3 different pieces of evidence supporting each of 3 claims above
	SCIREASPOST	3 different reasonings explaining the claim and evidence provided
	SCIDESVARPOST	Independent, Dependent and Controlled Variables identified for self-designed investigation
	SCIDESDATAPOST	Techniques of data collection such as tools needed, data recording table, necessary trials for investigation
Metacognition	REGCOGPOST	9 items from the JrMAI identified as Regulation of Cognition (Sperling et al, 2002)
	KNOWCOGPOST	9 items from the JrMAI identified as Knowledge of Cognition (Sperling et al, 2002)
SRS	SCIREGPOST*	3 items from science assessment to show planning, monitoring and summarizing
	COGSTRATSPOST	23 items from the MSLS associated with cognition strategies of learning (Liu, 2008)
	BEHSTRATSPOST	13 items from the MSLS associated with behavior strategies of learning (Liu, 2008)
	METASTRATSPOST	11 items from the MSLS associated with metacognition strategies of learning (Liu, 2008)

Note. *Excluded from final models

Prompt Responses

Across the analysis, independent variables were pre HBS, pre JrMAI, and pre MSLS scores. Dependent variables were the post scores for each of the assessments across the intervention. This analysis provided a test for the main effects of the intervention as well as modeling the relationship between metacognition, SRS, and science learning.

All quantitative analysis was conducted using IBM SPSS and AMOS 25. When using AMOS to conduct a Structure Equation Model (SEM), there can be no missing data if the analysis includes modification indices. There was one modification index recommended that was theoretically appropriate: to covary the error terms on the Metacognition variable. This suggestion was rejected because it rendered the model unidentified. In addition, all analysis used the Maximum Likelihood Estimate.

Even when conducting confirmatory factor analysis the sample needed to be free of any missing data as this program does not calculate Modification Indices on estimated data. Modification Indices on the measurement model were needed to determine if all variables should be included or a path added. In most analysis attempts the modification indices called for covariances that were not supported theoretically such as covarying errors from one latent variable to another, or covarying an error with a latent variable. The Confirmatory Factor Analysis, CFA, of ImprovedMetacognition did call for covarying the error terms of the factors REGCOGPOST and KNOWCOGPOST since these factor indicators were all items from the same survey it is theorized to be appropriate to covary their error terms (Byrne, 2010). Ultimately no error terms were covaried in the models.

I used SEM to test the validity of the various measures in predicting content learning, which would be considered predictive validity. The model to be tested is below (see Figure 1).

Building the structure equation model includes assignment of survey and assessment items as indicators for the latent variables. In AMOS, one requirement is that the variables need to be a scale category. Scale represents continuous variables and while the Science Assessment scores were continuous, the other two instruments used a four and five point Likert scale. The categorical variables of COGSTRATS, METASTRATS, and BEHSTRATS, REGCOG and KNOWCOG have been analyzed as if they are continuous variables as has been the norm in SEM (Byrne, 2010). Within the literature, the consensus on this issue supports this decision as long as the number of categories within the scale is large, at least five items, and the data is normally distributed (Byrne, 2010), which were both satisfied for this study.

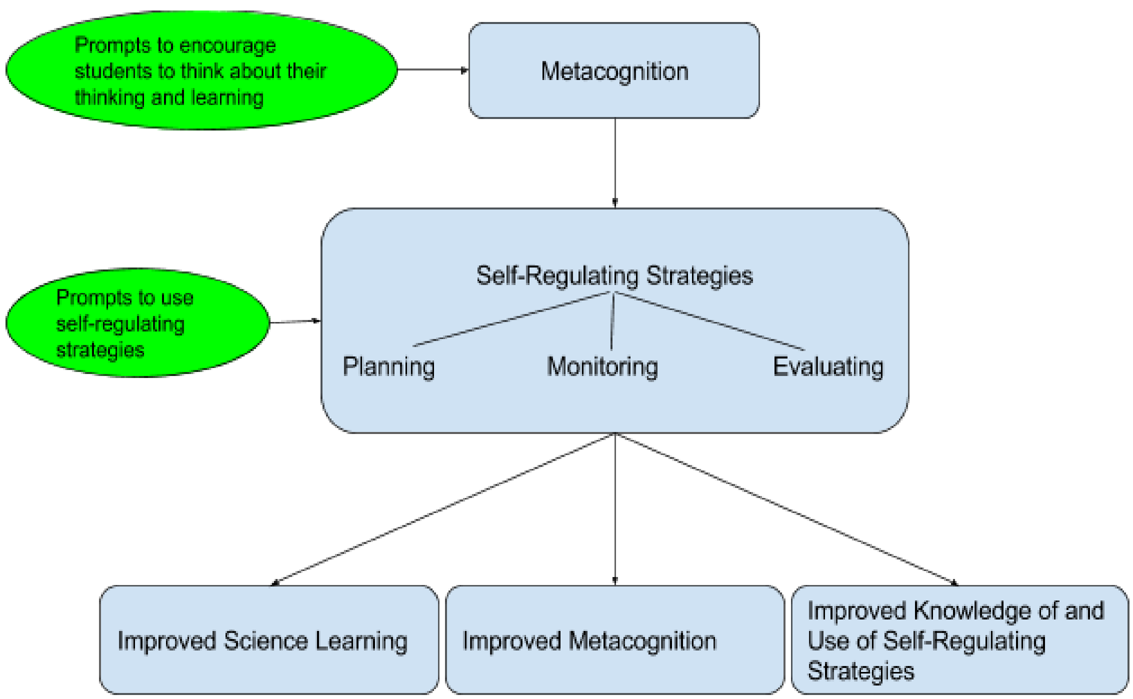


Figure 1: Model of relationship of metacognitive and self-regulating prompts on improved content learning and use of metacognition and self-regulating strategies

The model hypothesizes that effects of the pre-scores of science content, as well as the learner level (low, medium, high), will be moderated by metacognition and the self-regulating strategies of planning, monitoring, and evaluating. Pre scores on the science test are expected to directly mediate post scores. Additionally, self-regulation strategies should directly mediate the effects of metacognition on post science scores. Across the model, I would expect that those with higher pre science scores would have higher post science scores, that higher level learners will have more metacognition and self-regulating strategies, but that learning these strategies will moderate the effect of learning level and pre scores to predict post science scores.

Validity and Reliability

The study examines relationships between self-regulated strategies, metacognition, and content learning. Therefore, the study is a test of the predictive validity of self-regulation and metacognition on science learning. Quantitatively, I tested the reliability of the various measures using Cronbach's alpha. I conducted a frequency distribution on these three measures both for the pre and the post assessments as well as on the overall sample of students by their combined PARCC score to ensure normality and a lack of skewness or kurtosis.

The HBS pre and post assessments was graded by the researcher using several rubrics designed and reviewed by content experts in the field. Finally, using those rubrics, colleagues reviewed and scored a sample from each section of the HBS assessment to establish reliability. In addition, I ran a confirmatory factor analysis on the measurement model including the three latent variables, SRS, Metacognition, and Science Learning and all of the dependent variables. This allowed me to test whether or not these measures are functioning similarly to prior research and provided a test of construct validity for the study.

Finally, SEM was a test for the predictive validity of self-regulating strategies and metacognition for content learning. Therefore, this served as a validity test for the proposed model.

Results

I begin by reporting the normality, linearity, skewness and kurtosis of the scales. I provide the correlations of all of the measurement instruments to each other and to the standardized achievement test, the PARCC. The paired t tests on the scales are also provided along with the results of the prompts analysis. Finally I assess the measurement and structural equation models.

Normality, outliers, and linearity

To ensure that the variables were not so correlated as to be essentially measuring the same construct, I conducted correlation measures of each dependent variable to the other. The correlation between all of the dependent variables are all below .8. The only values that were close were the correlation of Cogstrats to Behstrats = .651, Cogstrats to Metastrats = .656, Behstrats correlated to Metastrats = .702. All three of these variables came from the same instrument, the MSLS. Additionally, Knowcog correlated with Regcog = .599 and these were both from the same instrument, the JrMAI. Still all of these are below the .8 threshold of concern. When comparing the total score on the science test, that is SCILEARNSCORE, the Variance Inflation Factor (VIF), coefficients of collinearity were all below 3.0 showing no collinearity (Gaskin, 2011).

There are two variables with minor issues for skewness, KNOWCOGPOST and SCIDESVARPOST and a kurtosis of 1.163 for SCIDESVARPOST. This variable reflects students' identification of the independent, dependent and controlled variables in their design. Most students could identify the first two variables which would contribute to a flattened curve.

Table 3 shows correlations between PARCC scores and the measurement instruments in the study. Of particular interest is the correlation between PARCC and the Science Post Assessment Score of .623, giving some support for the validity of this assessment. There was however a very low Pearson Correlation between the PARCC and the MSLS at .154 and a nonsignificant correlation between the

PARCC and the JrMAI Post scores. This seems to be inconsistent with prior research that has found a strong correlation between high level learners and their use of self-regulating strategies and metacognition (Zimmerman & Martinez Pons, 1986).

Table 3

Correlations between PARCC Scores and Measurement Instruments

Scores	Compared	Pearson Correlation	P Value <=
PARCC	Science Post Assessment Score	.623	0.01
	MSLS Post Score	.154	0.05
	Science Post SRS Questions Combined Score	.416	0.01
	JrMAI Post Score	Not significant	
JrMAI Post	MSLS Post Score	.315	0.01
Science Post Assessment Score	MSLS Post	Not Significant	
	JrMAI Post	Not Significant	

Comparing Pre to Post Data

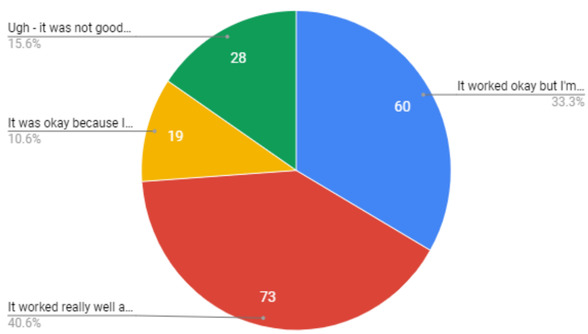
The paired t-tests showed significant differences for different scales in each measure (see Appendix D). Comparing the pre to post data for the Science Assessment all showed a significant increase at the $p<=0.05$. The SCIKNOW evaluated science content knowledge and the results were significant with t (180) = 34. 076, p = .001. Similarly significant paired t-tests resulted for the SCICER on Part Two was t (180) = 9.958, p = .001, that is reading the articles and writing a claim, supporting with evidence and reasoning and SCIDESIGN in Part Three (180) = 11.748, p = .001, designing an investigation.

For the JrMAI and MSLS the only significant difference was for KNOWCOG at $t(180) = -2.981$, $p = .003$. However for the JrMAI and the MSLS all t-test values were negative which indicates that the means went down from the pre to the post survey.

Prompts

The second of two research questions, “How will using self-regulation and metacognitive prompts change students' use of self-regulation strategies and metacognition?” is considered here by reviewing the prompt data. Only those students who completed all of the pre and post assessments and surveys are included in this analysis. In System 1, 180 students responded to the Evaluation prompt, In System 3 only 113 students responded, and in System 5 178 students responded. Although fewer students in System 3 completed the form for this prompt, there were students from each teacher and each period as there were for Systems 1 and 3.

The students’ first hurdle was the graphic organizer which most were unused to creating themselves. After their first efforts 57% of the students wanted to change it, see Figure 2. However, by the completion of the third cycle (see Figure 3), only 18% were planning a change. Consequently we did not prompt with this question for System 5. Therefore, the percentage of students who felt their graphic organizer worked increased from 41% to 82%. Given this increase, in System 4 we asked the students if they found the graphic organizers helpful, with over 90% of students who responded agreeing it was helpful.



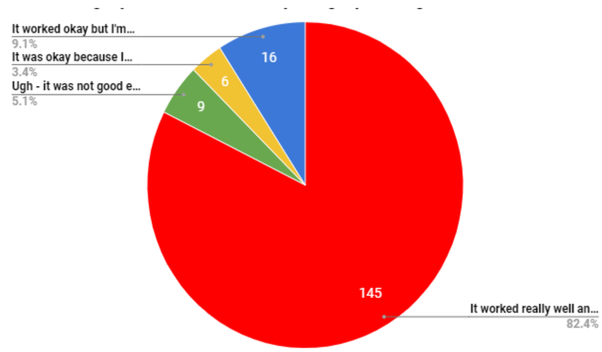
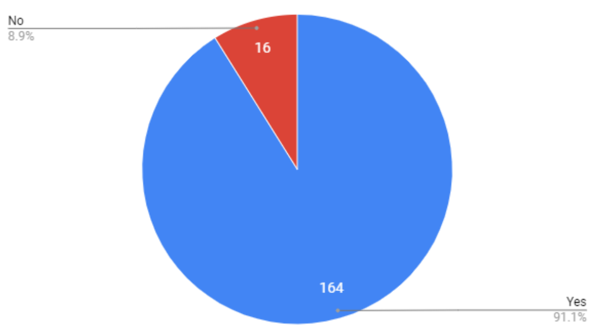


Figure 2. Evaluating Graphic Organizer System 1

Figure 3. Evaluating Graphic Organizers System 3

Similarly, as students were supported and became accustomed to the prompts they were able to manage their time better as 91% (see Figure 4) completed work on time during the first system but 97% (see Figure 5) completed work on time for the 3rd system with 96% completing work on time for the 5th system. See figures 4 and 5.



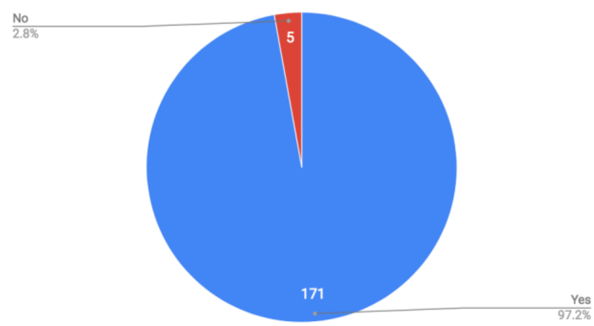


Figure 4. Finish on Time System

Figure 5. Finish on Time System 3

Overall students improved in completing work on time and not feeling rushed where the requirements were identical from Systems 1 through System 3. However, for System 5 the students had a new requirement they had not done before, to write Claim-Evidence-Reasoning (CER) statements for their designed investigation, so although 96% finished on time 26% of them felt rushed. It seems they were not able to predict how long it would take to complete this new requirement and so needed to rush (see Table 4). Still, the students were better with completing work than in system 1, even with this new assignment.

Table 4.

Timely completion vs Rushed

Question		System		
		1	3	5
Completed on Time?	Yes	164 (91%)	114 (100%)	170 (96%)
	No	16 (9%)	0 (0%)	8 (5%)
Completed on Time but felt Rushed?	Yes	80 (49%)	24(21%)	46 (27%)
	No	84 (51%)	90 (79%)	124 (73%)

A paired t-test was used to compare On Time Completion and On Time Completion Rushed or Not Rushed for systems 1 and 5. Comparing System 1 and 5 there were no significant differences, t (173) = 1.464, p = .07. However, when comparing the differences between students in Systems 1 and 5 who were on time, but felt rushed or not, the difference was significant, t (156) = 2.417, p = .009. So it is possible that the improved planning and monitoring techniques benefitted the students who managed to complete on time but with less pressure as they did not feel rushed.

Assessing the measurement model

The confirmatory factor analysis (CFA) yielded suggested modification indices to improve model fit. However, only one of the suggestion modifications was allowable, to covary two error terms, SCIREAS and SCIDESVAR, on the Science Learning indicators. However there is little theoretical basis for this and this would increase the parameters being estimated from 23 to 24. Upon running that measurement model the model fit indices were good or permissible.

On this measurement model I have already excluded SCIEVI and SCIREG indicators see Figure 6. The regression weights for these two dependent variables were quite low with a loading value less than 0.3; SCIEVIPOST is .233 and SCIREGPOST is .101 so the information from these two variables did not add to the model.

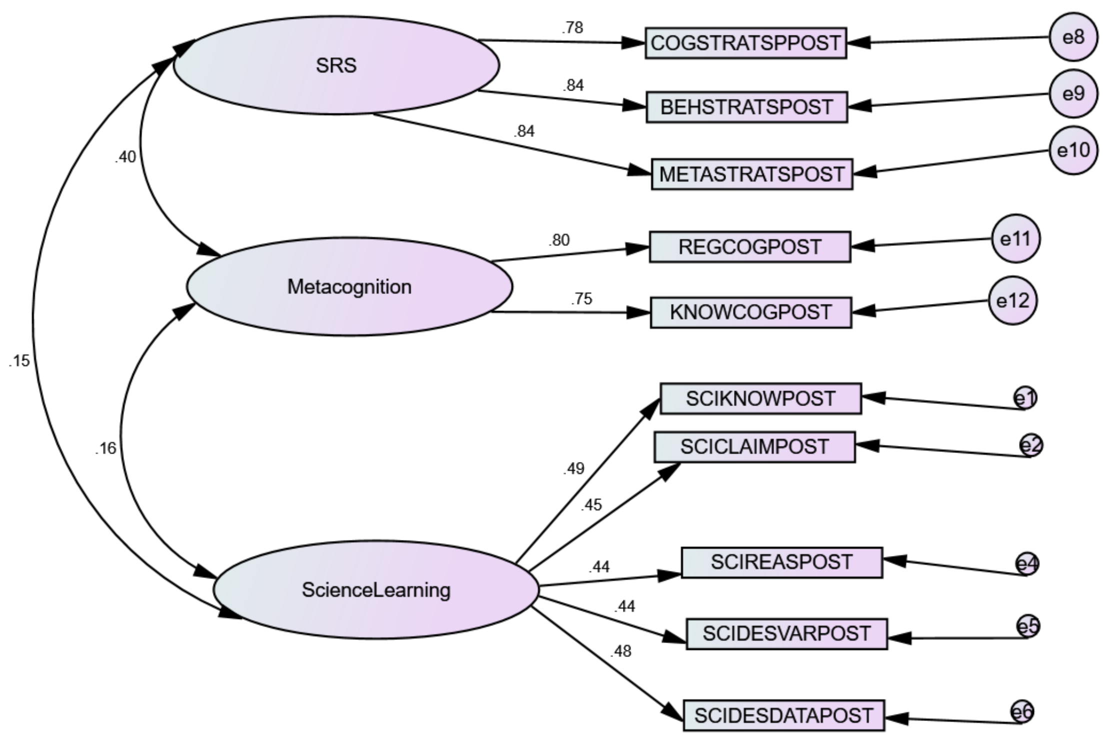


Figure 6. Confirmatory Factor Analysis of the 3 Latent Variables

Table 5

Validity and Reliability of Measurement Model in Figure 6 the Confirmatory Factor Analysis

Latent Variables	CR	AVE	MSV	MaxR(H)
ScienceLearning	0.572*	0.212*	0.026	0.574
Metacognition	0.750	0.600	0.158	0.753
SRS	0.859	0.671	0.158	0.863

Note. *indicates low values

The reliability concerns are the CR for ScienceLearning, which is 0.572 and less than the threshold of 0.70 (Hair, Black, Babin & Anderson, 2010). Additionally, the convergent validity, or AVE, for ScienceLearning is 0.212 which is less than the threshold of 0.50 (Hair et al, 2010). Coupled with the Cronbach alphas for this instrument (see Table 6), which are between .324 and .579, this indicates there are reliability concerns for this measures. As a reminder, this was a locally designed assessment focused on measuring the specific content learned, as well as the NGSS practices, rather than a standardized measure. While it went through content validity reviews, it has not been tested prior to this study.

Table 6

Measurement model loadings, significance and indicator reliability

Latent Variable	Indicators	Load-ings	CA	MSV	AVE	CR	Max R(H)
ScienceLearning	SCIKNOWPOST	.480	.374	0.026	0.212	0.572	0.574
	SCICLAIMPOST	.469	.552				
	SCIEVIPOST*	.233	.516				
	SCIREASPOST	.444	.526				
	SCIDESVARPOST	.428	.527				
	SCIDESDATAPOST	.483	.305				
Metacognition	REGCOGPOST	.802	.812	0.158	0.601	0.750	0.754
	KNOWCOGPOST	.747	.703				
SRS	SCIREGPOST*	.101	.127	0.158	0.505	0.767	0.863
	COGSTRATSPOST	.775	.726				

BEHSTRATSPOST	.843	.764
METASTRATSPOST	.836	.625

Note. CR is Composite Reliability, CA is Cronbach's alpha, *excluded from final model

There was a negative score change from pre to post on the JrMAI and a non-significant correlation between the post scores of the JrMAI and the Science assessment. To try to understand why I did a detailed analysis of the JrMAI data. This showed that this sample data had items which did not load similar to the factor loadings of Sperling et al. (2002). The sample was divided into 2 groups; the low group was determined by selecting students whose combined Math and Language PARCC scores were 1 Standard Deviation (SD) from the Mean and the medium/high group was everyone else. The low group yielded similar factor loadings to Sperling et al (2002). These were slightly different than the factor loadings of the other group which included everyone else. Note that the factor loadings are not the same items as those in theorized Knowledge and Regulation of Cognition groups. These items in this study were grouped based on theory whereas the factor loadings resulted from an Exploratory Factor Analysis, EFA, performed to see which items correlated statistically.

Assessing the structural model

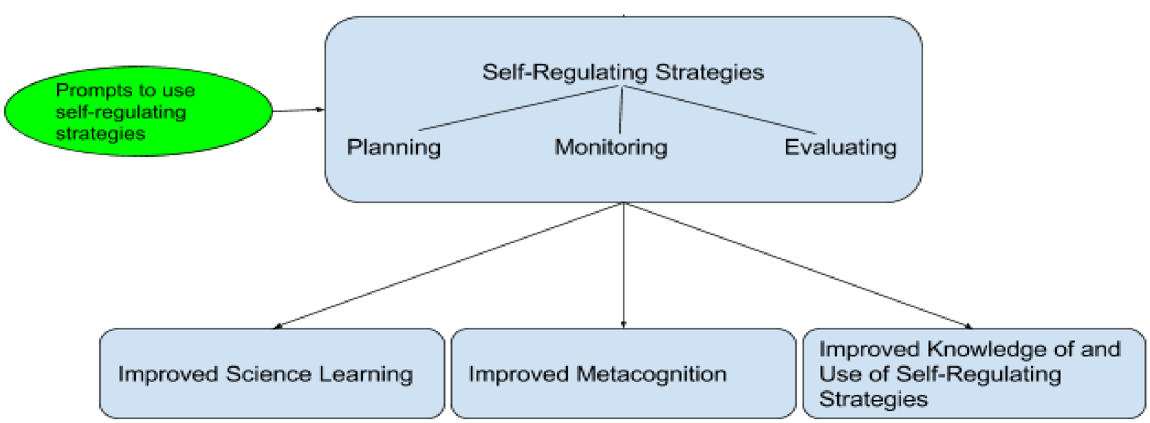


Figure 7. Conceptual framework model

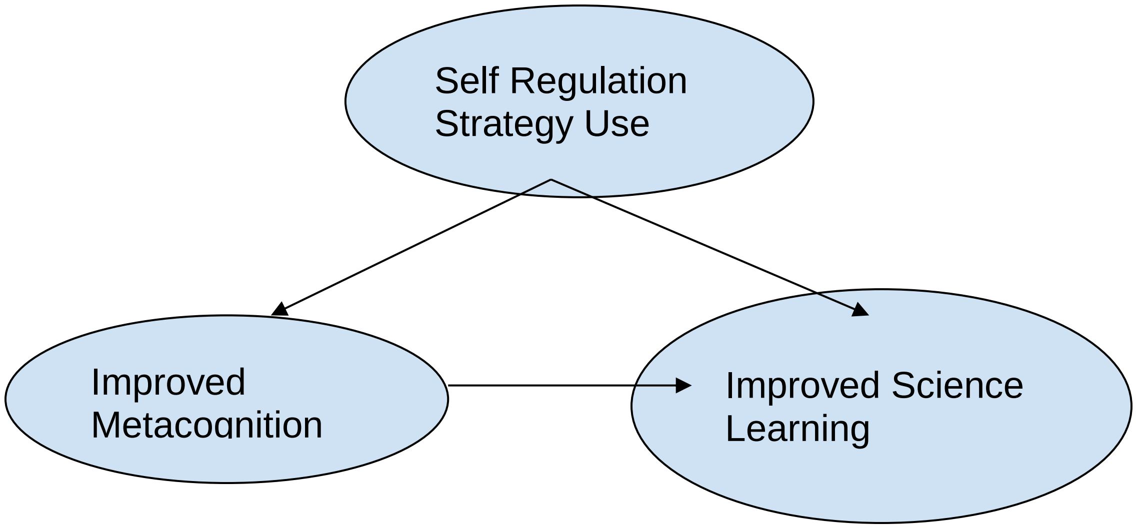


Figure 8. Path design of substantive model

The path diagram of Structural Equation Model showing direct and indirect effects to show the effect of self-regulation strategy use on improved metacognition and improved science learning as well as the indirect effect of self-regulation strategy use through improved metacognition on science learning.

Structural Equation Model

I began with a 3 latent variable model, to test the hypothesis that self-regulating strategy instruction through metacognition would improve the students' use of those skills, as well as improve content mastery. I will discuss the refining of the models using four specific models to illustrate the process to arrive at a model that reflects theory and best fits the data. All of the Goodness of Fit indices are in Table 7 for comparison across the four models. There were no modifications performed on any of the models.

For comparison, I used goodness of fit thresholds from Hu and Bentler (1999), as well as a summary of cutoff criteria from Schreiber, Nora, Stage, Barlow and King (2006). The choice to include the TLI, CFI, RMSEA, and Chi-squared/degrees of freedom is a best practice when examining goodness of fit for the models (Schreiber et al, 2006). The Akaike information criterion (AIC) is a useful indicator when comparing models, the smaller the better (Schreiber et al, 2006).

Table 7

Models and Goodness of Fit

Model	# latent Variables	n	Absolute/predictive fit		Comparative Fit to a baseline		Other		Para-meters Esti-mated
			Chi-square /df <=2 or 3	AIC Smaller is better	TLI >= .95	CFI >= .95	RMSEA <.06 to .08 with confidence interval	P close >.05	
Figure 9. SRS to Metacognition & Science Learning. Variables split	3	181	1.076	80.448	.991	.994	.021	.866	23
Figure 10. SRS to Metacognition & Science Learning. Variables comb.	3	181	.969	54.468	1.002	1.000	.000	.851	19
Figure 11. SRS to ScienceLearning No Metacognition. Variables split	2	181	1.290	58.504	.974	.982	.040	.607	17
Figure 12. SRS to ScienceLearning Variables combined	2	181	1.210	35.684	.989	.994	.034	.584	13

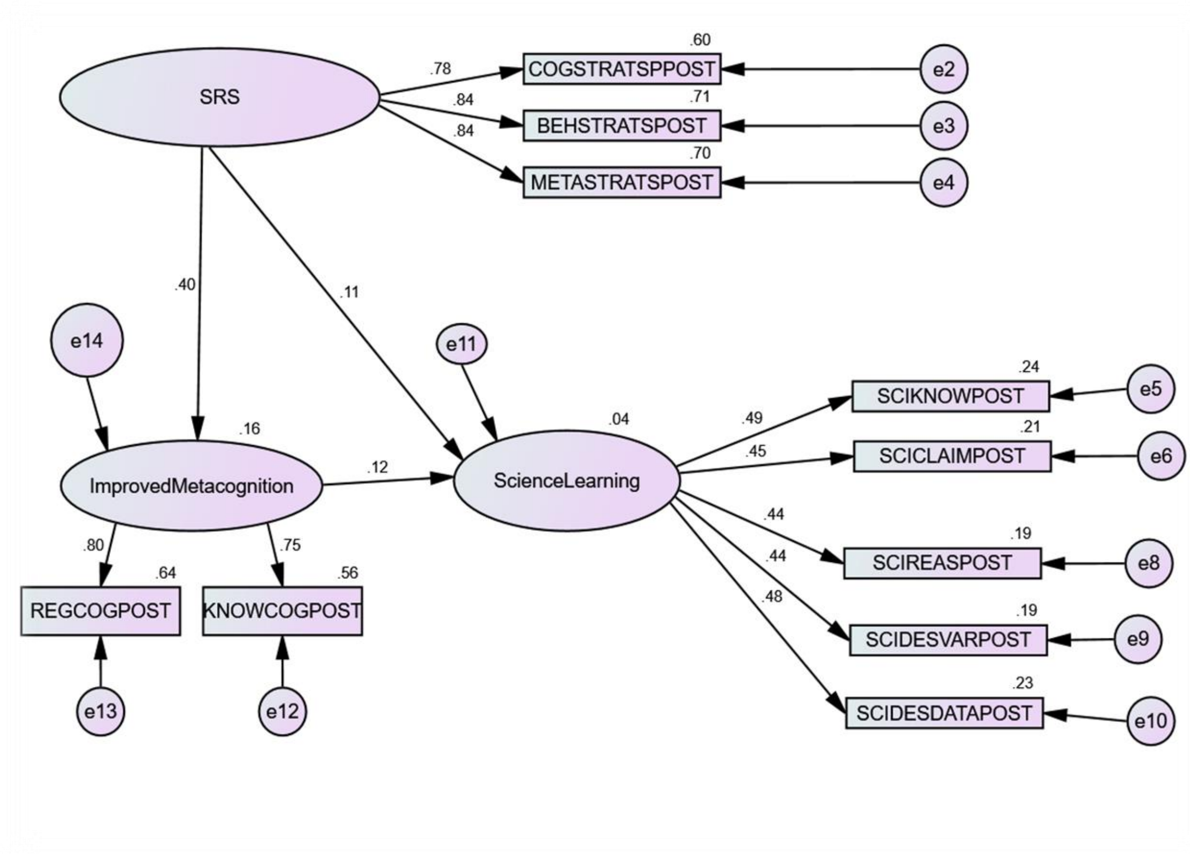


Figure 9. SEM SRS, no SCIREGPOST, no SCIEVIPOST, to ScienceLearning, split variables, Mediated through Improved Metacognition. n=181, Chi-square/df = 1.076, TLI = .991, CFI = .994, GFI =.962, AGFI = .935, RMSEA = .021, PCLOSE = .866, AIC =80.448, Parameters estimated = 23

This model, Figure 9, had no modification indices (MI) recommended that are theoretically appropriate. For example, the MI recommends covarying SCICLAIMPOST with COGSTRATSPOST and covarying across latent variables is not appropriate (Byrne, 2010).

SRS has a direct effect on ScienceLearning
SRS has a direct effect on ImprovedMetacognition
SRS has an indirect effect on ScienceLearning through ImprovedMetacognition

The Structural Equation Model (SEM) in Figure 9 shows SRS as an indirect effect on improved Science Learning through metacognition as well as a direct effect from SRS to Science

Learning. This model showed only the AIC model fit that is of concern at 80.448, since the when comparing across models it is the largest AIC, see Table 7. However aside from reasonably good model fit numbers the parameters estimated for this model were 23. Schreiber et al (2006) recommend a rule of thumb that there be 10 participants for each parameter estimated that would require a 230 participant sample and the sample is just 181.

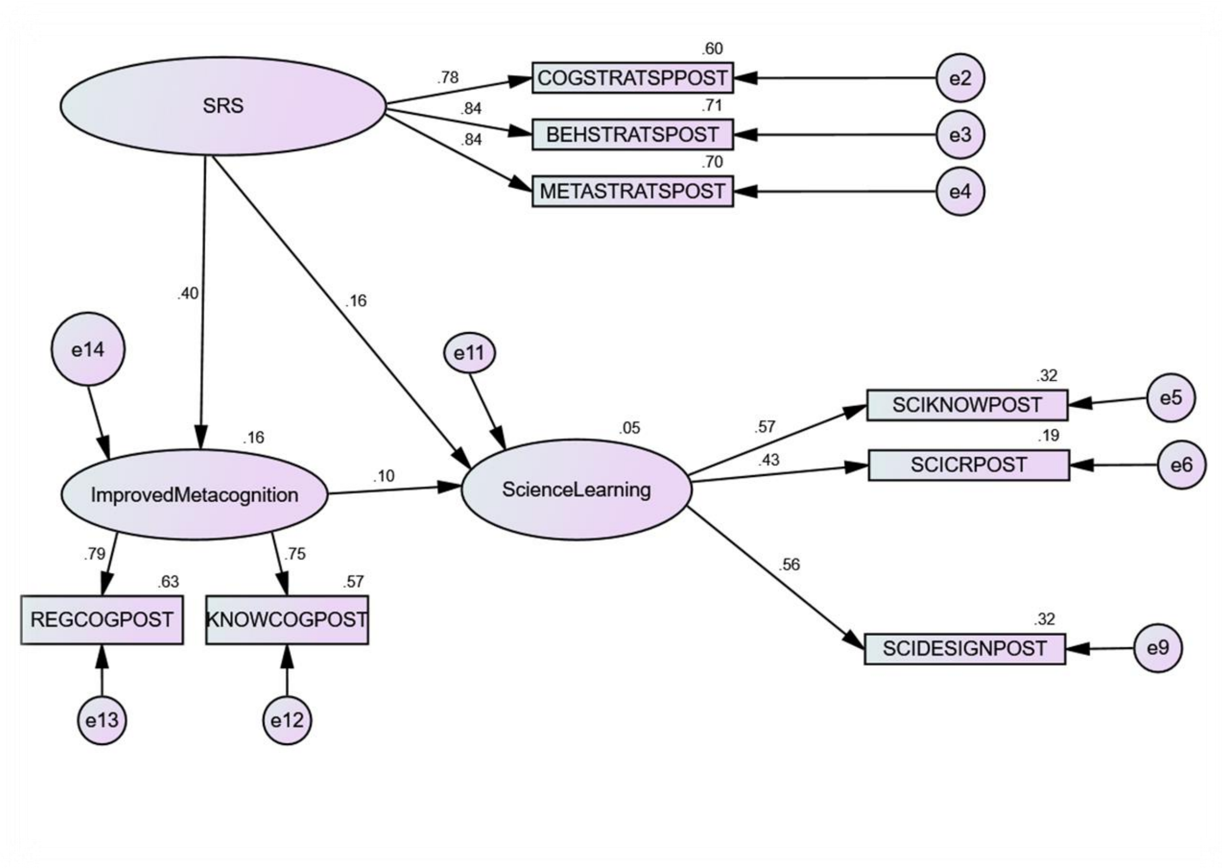


Figure 10. SEM SRS, no SCIREGPOST, no SCIEVIPOST, to ScienceLearning, combined variables. Mediated through Improved Metacognition. n=181, Chi-square/df = .969, TLI = 1.002, CFI = 1.000, GFI = .978, AGFI = 954, RMSEA = .000, PCLOSE = .851, AIC = 54.468, Parameters estimated = 19

The SEM in Figure 10 shows the five dependent variables on ScienceLearning combined into three. Each dependent variable reflects the test responses associated with each part of the science assessment. However the SCICRPOST excludes the evidence scores as previously mentioned, a result of the CFA. However for this model the TLI at 1.002 is high and the AIC though smaller is still high at 54.468. The parameters estimated were 19 which is much better for our sample of 181. The SEM shows SRS relating to SciLearning directly and indirectly through Metacognition. The regression weight from ImprovedMetacognition to ScienceLearning is .11, the regression weight from SRS to ScienceLearning is .09 and the regression weight from SRS to ImprovedMetacogntion is a .40. The direct effect of SRS on ScienceLearning is .09 but the indirect effect of SRS through ImprovedMetacognition is the product of .40 and .11 or .04. But regression weights for SRS to ScienceLearning has a p of .209, and ImprovedMetacognition to ScienceLearned ha sa p of .450, neither is significant.

Each of the models in Table 7 were constructed based on the original hypothesis and what was actually taught during the intervention. The hypothesis was that teaching and prompting the use of self-regulating strategies would improve students' science learning, improve their knowledge of metacognition and their knowledge and use of those self-regulating strategies. However there was only one partial day's explanation of metacognition and so it was determined to remove metacognition from the SEM.

An SEM was run excluding metacognition data and looking at the use of self-regulation strategies and the effect on improved ScienceLearning. This shown in Figure 11. The parameters dropped to 17 however the AIC climbed up to 58.504 and the regression weight from SRS to ScienceLearning icreased to .15 however it was nonsignificant at a p = .157.

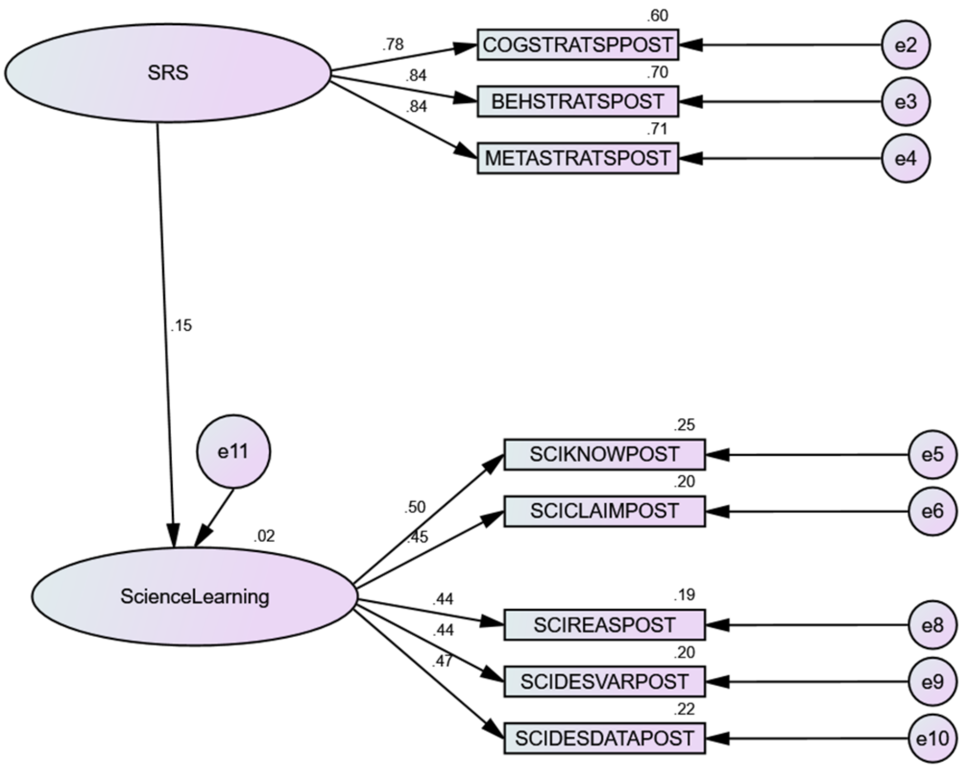


Figure 11. SEM, SRS to Sciencelearning, no Metacognition, split variables. Chi-square/df = 1.290, TLI = .974, CFI = .982, GFI = .966, AGFI = .935, RMSEA = .040, PCLOSE = .607, AIC = 58.504, Parameters = 17.

In order to improve the p significance of SRS on ScienceLearning one more model was test, Figure 12. In this model the variables were again combined as in the model in Figure 10. The results were quite good as the AIC dropped to 35.684 and all other model fit indices were good. The regression of SRS on ScienceLearning is now .20 with a p value of .084. This p value is a two tailed test and when reviewing the effect of SRS on ScienceLearning I am looking for a one tailed effect which would drop the p value to .042 a significant number.

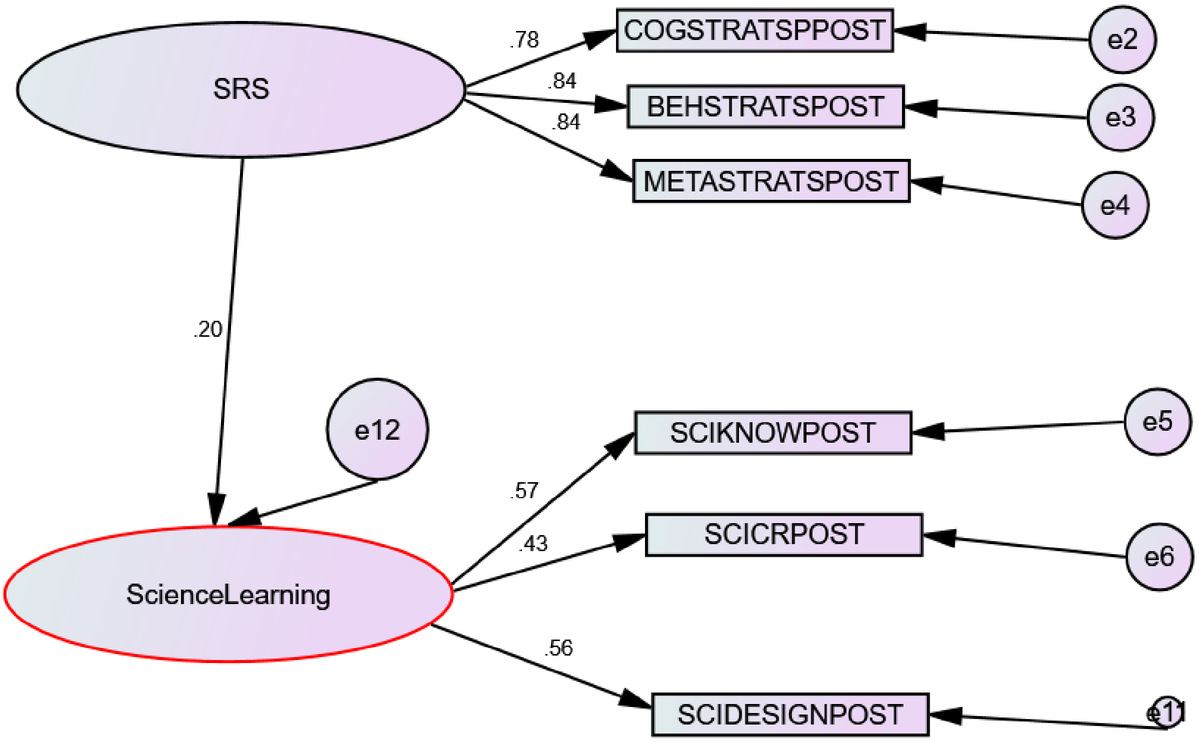


Figure 12. SEM, SRS to Sciencelearning, no Metacognition, combined variables. Chi-square/df = 1.210, TLI = .989, CFI = .994, GFI = .983, AGFI = .955, RMSEA = .034, PCLOSE = .584, AIC = 35.684 Parameters estimated = 13.

Discussion and implications

It is possible to quantitatively support the claim that teaching SRS will improve Science learning, but there remain a number of challenges, specifically the science assessment and assessing SRS skills of middle school students. In this research, the assessment of science learning was a locally designed and under-developed instrument that had poor internal reliability.

The decision to show metacognition having a mediating effect from self-regulating strategy to science learning resulted from three considerations. Initial review of teacher interviews and the carefully followed Things to Remember slides showed that metacognition was only mentioned one time throughout the intervention. In this assignment students self recorded their choice of effective workplace, a strategy based on metacognition, and to record the intrusions and how they dealt with those while they tried to learn something new. This gave short shrift to teaching and encouraging students' metacognition. The thinking was that students would have a reciprocal relationship with self-regulating strategies, that is, as they practiced the strategies they would become more metacognitive which would encourage better choices of the strategies. Consequently metacognition was not explicitly taught which may account for the small regression effect from Metacognition to ScienceLearning.

Instruction on metacognition needed to be more explicit, middle school students need to be taught to recognize metacognitive thinking and to apply it in order to understand the language of the questions regarding metacognition. The understanding about metacognition was that students would become more metacognitive with the use of self-regulating strategies not as an initial impetus for the strategies necessarily so some change was expected.

Despite this, self-regulating skills that were explicitly taught contributed to science learning. This is evident in the final SEM model showing the effect of SRS on Science Learning. Using Schunk (2005) formula for self-regulation of planning, action, and reflection, here referred to as planning, monitoring, and evaluating, we prompted students to plan how they would accomplish their assignment, monitor how they were doing on their plan, and reflect on how well their plan worked. Students were not prompted to plan for their content learning explicitly nor were they prompted to monitor or reflect on their content learning. The focus was on the skills needed. The hypothesis was that their content learning would grow as they honed their self-regulating skills and we have evidence of that happening.

Additionally, it is difficult to determine how self-regulating middle school students are. You can interview them, however, this would be difficult and time consuming for 200 students. You can record them as they think aloud, however, again this would be very time consuming since Greene and Azevedo (2007) had to continually prompt their students to remember to say things aloud. Winne (2010) states that students regulate as they go. Therefore, the above needs to be repeated perhaps several more times as self-regulation changes. Thus, the self-report instruments of the JrMAI and the MSLS were used for this study.

The idea of using a self report measure on an electronic form seemed practical, but in nearly 80% of the items for both surveys, the students' performance decreased in the post survey. While I do not believe that this represents unlearning of SRS, it does raise the difficulty in measuring SRS with this student population. Students tended to have an inflated view of what their skills were and their use of SRS.

The student responses to the JrMAI were not as expected possibly for two reasons, the vocabulary of metacognition was not explicitly practiced and the two constructs of the survey itself. Unfamiliar with the vocabulary students may have had difficulty accurately assessing their own behaviors and thought processes. In addition, there were few statistically significant differences in the responses when comparing pre to post. One of the challenges that presented itself for including metacognition as a latent variable was in using a two factor model for the 18 items in the JrMAI. Since the authors of the survey found in their EFA that 15 items loaded on one factor, with only 2 items loading on a second factor, and one item loading nearly equally on both, they subsequently recommended that the all items be used as one. This is in contrast to their grouping of the 18 items into two groups of 9 representing two constructs in their research (i.e., knowledge of cognition and regulation of cognition). Given their research had used the two constructs that were followed in this study as two indicator variables loading onto the latent variable of ImprovedMetacognition. Ning (2016) encountered similar problems with using the items as two constructs and hypothesized that the factor structure might be for very specific populations. Using an additional instrument he divided his population into levels of metacognition and found different factor loadings for different student samples. Not having this additional information, I used the combined PARCC scores and divided the population into low and mid/high achievers where the low group was <= one SD below the mean. Conducting an EFA on this group, I was able to nearly match the author's results just for this sample of the population. Therefore, future work may need to tease out analysis, based on prior achievement, to develop a deeper understanding of the impact of metacognition on learning.

Regarding the MSLS, we deliberately taught the three overarching skills of planning, monitoring, and evaluating along with graphic organizing. Additionally, the MSLS asks about many other SRS that were implicitly taught but expected such as I “put things I read into my own words”. And others where the teachers provided the environment to “ask friends for help with schoolwork if I need it”. There was no significant change, so no improvement in these two behaviors according to this measurement. Winne and Perry (2005) reports that SR is context specific, therefore, we could trim the MSLS items to represent what we actually taught explicitly and implicitly as the MSLS is measuring many that the intervention did not deliberately teach nor are the questions directed specifically to science. With these changes, a more reliable science assessment and students more familiar with metacognitive terms, a significant quantitative connection could be drawn.

This study used the same three scales as Liu (2009) found from a factor analysis of the MSLS: cognitive, behavioral and metacognitive. Although there was some indication of correlation across the three scales, they remained distinct constructs for our population and all three were loaded as indicators factoring onto one latent variable, SRS. Most of the items as written were clear to our 7th grade students, however, there were 47 items including some SRS that were not explicitly taught in this intervention.

The intervention was designed following the guidelines of Perry et al. (2002). Teachers gave them choices for their task product, opportunity to plan, monitor, and evaluate themselves, and others provided scaffolds to individuals as needed and found that they improved in the skills. Although teachers prompted the use of these skills throughout, they did not consistently prompt for metacognition. I had surmised that their metacognitive skills would improve along with their developing self-regulating skills. Unfortunately the pre to post t-tests yielded no significant improvement in either metacognition or use of self-regulating strategies. The only evidence for this was the students' reflections on improving their use and design of graphic organizer and their improved ability to complete their tasks on time and with less of a rushed feeling. It remains unclear how strong the relationship is between metacognition, self-regulation, and science learning. There was no significant correlation between the Science Post Assessment and either the MSLS total score nor the JrMAI total score. Cotterall and Murray (2008) found in Japanese college students who were self-directing their learning of english that an increase in metacognition resulted in improved ability to self-regulate. There was some evidence in this study of increased metacognition resulting in improved ability to self-regulate since the correlation between the post JrMAI and the Post MSLS yielded a small coefficient of .315.

This study used domain specific prompts for planning and monitoring in that the written prompts were specific to the amount of questions they needed to research and not the content of the questions. The teachers used domain specific prompts in our evaluating, such as "How did you do?" and "Did you finish on time?" Our prompts in each of the categories of planning, monitoring, and evaluating began with a general prompt such as "How are you doing?" and was followed by directed prompts as Davis (2003) defined them, that is the prompts were potentially productive directions for reflection. Prompts changed in response to students needs as over several cycles the students expressed frustration when being asked the same directed prompts and so they were modified subsequently.

Conclusion

Much research has been done to show a need to teach self-regulating strategies to middle school students. Although teachers agree that their students need to know how to self-regulate, they don't always teach these strategies and may need to be shown explicit ways to do so (Perry, Hutchinson, Thauberger, 2007; Spruce & Bol, 2015). In addition, many students need instruction of metacognitive skills (Zepeda et al, 2015). Teachers' responsibilities inside the classroom are increasing as special education and honors level students are included in the general education classroom (Valli & Buese, 2007). New models of understanding the relationships of SRS, metacognition, and science learning are needed, but as we develop new models, we need to think about the ways in which teachers can blend these skills to support the broadest range of learners as well.

Chapter 3: Practitioner Article for Science Scope (NSTA) Submission "Teaching and then Prompting Self-Regulating Strategies"

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Rutgers University

May 2019

Content Area: Science Human Body Systems
Grade Level: 6-8
Big Idea/Unit: NGSS Practices
Essential Pre-existing Knowledge: ?
Time Required: 3-4 months
Cost: None

Introduction

"Give a man a fish - feed him for a day. Teach him how to fish - feed him for a lifetime" Chinese Proverb

Students today can access unlimited information with even less effort than the click of a mouse. Next Generation Science Standards, Google, and One-to-One districts are changing the science classroom. As a result, teachers today are less challenged by the scope of textbooks or reference materials because instead of pre-fit labs students can design their own investigations to explore scientific principles. Consequently, students need to learn skills and develop strategies to process information. Students have access to all the fish they want but they need to know how to catch those fish. They need tools to manage information, budget time, and evaluate the efficacy of their efforts. Ultimately, they need to incorporate personal skills so they can self-regulate and not just respond to a teacher's instruction. In a study using metacognitive prompts embedded in a science inquiry unit, students "showed significant gains in content knowledge" when comparing the experimental group to the control group (Peters & Kitsantas, 2010). Of course, we must still teach the principles of science, but with the vast opportunities provided by the information age, effective education includes helping students learn how to learn. This facet of teaching is particularly challenging because each student learns in different ways. As our classrooms continue to become more diverse, teachers need strategies for all learners as recognized in NGSS Appendix D (Lee, Miller, & Januszyk, 2014).

Given the need to support student self-regulation of their learning, teachers at XX middle school decided to support students in science by teaching students to become more metacognitive and use self-regulation strategies like planning, monitoring and evaluating their progress (Zimmerman, 2002), their ability to learn will improve. Metacognition is understanding how you learn and knowing your learning strengths and weaknesses (Bransford, Brown and Cocking, 2000). Metacognition and effective self-regulation strategies are useful for all learners, including high achievers and Special Education students.

Metacognition Passage altered from *Metacognition in Young Children*
Shirley Larkin, 2010

While working on difficult math problems, studying for a test, writing an essay…. I may think “I will stop to answer that text now”, a normal thought, but if instead of immediately acting on that thought, I stop and take a little time to reflect, I might think about why I had that thought in the first place. Am I waiting for a text from a friend to help me with my work? Or is it likely the text has nothing to do with work? Perhaps the reason for my thought was not related to the text but to feeling tired or bored? Or maybe I am feeling stuck or even in need of a reward for having done some work today? From any one of these thoughts I could follow where my own thinking leads. I may become interested in planning with a friend what I will do later, or getting something to eat or drink, or looking up something on the computer that will help me do my work, or contacting a friend with a question about the work.

On the other hand I might act on this thought and make a conscious decision to stop and respond to the text. Or maybe I'll silence my phone and put it in my backpack so I don't hear the vibration and return to my work. Having considered other thoughts maybe I will look up something for reference on youtube or at school, or maybe take a walk to the kitchen, or play some video games. I might choose to ignore all these.

Becoming aware of all the different thoughts which might lie behind my initial thought means that I have shifted from the ordinary level of thinking to thinking about the thought itself; why I had that thought and how it was linked to how I am feeling right now (anxious, bored, confused, hungry).

At the same time, while considering this, I have been partially monitoring that initial thought and occasionally checking back in to see if I still really want to stop and answer the text or if the moment has passed. From the initial fairly ordinary thought, I have been on a thinking journey to make a conscious decision about what to do about the thought. What responding to the text would do for me and about whether I want to stop what I am doing to text or to wait a little while longer and then have a proper break.

Figure 1. Metacognition Journal Sample

Do you think your students have these skills already? We assessed our 7th graders and were surprised about how many had limited skills in self-regulating their own learning.

In an effort to explore how effective modern learning tools could be taught, we embedded specific skills within a science unit. Students, working in groups, were assigned to research the human body system, find instructive videos, write about their findings, and create a screencast describing the system. They were also required to come up with a question they had about an aspect of the system, design and execute an investigation, and report their findings in a podcast created with their group members. They were given a ten-day period to complete the assignment and were told they had to plan and monitor themselves to reach their goal on time.

How do you convince students they need to do this?

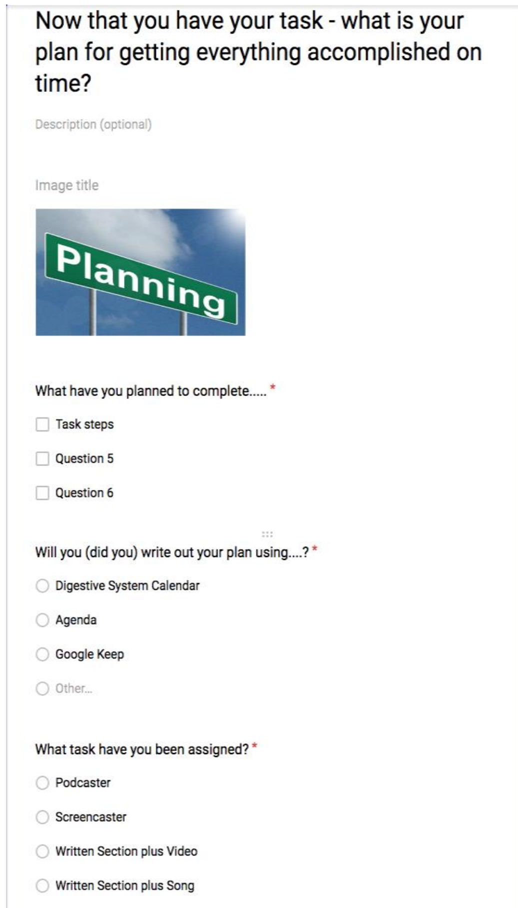
To help students understand the broader goals of the project, we gave them an exercise in thinking about how they learn. We showed them a journal excerpt discussing the numerous distractions a student experiences when sitting down to study, Figure 1. The excerpt includes distractions such as texts from friends, 'just checking' email, a snack, "just a few minutes" playing Fortnite, or pleas for help from little sisters. We then asked them to keep a similar record while doing their homework that night. Throughout the unit we would refer to this journaling and gently remind students to consider how efficient their efforts were and what obstacles continued to get in their way.

The Project

We embedded four self-regulating strategies in our Human Body Systems unit; planning, monitoring, evaluating, and organizing information using a self-designed graphic organizer. During the unit, we issued prompts for each strategy using individual Google forms during each system studied requiring a written response. An example of a Planning Prompt is in Figure 1. We also prompted them daily. We used different prompts depending on the tasks as some were more difficult than others such as the podcaster task. So we prompted podcasters to create, or find, an investigation, lead their group mates through the investigation, and then interview them afterwards. The interview asked them to describe the investigation, discuss their findings, and explain how their investigation related to the system they were studying. We prompted our writers and screencasters with task specific reminders. Each teacher could also give additional verbal prompt support as needed.

Planning

We gave the students deadlines and specific days when they could conduct lab investigations, visit the library and have opportunities to work independently in the classroom. From this basic outline, they had to estimate how long it would take them to research their questions, when they would do their work (in class and at home), when they would get together to discuss shared writing responsibilities, write a script, and when they would plan and create the podcast of their lab. We wanted them to be very deliberate about their plan, thus we prompted them using the Google form.


Now that you have your task - what is your plan for getting everything accomplished on time?

Description (optional)

Image title

What have you planned to complete..... *

- Task steps
- Question 5
- Question 6

Will you (did you) write out your plan using....? *

- Digestive System Calendar
- Agenda
- Google Keep
- Other...

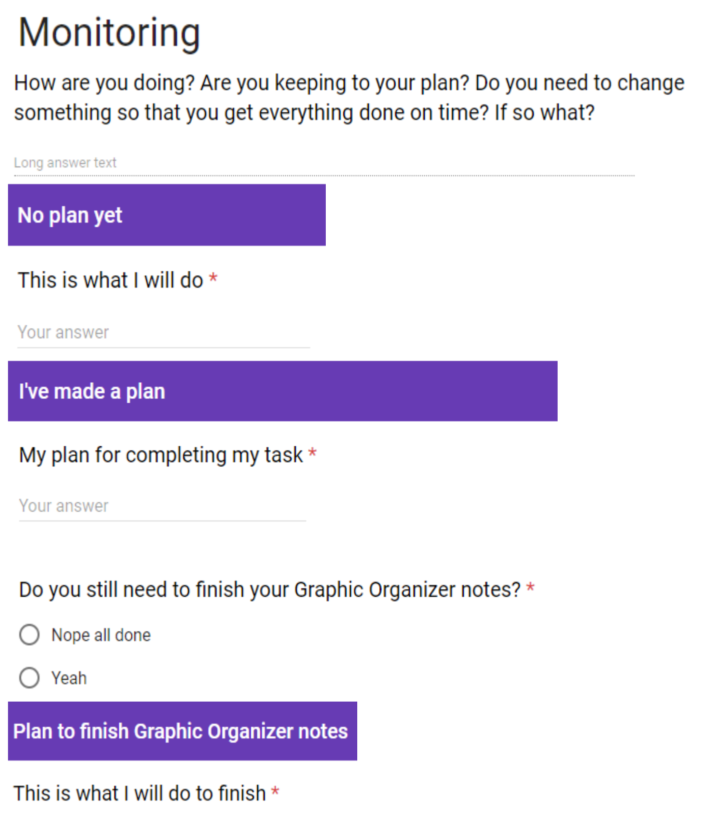
What task have you been assigned? *

- Podcaster
- Screencaster
- Written Section plus Video
- Written Section plus Song

Figure 2. Planning Prompt Google Form

Renee, a science teacher, noted “they didn't have a model for how to break up an assignment. They're used to either us posting it in our classroom, on homework calendars, or perhaps a space on a whiteboard. And so for them to actually have to do it themselves-to break it up- I found that they weren't sure of what to do.” To help students get started, we modeled how they might plan by showing our own planning calendars. We discussed different planning tools including Agendas, Google Keep, or paper calendars. We offered new tools such as the Calendar Templates from Google Add-Ons for students who wanted a calendar but preferred something they did not have to carry around (and possibly misplace). Although many students were familiar with Google Keep, we made a simple Screencast to show them the Google Calendar Templates.

Monitoring


Monitoring

How are you doing? Are you keeping to your plan? Do you need to change something so that you get everything done on time? If so what? *

Long answer text

No plan yet

This is what I will do *

Your answer

I've made a plan

My plan for completing my task *

Your answer

Do you still need to finish your Graphic Organizer notes? *

- Nope all done
- Yeah

Plan to finish Graphic Organizer notes

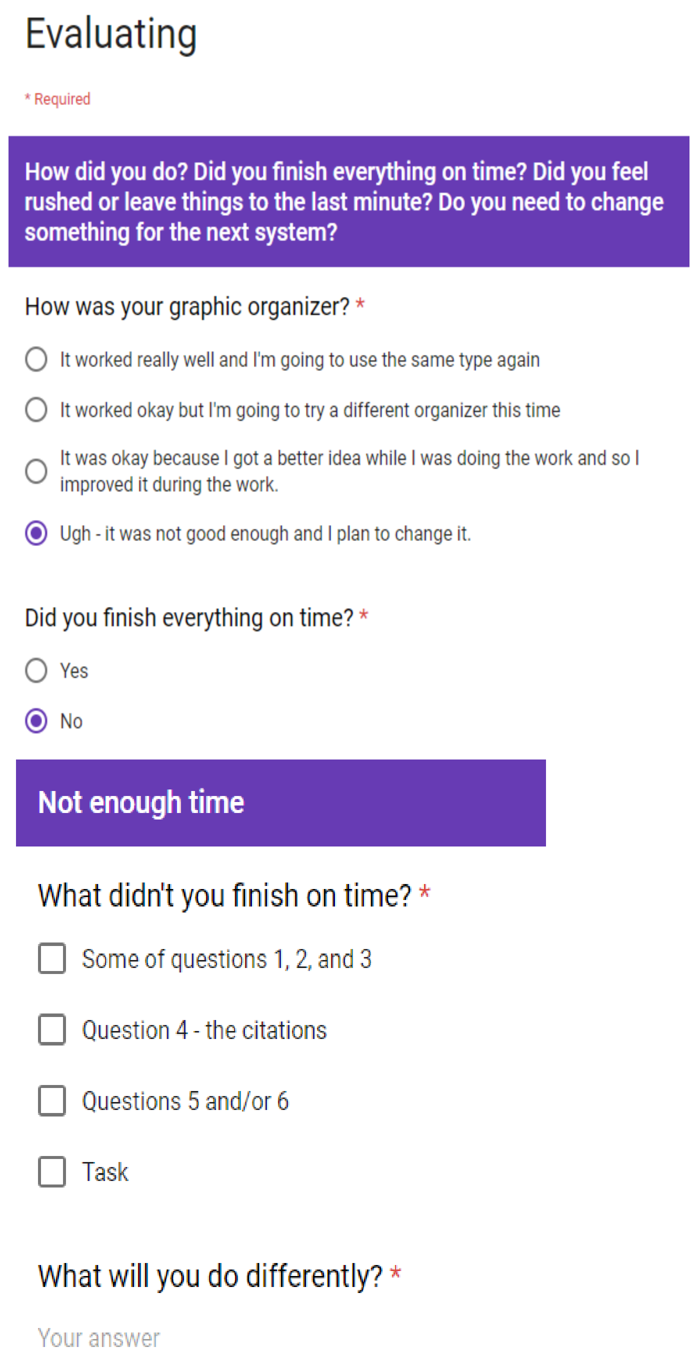
This is what I will do to finish *

Figure 3. Monitoring Prompt Google Form

Self-regulation through monitoring was also built into the unit. Two days into a system, they used a Google Form to monitor their progress. Some teachers used the form at the beginning of a class to help the students focus on what they needed to do that day, while other teachers preferred to use the form at the close of class so the students could consider assigning themselves homework if needed. The students needed to monitor their learning progress as they researched the answers to the questions on a particular human body system or as they planned and executed a task such as writing and recording a screencast, writing and illustrating a summary of the system or planning an investigation and then conducting it with their group. The special education teachers used their study skills class to support their students' monitoring. Marie explained, "My students work really well with checklists, so we have checklists for them and a lot of this was done in flex, our study skills class, to have a checklist to go through their work to see what they've done and what they have not done."

Evaluating

With each round of investigations students evaluated their progress to determine what they should keep, throw out, or improve. The teachers felt it was important for students to reflect on their own learning progress even though the easiest step to drop when pressed for time is this evaluation step. This is a dangerous trap, because if students do not reflect on what strategies are working they will fail to improve their efficiency, not build on the skills we are helping them to develop and, in fact, become even more pressed for time. Students evaluated progress using templates such as in Figure 3.



Evaluating

* Required

How did you do? Did you finish everything on time? Did you feel rushed or leave things to the last minute? Do you need to change something for the next system?

How was your graphic organizer? *

- It worked really well and I'm going to use the same type again
- It worked okay but I'm going to try a different organizer this time
- It was okay because I got a better idea while I was doing the work and so I improved it during the work.
- Ugh - it was not good enough and I plan to change it.

Did you finish everything on time? *

- Yes
- No

Not enough time

What didn't you finish on time? *

- Some of questions 1, 2, and 3
- Question 4 - the citations
- Questions 5 and/or 6
- Task

What will you do differently? *

Your answer

Figure 4. Evaluating Prompt Google Form

Graphic Organizing

At the start of the unit the students were given specific questions to research about the human body system. They were encouraged to design graphic organizers for their notes. We showed the students different types of graphic organizers from websites like StoryboardThat (Figure 4), Lucidchart (Figure 5), or simple tables with the questions in one column and a second column for conclusions (Figure 6). These tended to evolve into more elaborate organizers as the students grew aware of what they needed to do to effectively research the complex questions. For example, in Figure 4 a student drew each of the five systems that the Muscular System supports or in Figure 6 a student included images and descriptions of the three types of muscles.

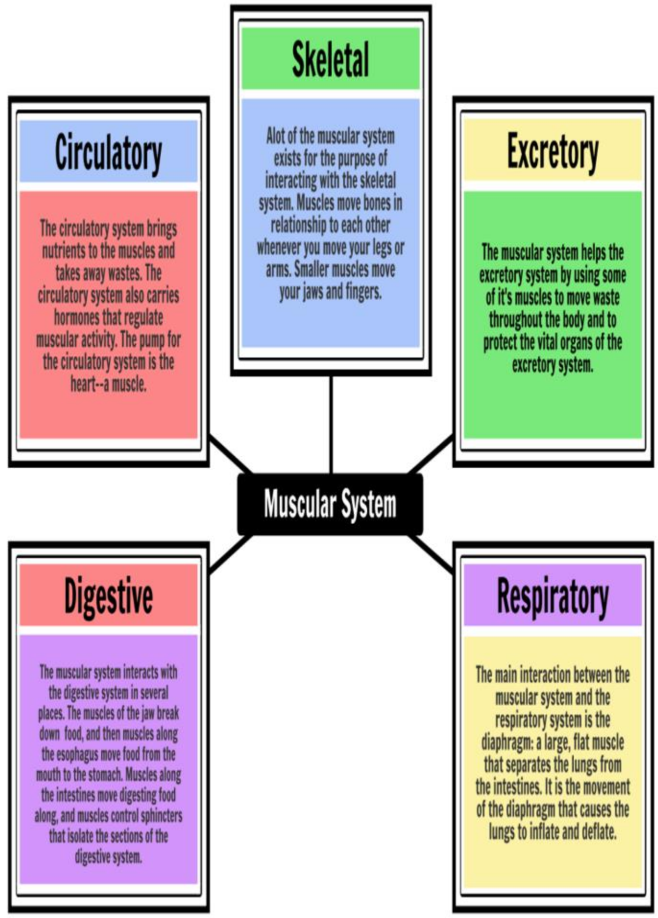


Figure 5. Student Graphic Organizer

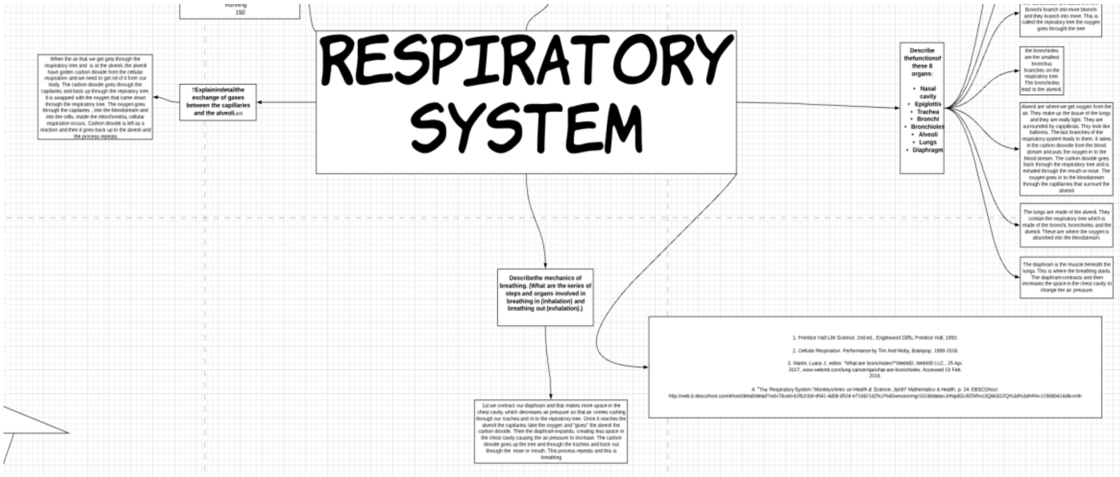
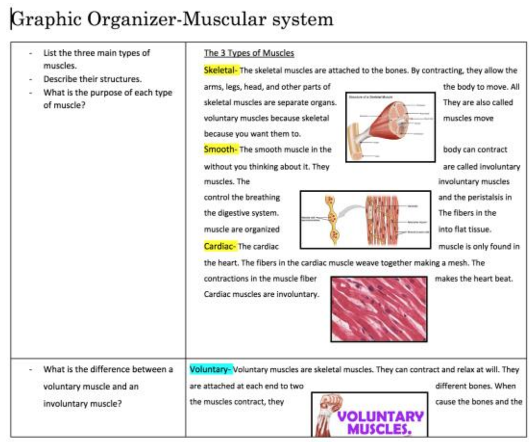


Figure 5. Student Graphic Organizer *Lucidchart*

The teachers found they needed to provide more scaffolding for some of their students. For those students, and most of the special education students, teachers provided the graphic organizers. Megan, a special education teacher, explained, “I just adapted it a little bit more ... they work best when they have a graphic organizer that almost outlines what they need to include. So I provided that for only some of them, not all, because some of them are able to do it on their own. I would say four were able to be independent in doing the research aspect and taking notes on their own.”

Over the next five systems studied, and subsequent autonomous projects, teachers were able to reduce this support for many of the special education students. With repeated practice, students improved "especially with taking notes and having ways to keep them and making sure that they were getting stuff done." As Laura explained, "For the Human Body Systems Unit I had to give them the graphic organizers... Then as we started going through the unit, some of my kids were making their own graphic organizers and then by the Plainsboro Preserve [outdoor project in May], it was more check-in based, they had a template but some of them didn't even use that." Marie observed, "three students whose classes are half resource center, ie; no general education students and half in class with general education students, did still need some support with planning their schedules, but I saw improvement from when we started the Human Body Systems in January until now [June]. [In our current unit] those three particular students took the initiative to meet with me to kind of plan out their daily schedule and what they needed to get done. So I did see growth in that way."


Graphic Organizer-Muscular system

- List the three main types of muscles. - Describe their structures. - What is the purpose of each type of muscle?	The 3 Types of Muscles Skeletal- The skeletal muscles are attached to the bones. By contracting, they allow the arms, legs, head, and other parts of the body to move. All skeletal muscles are separate organs. They are also called voluntary muscles because skeletal muscles move because you want them to. Smooth- The smooth muscle in the body can contract without you thinking about it. They are called involuntary muscles. The involuntary muscles control the breathing and the peristalsis in the digestive system. The fibers in the muscle are organized into flat tissue. Cardiac- The cardiac muscle is only found in the heart. The fibers in the cardiac muscle weave together making a mesh. The contractions in the muscle fiber makes the heart beat. Cardiac muscles are involuntary.
- What is the difference between a voluntary muscle and an involuntary muscle?	Voluntary- Voluntary muscles are skeletal muscles. They can contract and relax at will. They are attached at each end to two different bones. When the muscles contract, they cause the bones and the

Figure 6. Student Graphic Organizer Table

Some unforeseen benefits resulted from the unit. The students enjoyed the independence of planning their studies. Laura said, "I think they like it too. They know what's coming. It's not like what are we doing today in science? I really think that they enjoy seeing a calendar of, okay, 'well I know Monday is my work day or I know Tuesday's a lab.' So I saw them getting more interested in it."

Further, teachers found they were able to focus their efforts to be more effective. As some students became more independent, extra attention could be paid to those who still needed it. Laura found this about her special education students "at the start of the unit they needed everything given to them and then by June, many were kind of hands off so that left me like half of them to kind of still troubleshoot with."

All of the teachers, felt that improvement would be even better if self-regulating strategies were introduced at the start of the year and students could continue to practice these skills within a consistent environment across different classes. Even so by the final independent problem solving project on ecosystems more than 95% of the students succeeded in completing their work on time. As we cycled through five different systems and the students practiced these skills, they became more adept at them, they caught more fish on their own.

Self-regulating Skills	Supports	Examples/Resources
Planning	Provided beginning and end dates, library visit days, and lab investigation days. Google form prompt Paper Calendar Teacher modeling Verbal check-ins Screencast of How to Use Google Add-ons Template Gallery	Google Keep Monthly paper calendar Google Add-ons Template Gallery Due dates on Google Classroom
Monitoring	Google form prompt Daily visual prompt "How is your plan going?" Verbal check-ins	
Evaluating	Google form prompt Student share self-designs with each other	
Organized note-taking (self-designed	Modeled table building and merge/split columns in google docs Encouraged using Storyboardthat.com	StoryboardThat.com Lucidchart.com Google docs tables

graphic organizer)	Student share self-designs with each other SPED scaffolding and then fading of teacher created organizers Verbal check-ins	

Figure 7. Self-Regulating Skills, Supports, Examples/Resources

Chapter 4: Self-Regulation Strategies Professional Development Plan

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Rutgers University

May 2019

Teaching Self-Regulation Strategies to Middle School Students

Problem

Middle school students should be developing self directed learning skills by using self-regulating strategies. They will need them in science class to navigate the NGSS Science and Engineering Practices (Lee, Miller, and Januszyk, 2014) and well as a 21st century skill our school wishes to develop (Aderhold, 2015). To be self-directed one must self-regulate your learning which is important in today's world of readily available information (Fahnoe & Mishra, 2013) where students often must manage their own work (Darling-Hammond, 2008). Some do not develop these strategies on their own because they may not have been taught them explicitly. Despite their value these strategies are not embedded in all regular content learning upon reaching middle school. Some regulating strategies are taught as part of the skills needed to read in K-8 grades (Schmitt, M.C., 2003). And possibly some skills are taught in Math however rarely is time taken from content during Science education to embed these strategies. Skills need to be taught in each context (Winne, 2010).

When faced with a new learning challenge students may become dependent on another's direction such as their parents or their teachers and so are simply going through the motion of learning. Sometimes they just give up. This lack of direction can be due to lack of motivation, low self-efficacy, or simply lacking knowledge of strategies.

Solution

As teachers there are some things within our control - we can teach our students these strategies. To facilitate the teachers' self-regulation instruction, a 7 day PD will be offered during the summer, with one more full day half way through the year, and monthly PLC meetings during the year for a total of 50+ hours as is necessary to change teacher practice (Wei, Darling-Hammond, Andree, Richardson, and Orphanos, 2009).

If students can regulate then they can learn more deeply as well as more efficiently. This improved learning could lead to improved self-efficacy (Bandura, 1977). Self-regulating learners regulate while they are learning that is they change what they are doing to learn, such as changing their learning environment, or finding a different resource such as find a book, website, or video while they learn. They regulate as they go (Winne, 2010). We use self-regulating strategies when learning. Some of our students have developed good self-regulating strategies while others have not. We can help students become aware of how they learn, what they know and what they do not know, and some strategies to do this. We can teach students to plan, monitor and evaluate their learning progress. Self-regulation is also context dependent (Winne, 2010) so as students are taught strategies in Science they may not use these in Social Studies so it is best to teach the strategies in all classes. Some of these strategies could be used in all classes, thereby reducing the need to re teach them and instead build upon them.

Successful development of the use of these strategies depends on several things including offering them choices, giving them opportunities to control challenge in completing tasks, and providing them with opportunities to evaluate their own and others' work (Perry, VandeKamp, Mercer & Nordby, 2010)

Participants

The program will be available to all core subject teachers i.e.; science, language arts, social studies, math and special education, in the two middle schools of the district. Ideally the participants should attend with their team of core subject teachers, i.e.; the science, language arts, social studies, math and special education teachers of one group of students so that the developed strategies can be consistently applied. Or teachers could attend with their content specific teams, for example: 7th grade science or 8th grade language arts including the content specific special education teacher.

Setting

This would be a 7 day summer professional development opportunity potentially at the district office where a large group could be accommodated to sit in groups of 4-6 and also allow movement around the room. This time would allow the teachers the chance to develop their plans together. Teachers would be in grade level content, i.e.; all the 6th grade social studies teachers or across content groups of no larger than six. These smaller groups will allow them to plan their unit together with embedded strategies. An additional full PD day approximately half way through the school year is planned. Then the teachers will continue to meet monthly as a PLC. In our middle schools Core teams meet weekly as do content teams so it would be natural for those teams to set aside one meeting per month.

Professional Development Design

Goals and Objectives

There are five goals for this training about what teachers will understand 1) What self-regulating strategies are and 2) Why we should teach them now. 3) How to help our students develop metacognitively. 4) How to embed the strategies in their lessons. 5) That time taken to teach our students to regulate their learning will reduce our time spent on content (Joseph). There are several objectives that will help me achieve these goals and they are: 1) Teachers will design an autonomous unit or project with embedded strategies. 2) Teachers will weave the prompts for the strategies across content areas. 3) Teachers will practice protocols that can efficiently support their conversations within their PLCs.

Training Plan

Overview

We begin on Day one with setting norms for our training and introducing ourselves, finding out how much the teachers know about self-regulation, the learning environment necessary to build strategies, and begin with the planning strategy. On Day 2 we will discuss how to engage our students in learning this, introduce the steps for planning including introducing the skill, the tools needed, schedule this in our plan, and build in teacher created prompts. The PD will include several training strategies, i.e.; presentation via slides, video, and shared materials, whole group sharing via Padlet.com and chart paper, small group discussion, gallery walks, and self reflection. The teachers invited to the PD are asked to come with a partially autonomous unit or project. The unit or project should have a start date and an end date at least 2 weeks apart. Allow choices for the students to create their own plan. See Appendix N for detailed description of daily activities.

Needs Assessment

I will conduct a needs assessment to help narrow down the content of the training, to determine the level of self-regulating strategy knowledge, and the expectations of the participants (Silberman, 2006). Initial questions would determine what the teachers think it means to be self-regulating and what metacognition in their middle school students would look like. In addition, it will be helpful to identify which self-regulating strategies they would most like to concentrate on, see Appendix K for a list of strategies to be considered.

Summer PD Description

As a way to introduce norms for the next 7 days of meetings I will explain the seating, ultimately they will sit with their middle school team or content team, although it is not necessary for the first day, and then I ask them to join the Google Classroom where we will share ideas and I can easily share with them the models I have.

We will begin with goals one and two, to help teachers learn what self-regulation is and what strategies are used to self-regulate and why we should them now. I will begin by asking each participant to introduce themselves, including their content area and the grade they teach, to establish inclusion (Wlodkowski, 2003). I need to establish why teachers would want to do this, I will begin with a short review of some of the research. Self-directed learning is a skill necessary to be successful both in school and in the job environment (Zimmerman & Martinez-Pons, 1986). However a self-regulated learner is given the learning challenge and takes the responsibility to plan for the learning, monitor their own understanding and behavior, evaluate whether they have achieved the goal and what they did to achieve it or not, and make appropriate adjustments (Schunk & Zimmerman, 2007). Self-regulated learning is context specific and learners regulate as they go (Winne, 2010).

In further support for goal two, I will explain and showing student examples for comparison. To begin I will give a brief overview of the 7th grade science “Big Wiki”. We designed a partially autonomous activity, chose skills to teach, planned when to introduce them and when to prompt for them. We also addressed how to motivate the students to want to do this. Finally we layered in scaffolds for diverse learners. Teachers will look at data from improved planning and monitoring from System 1 to System 3. How can we get students from here to there? Then they will review Prompt responses from the students evaluating their own graphic organizers will be compared. The teachers will review three student examples comparing the first graphic organizers to later ones, in Appendix. I will ask for the differences they noticed, such as, two of the students built in sections so they would not forget to relate the current system to the other five as they had done initially. One student, who did not copy the questions completely in the first system, consequently decided to use the teacher's question document and build his own tables within it.

As a group we will build some consensus on the strategies so in small groups they will discuss what it means to self-regulate. Teachers will pool all of their ideas and write them down. Then we will sort these strategies looking for commonality. It will be important to build trust among the teachers as they work in this summer PD because they will need to support one another during the school year as they try and sometimes fail to help all of their students to adopt the strategies (Dana and Yendol-Hoppey, 2008).

Each group will establish which skills they will concentrate on. As an introduction, I will show the strategies the teachers have most chosen to work on with their student from the Needs Assessment. Teachers will review the questions in the Middle School Learning Strategies Scale, MSLS, (Liu, 2009). Using the list of strategies from the MSLS they should choose 4-6 skills. The MSLS was the instrument used to determine the extent and which strategies the students were using but also to prompt their own thinking about what they could be doing. Next we will order the strategies into a timeline asking "do some need to come before others?" They will need to build these skills into their lessons in the early part of the year and then schedule the prompts to remind students to plan, monitor, and evaluate their developing skills.

I anticipate the teachers will name organization skills. Many of us try to teach them but sometimes find ourselves doing it for them - such as organizing their papers for them or providing spaces in our classrooms so they don't forget things. However, just throwing them into a project and asking them to do it isn't the answer. Only those who are already successful at organizing could handle such a challenge. We need to support them in their own development of organizational skills. I will show the prompts for planning, monitoring and evaluating and how we embedded those into the unit.

In a brief introduction to goal four, how to embed the strategies, I will introduce the skill that the science teachers found worth choosing, the student designed graphic organizer. This may be appealing to a variety of content teachers, especially those who have students research their own answers to questions. Here I will show the teachers how we developed the graphic organizer skill for our students. Model the original questions given to the science students and their use of Google docs, Storyboardthat.com, and Lucidchart.com. Examples of student work using these different tools will help the teachers see how the graphic organizers can be developed by the students and yet allows them the choice to do it their way.

To enact objective one, designing an autonomous unit/project with embedded strategies, we begin with a checklist. In order for teachers to give their students room to practice these skills they need to craft their units in such a way that the students have some autonomy (Perry, VandeKamp, Mercer & Nordby, 2010).

1. Offer them choices
2. Give them opportunities to control challenge in completing those tasks
3. Provide them with opportunities to evaluate their own and others' work.
4. Provide support to students by carefully orchestrating instruction to provide students with the science knowledge and strategy knowledge they need to operate independently.
    a. help them to make appropriate choices
    b. encourage them to expand their developing abilities by attempting challenging tasks
    c. use non-threatening evaluation practices that emphasizes personal progress and encourages students to interpret errors as opportunities to learn.

5. Ultimately provide just enough support to ensure students' application of independent, academically effective forms of learning.

Given this list as a checklist the teachers will evaluate the learning activity they have brought with them so they can decide if the activity allows for the first two listed, i.e.; choice and opportunity to control challenge. Next, as a group they must decide in which project/unit they will embed their strategies. Here I will show Calendar used by the Science teachers for their unit so the teachers can have a model of what they could do (Pike, 2003) from (Silberman, 2006). The teachers will end their first day with a good idea of the unit/project they will use with their team.

On the second day we begin to think of how to engage the students and addressing goal 3 how to help them develop metacognitively. As metacognition is closely correlated with self-regulation the teachers will need to know what some of the relationship between being metacognitive and self-regulating. I will begin by showing a student Ted Talk. The talk is by a 20 year old Briton who really engages his audience by revealing his own problems with procrastination and then explains metacognition.

Undoing procrastination requires planning so begin with the first skill of planning I will ask the teachers "How do you get your students to plan?" They will write their strategy on the papers around the room. The exercises of the teachers walking around and posting these strategies may facilitate a broader exposure to techniques and allow for a team discussion afterwards. Here I will show examples of tools we used in the study for the students, i.e; Google Keep, Google Add-ons Template Gallery (screencast How-to), and monthly paper calendars and show how we modeled using these tools ourselves. Here is where the start and end date of the unit/project is useful as we would show our students where we put those dates into a chosen calendar. The tools were introduced to the science students by a google slide presentation or a screencast and then we shared that with the students on Google Classroom. Each skill we introduced to the students was first explained, then modeled, enacted by the students, and shared with them on their own Google Classroom so they could refer back when needed. These slides and screencasts will be available to the teachers in the Google Classroom.

Weaving prompts across content area is our second objective and in this activity the cross content teams will create their specific prompts. As the teachers distribute throughout their schedule when they will ask the students to do their own planning I will share the planning prompts and student exemplar responses. These too will be available in the Google Classroom. The teachers will craft their own prompts for their particular unit. Since being metacognitive and self-regulating is context specific (Winne, 2010) the teachers will need some time to determine what they will ask. They will also begin to see that different tasks will require different prompts. Teachers could address this in different ways. They could use the Google Forms, a checklist or rubric specific to the various tasks, and/or daily verbal prompts. At this time I would share the Prompt Planning Sheet, see Appendix K to help teachers identify their prompting questions and to plan out when they will prompt. It is possible that these original ideas to prompt for planning will change over the course of the unit. These are the kinds of discussions they will have during their yearlong PLC meetings.

Referring back to number 3 of our checklist from Perry et al providing opportunities to evaluate their own and others work we will need to build these opportunities into our unit plans as well. I will describe how we had our students show their graphic organizers to each other. And we asked the students for a ‘Quick shout out - tell me something you thought was good about a neighbors’.

Why should the students want to do this? This is goal three, helping our students develop metacognitively. To help students understand the broader goals of the project, we gave them an exercise in thinking about how they learn. We asked the students to write down all of the intrusions both physically and mentally, what or who came in their space and in their own thoughts during a period of doing homework. We modeled a metacognitive journal entry for them, a sample will be provided in the Google Classroom and is in the Appendix. We would refer back to their journal entries as we tried to establish their own felt need to adopt these strategies.

But how can we help our students achieve each goal? How do we help those who have difficulty? The special education teachers who worked alongside the science teachers created more scaffolded graphic organizers for their students although gradually they could yield that back to them as some of them became more confident. If their special education teacher has joined them during the PD this will be when they will begin developing appropriate additional supports. In addition the checklist that the special education teachers is shared here and in the Google Classroom. Also the need to verbally prompt the students and will need to explicitly plan this into their unit.

For the next 4 summer PD days we cycle through the teachers designs, creation of prompts and embedding the. On the sixth day we will begin to address some other challenges teachers will face helping their students develop these skills.

On day 7, as we prepare for the ongoing school-year meeting we will enact objective three, practicing protocols. The norms for group meetings need to be established so they can get the most accomplished in their brief meetings and yet address each team's needs to develop their self-regulating program. The teachers will brainstorm here what they predict they will need and how they best want to approach their challenges. They have not done their program yet but I feel they will need to go through the actions of preparing for their best meetings during the year. I will provide a sample agenda distilled from planning experiences with 7th grade science teachers.

To help the teachers facilitate their PLC meetings I will introduce several protocols to them. The teachers will need to practice them during the PD so that individual PLCs can have something to base their decision whether or not to use them. As part of the teachers resources several protocols would be included such as the Charette Protocol from the National School Reform Faculty Harmony Education Center, see Appendix J. This particular protocol can be a request by a team or an individual when the team/individual is experiencing difficulty with the work, or a stopping point has been reached, or additional minds (thinkers new to the work) could help move it forward.

Year-long PLC Description

Teachers will meet monthly in their PLCs to support each other and brainstorm solutions to problems that will invariably arise in teaching these strategies. They will also have one more full day PD to revisit some techniques that may have been overlooked and to problem solve with the trainer. The PLCs will meet in two different middle school buildings, across three different grade schedules, and across four content areas, consequently I will not be able to be present for many of the PLC meetings. Preparing for that, the teachers will use the protocols they were able to practice in the summer. Towards the close of the year the teachers in the PLCs and I will come together to share group/partner experiences and build on these. *Things to Remember* Slides could be used to help teachers focus on the particular skill they are introducing and use the same language as their team mates.

The PLC discussions will allow teachers to address the challenges they face such as supporting diverse learners, effectively prompting strategy use, and consistency across the team, content or core. The PLCs will encounter questions like “how much do you scaffold and when do you let go?”

The effectiveness of a PLC is founded on the technique and skill sharing among the members. It will be critical that trust has been established between the team members ahead of time (Dana and Yendol-Hoppey, 2008). As challenges arise the teachers can share their own techniques for modeling the strategies, refer to examples shared in the PD Google Classroom, and reach out to me. Teachers may find the Tuning a Plan protocol helpful (National School Reform Faculty). Although the meetings will be monthly it is likely that the PLCs will meet much more frequently albeit more informally to address their alignments. As each team is focused on specific skills they want their students to adopt they will find they need to be consistent across team members so that there is a shared responsibility and consistent goals for their students.

It is anticipated that as there is success among the PLCs this will spread through the ‘grapevine’ and inspire others to follow suit. It will be important for Administration in both buildings including content Supervisors to support this effort by encouraging the meetings, celebrating their successes, and helping with the challenges. Consequently they will be invited to the summer PD so they have some knowledge of the techniques the teachers will use however it would be best for the PLCs to meet only with each other so that there is a free sharing of ideas and failures without concern for evaluation.

Evaluation

Evaluations will be used to assess the goals and objectives stated earlier. At the end of the 7 summer PD days a survey will be used to ask teachers their intent for self-regulation strategy instruction. Questions such as Which self-regulating strategies do you plan to introduce to your students? Why did you choose those strategies? When and how will you introduce these?

At the end of the year as part of the final PLC meetings teachers will reflect on student work they have brought with them using a protocol, Adapted from Atlas Learning from Student Work (National School Reform Faculty, 2000). I will also ask the teachers to evaluate their practice of teaching and prompting self-regulating strategies. Ideally some will identify goal five that time taken for the strategies instruction reduces the content learning time later. These reflections will be submitted by google form to help evaluate the effectiveness of this PD.

Conclusion

This PD should help teachers streamline the process of embedding self-regulation strategies throughout units. In addition, the 8th PD day and the PLC meetings will help support the teachers in the ever fluctuating response to our students' learning. The support of building and content administration will show the teachers that their effort is valued. It is my hope that teachers will find as Joseph (2010) says that front ending this kind of instruction for students reduces the amount of time students spend learning new content because they become more efficient at learning.

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Appendices

Appendix A: Prompts

Domain specific and general prompts used during HBS unit

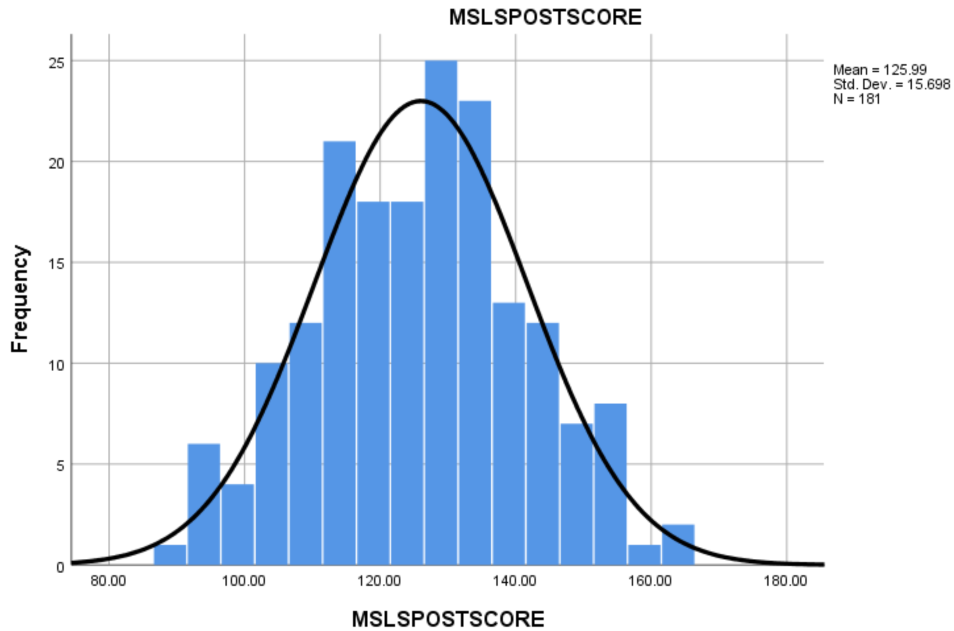
System/ Prompt	Question 1	2	3	4	5	6
P1	Now that you have your task - what is your plan for getting everything accomplished on time?					
	What have you planned to complete.....	Will you (did you) write out your plan using....?	What task have you been assigned?	If you are a Podcaster or Screencaster: Did you break the task into steps on separate days or plan to do it all on one day?	If you are a Writer: How did you plan to do this?	
P2 & P3	What is your plan for getting your questions answered, citations recorded and task completed on time?					
	What have you planned to complete.....	Will you (did you) write out your plan using....?				
P4	What is your plan for getting your questions answered, citations recorded and task completed on time? Explain your plan.					
P5	What is your plan for designing your investigation? Remember you will need to set up the lab report to include the testable question, your hypothesis, materials, identify variables, create a data table AND build your model.					
	Explain your plan for setting up the lab report	Explain your plan for building your model.				
M1	How are you doing? Are you keeping to your plan? Do you need to change something so that you get everything done on time? If so what?					
M2	How are you doing? Are you keeping to your plan? Do you need to change something so that you get everything done on time? If so what? Do you still have Graphic Organizer notes you have not finished?					
M3	Have you made a plan to complete your task? If No goto Q1 &Q5 If Yes goto Q3, Q4 & Q5	No plan yet. This is what I will do	I've made a plan. My plan for completing my task	Do you still need to finish your Graphic Organizer notes?	Plan to finish Graphic Organizer notes. This is what I will do to finish	

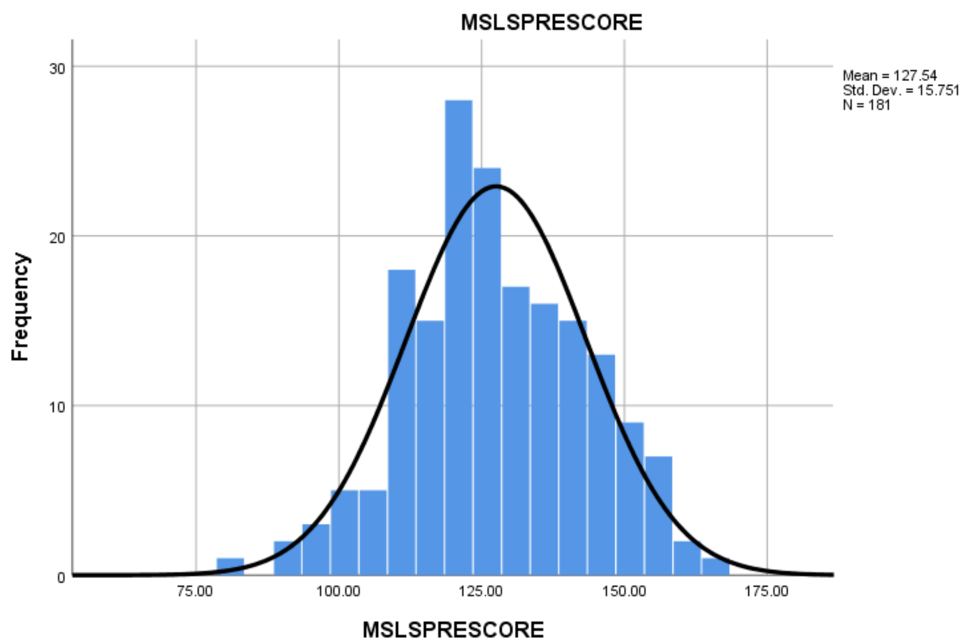
M4	Have you made a plan to complete your task?	No plan yet. This is what I will do	I've made a plan. My plan for completing my task	Do you still need to finish your Graphic Organizer notes?	Plan to finish Graphic Organizer notes. This is what I will do to finish	
M5	How is your lab design coming? Tell us what you have done and what you still need to do.					
E1	How did you do? Did you finish everything on time? Did you feel rushed or leave things to the last minute? Do you need to change something for the next system?					
	How was your graphic organizer?	Did you finish everything on time? If No goto Q3 and Q4 If Yes goto Q5	What didn't you finish on time?	What will you do differently?	Although you finished everything on time did you need to rush or were certain things last minute?	
E2 &E3	How did you do? Did you finish everything on time? Did you feel rushed or leave things to the last minute? Do you need to change something for the next system?					
	How was your graphic organizer?	Did you finish everything on time? If No goto Q3, Q4, & Q5 If Yes goto Q6	Not enough time. What didn't you finish on time?	Not enough time. Is your planning calendar (or Google Keep or Agenda) working for you? Do you need to use something else?	Not enough time. What will you do differently?	Yes...but. Although you finished everything on time did you need to rush or were certain things last minute or was it all good?
E4	How did you do? Did you finish everything on time? Did you feel rushed or leave things to the last minute? Do you need to change something for the next system?					
E4	Now that you have had some experience with creating and using your own graphic organizers tell us what you found helpful or not, and whether you would use graphic	Did you finish everything on time? If No goto Q3, Q4, Q5 If Yes goto Q6	Not enough time. What didn't you finish on time?	Not enough time. Is your planning calendar (or Google Keep or Agenda) working for you? Do you need to use something else?	Not enough time. What will you do differently?	Yes...but. Although you finished everything on time did you need to rush or were certain things last minute or was it all good?

	organizers in another class.					
E5	How did you do? Did you finish everything on time? Did you feel rushed or leave things to the last minute?					
E5	Did you finish everything on time? If No goto Q2 &Q3 If Yes goto Q4	What didn't you finish on time?	Did you use a planning calendar (or Google Keep or Agenda) to schedule or list the work you needed to do? Do you need to use something else?	Yes...but. Although you finished everything on time did you need to rush or were certain things last minute or was it all good?		

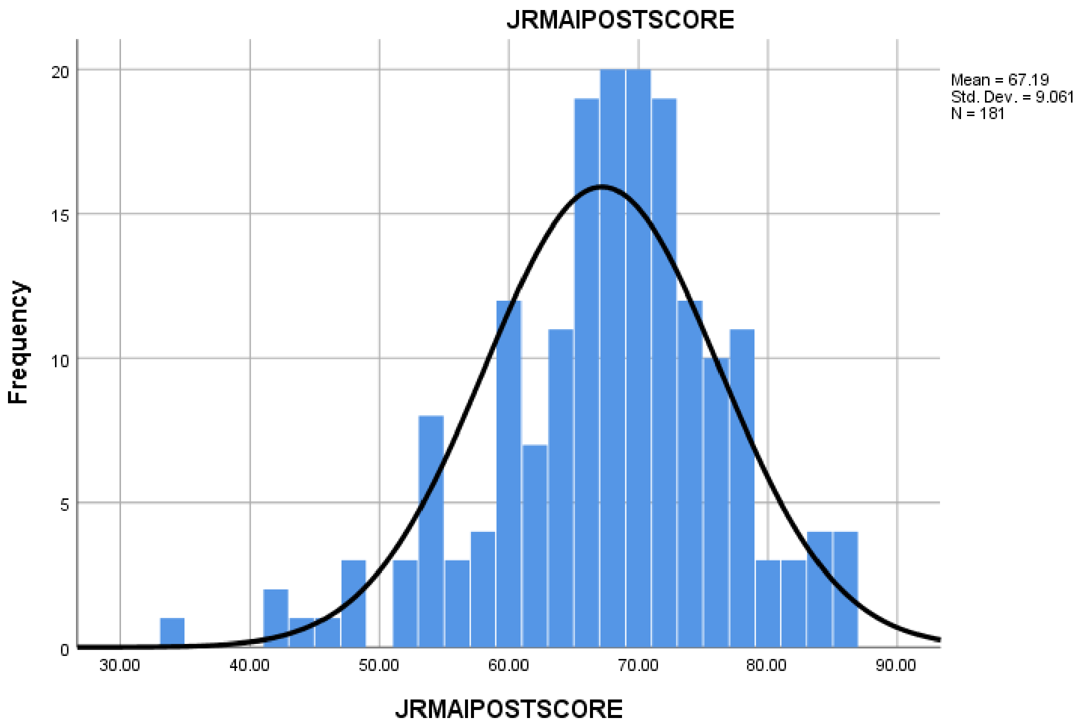
Appendix B: Frequency Distributions of Pre and Post scores on all measures

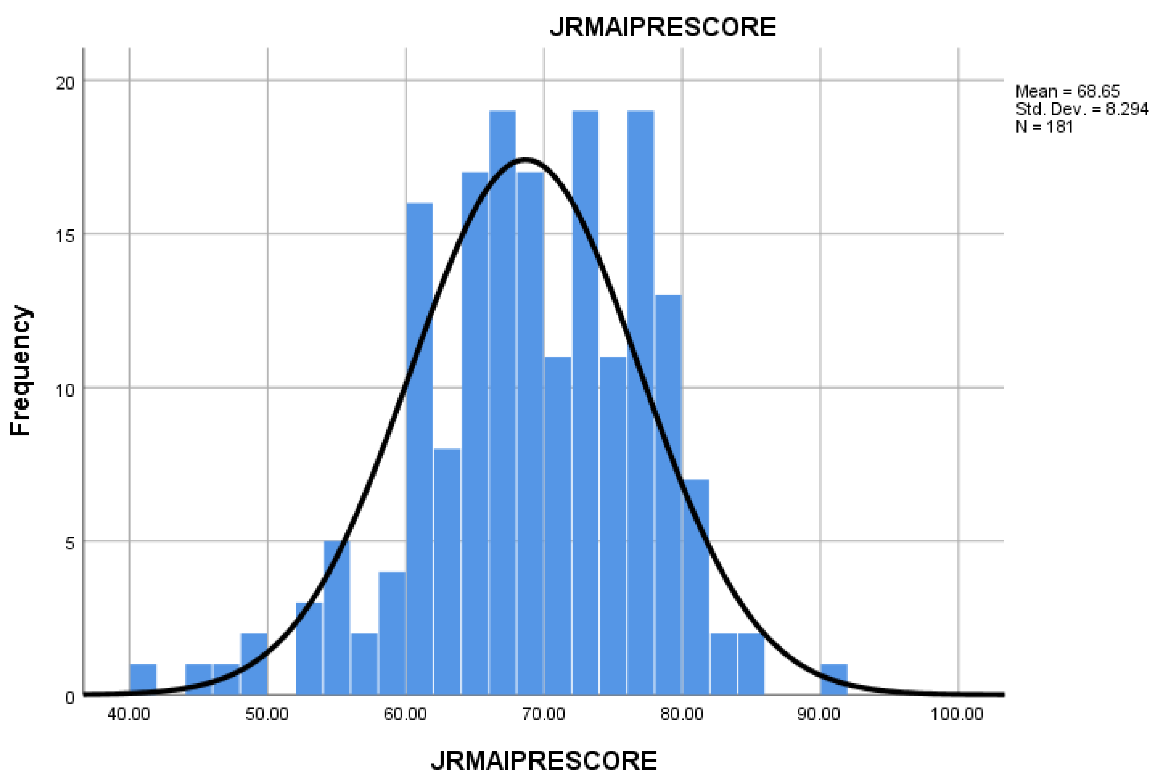
Middle School Learning Strategies Survey



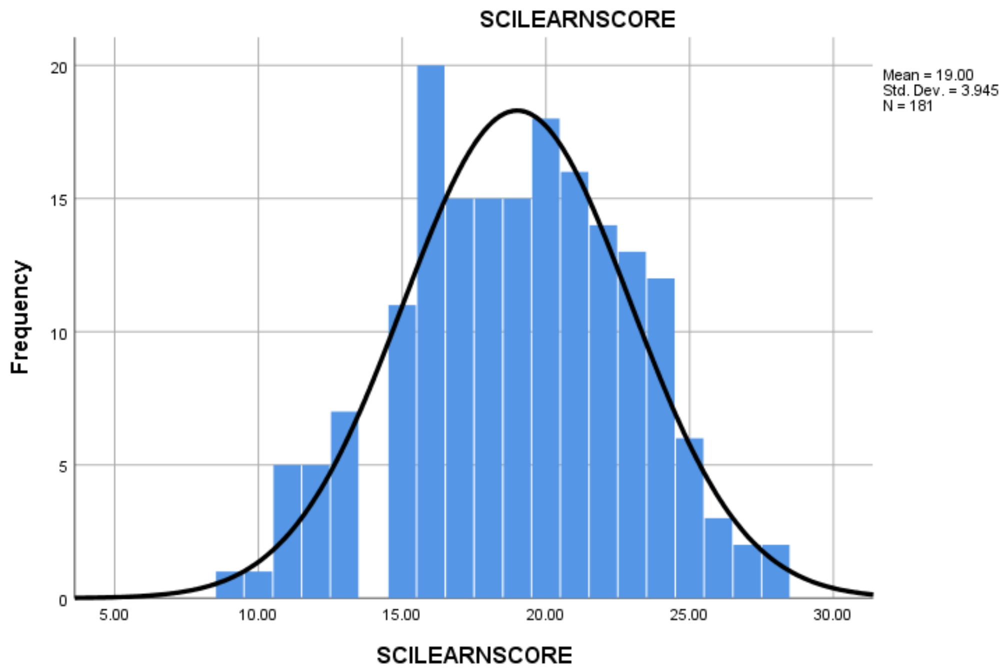


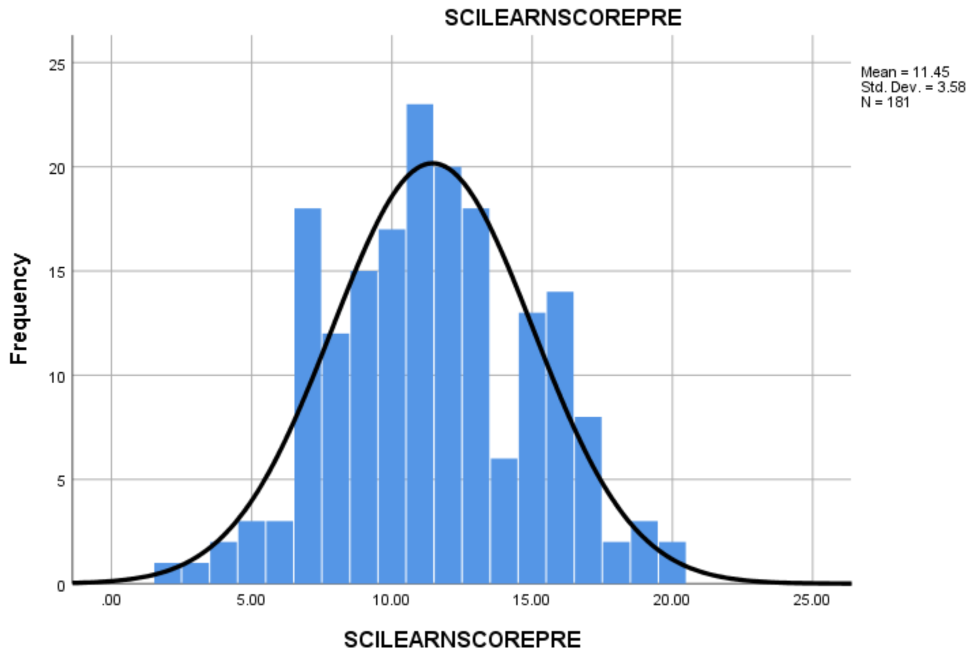
Normal distribution of the Junior Metacognitive Awareness Index





Normal distribution of the Science Assessment




SCILEARNSCOREPRE
Mean = 11.45
Std. Dev. = 3.58
N = 181
Frequency
0
5
10
15
20
25
.00
5.00
10.00
15.00
20.00
25.00
SCILEARNSCOREPRE

Appendix C: Residual Covariance and Standardized Residual Covariance Matrices

Matrices (Group number 1 - Default model)

Residual Covariances (Group number 1 - Default model)

	KNOWCOGPOST	REGCOGPOST	METASTRATSPOST	BEHSTRATSPOST	COGSTRATSPPOST	SCIREGPOST	SCIREASPOST	SCICLAIMPOST	SCIEVIPOST	SCIDESDATAPOST	SCIDESVARPOST	SCIKNOWPOST
KNOWCOGPOST	.000											
REGCOGPOST	.000	.000										
METASTRATSPOST	-.610	-.270	.000									
BEHSTRATSPOST	.343	1.026	-.074	.000								
COGSTRATSPPOST	.078	-.808	.286	-.131	.000							
SCIREGPOST	-.218	-.481	-.018	.124	-.274	.000						
SCIREASPOST	-.512	-.053	-.295	-.150	-1.527	.378	.000					
SCICLAIMPOST	.059	.045	-.301	-.528	-1.535	.300	.181	.000				
SCIEVIPOST	-.380	-.492	-.260	-.660	-.418	.217	.000	.064	.000			
SCIDESDATAPOST	.280	.221	.053	.427	-.022	.297	.032	-.056	.024	.000		
SCIDESVARPOST	.036	-.422	.384	.221	.438	.533	-.197	-.020	-.020	.040	.000	
SCIKNOWPOST	.386	-.147	.338	.411	.412	.278	-.005	-.033	-.033	-.033	.088	.000

Standardized Residual Covariances (Group number 1 - Default model)

	KNOWCOGPOST	REGCOGPOST	METASTRATSPOST	BEHSTRATSPOST	COGSTRATSPPOST	SCIREGPOST	SCIREASPOST	SCICLAIMPOST	SCIEVIPOST	SCIDESDATAPOST	SCIDESVARPOST	SCIKNOWPOST
KNOWCOGPOST	.000											
REGCOGPOST	.000	.000										
METASTRATSPOST	-.389	-.121	.000									
BEHSTRATSPOST	.200	.420	-.031	.000								
COGSTRATSPPOST	.033	-.240	.088	-.037	.000							
SCIREGPOST	-.440	-.683	-.031	.193	-.308	.000						
SCIREASPOST	-1.115	-.082	-.543	-.253	-1.860	2.142	.000					
SCICLAIMPOST	.142	.076	-.608	-.976	-2.050	1.865	1.192	.000				
SCIEVIPOST	-1.163	-1.060	-.674	-1.566	-.715	1.729	.000	.599	.000			
SCIDESDATAPOST	1.094	.607	.175	1.293	-.048	3.013	.348	-.655	.365	.000		
SCIDESVARPOST	.099	-.807	.884	.464	.665	3.771	-1.476	-.160	-.209	.536	.000	
SCIKNOWPOST	1.186	-.319	.882	.979	.708	2.225	-.043	-.309	-.402	-.505	.936	.000

Appendix D: Paired T Tests

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
REGCOGPOST - REGCOGPRE	-0.56354	5.20604	0.38696	-1.32710	0.20003	-1.456	180	0.147
KNOWCOGPOST - KNOWCOGPRE	-0.90055	4.06490	0.30214	-1.49675	-0.30436	-2.981	180	0.003
COGSTRATSPPOST - COGSTRATSPRE	-1.32044	9.91223	0.73677	-2.77426	0.13338	-1.792	180	0.075
BEHSTRATSPOST - BEHSTRATSPRE	-0.10497	7.00357	0.52057	-1.13218	0.92224	-0.202	180	0.840
METASTRATSPOST - METASTRATSPRE	-0.11602	6.38077	0.47428	-1.05188	0.81984	-0.245	180	0.807
SCIKNOWPOST - SCIKNOWPRE	3.33702	1.31749	0.09793	3.14378	3.53025	34.076	180	0.000
SCIREGPOST - SCIREGPRE	1.80387	2.30553	0.17137	1.46572	2.14202	10.526	180	0.000
SCICERPOST - SCICERPRE	2.33702	3.15739	0.23469	1.87392	2.80011	9.958	180	0.000
SCIDESIGNPOST - SCIDESIGNPRE	1.87569	2.14794	0.15965	1.56065	2.19073	11.748	180	0.000

Appendix E: Standardized Residual Covariances For all POST Indicators

	REG COG	KNOW COG	SCIDES DATA	SCIDES VAR	SCIREAS	SCIEVI	SCICLAIM	SCIKNOW	META STRATS	BEH STRATS	COG STRATS
REGCOG	.000										
KNOWCOG	.000	.000									
SCIDESDATA	.608	1.095	.000								
SCIDESVAR	-.805	.101	.546	.000							
SCIREAS	-.083	-1.116	.345	-1.475	.000						
SCIEVI	-1.060	-1.163	.364	-.208	-.005	.000					
SCICLAIM	.075	.141	-.660	-.161	1.178	.592	.000				
SCIKNOW	-.317	1.188	-.498	.948	-.044	-.402	-.312	.000			
METASTRATS	-.129	-.396	.217	.922	-.507	-.655	-.571	.924	.000		
BEHSTRATS	.416	.198	1.336	.503	-.216	-1.546	-.937	1.023	-.025	.000	
COGSTRATS	-.250	.024	-.010	.700	-1.827	-.698	-2.016	.747	.077	-.038	.000

Appendix F: Jr. MAI

Jr. MAI

Junior Metacognitive Awareness Index, Sperling, Howard, Miller, & Murphy, 2001

* Required

1. **We are interested in what learners do when they learn new things. Please read the following sentences and select the answer that relates to you and the way you are when you are doing in school work or at home work. Please answer as honestly as possible. ***

Check all that apply.

	Never	Seldom	Sometimes	Often	Always
I know when I understand something.	☐	☐	☐	☐	☐
I can make myself learn when I need to.	☐	☐	☐	☐	☐
I try to use ways of studying that have worked for me before.	☐	☐	☐	☐	☐
I know what the teacher expects me to learn.	☐	☐	☐	☐	☐
I learn best when i already know something about the topic.	☐	☐	☐	☐	☐
I draw pictures or diagrams to help me understand while learning.	☐	☐	☐	☐	☐
When I am done with my schoolwork, I ask myself if I learned what I wanted to learn.	☐	☐	☐	☐	☐
I think of several ways to solve a problem and then choose the best one.	☐	☐	☐	☐	☐
I think about what I need to learn before I start working.	☐	☐	☐	☐	☐
I ask myself how well I am doing while I am learning something new.	☐	☐	☐	☐	☐
I really pay attention to important information.	☐	☐	☐	☐	☐
I learn more when I am interested in the topic.	☐	☐	☐	☐	☐
I use my learning strengths to make up for my weaknesses.	☐	☐	☐	☐	☐
I use different learning strategies depending on the task.	☐	☐	☐	☐	☐
I occasionally check to make sure I'll get my work done on time.	☐	☐	☐	☐	☐
I sometimes use learning strategies without thinking.	☐	☐	☐	☐	☐
I ask myself if there was an easier way to do things after I finish a task.	☐	☐	☐	☐	☐
I decide what I need to get done before I start a task.	☐	☐	☐	☐	☐

Appendix G: MSLS

Middle School Learning Strategies 2017 Liu (2009)

Using 2008 Field Trial for question framing, however included only reliable questions from 2009 Journal article

Your email address (**jeanne.weinmann@wwprsd.org**) will be recorded when you submit this form. Not **jeanne.weinmann**? Sign out

* Required

1. **When learning something new in class, I.....** *

Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost always
take notes in class and read them over.	⬭	⬭	⬭	⬭
use headings in my notes so I can find information when I look through them again	⬭	⬭	⬭	⬭
ask questions in class	⬭	⬭	⬭	⬭
find that taking notes in class isn't helpful	⬭	⬭	⬭	⬭
have strategies I use when taking notes so that I can understand them when I look at them again.	⬭	⬭	⬭	⬭

2. **When learning something new, I....** *

Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost always
use a textbook or website to add to my notes.	⬭	⬭	⬭	⬭
use graphic organizers.	⬭	⬭	⬭	⬭
relate new things to things I already know.	⬭	⬭	⬭	⬭
avoid asking for help even when Ineed to.	⬭	⬭	⬭	⬭
read over my class notes and put the teacher's lesson into my own words.	⬭	⬭	⬭	⬭
use the KWL method (what I already Know, what I Want to know, what I have Learned).	⬭	⬭	⬭	⬭
like certain words, I keep repeating them.	⬭	⬭	⬭	⬭
offer help to classmates.	⬭	⬭	⬭	⬭

3. **When you are reading or writing something new I ... ***
Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost always
pre-write by drawing a diagram.	⬭	⬭	⬭	⬭
pre-write by making an outline.	⬭	⬭	⬭	⬭
outline what I read.	⬭	⬭	⬭	⬭
put things I read into my own words.	⬭	⬭	⬭	⬭

4. **When doing homework I ... ***
Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost Always
adjust music or TV to concentrate on homework.	⬭	⬭	⬭	⬭
do homework in a place hard to concentrate.	⬭	⬭	⬭	⬭
only do as much work as I have to.	⬭	⬭	⬭	⬭
think of ways to make homework more interesting so I can get it done.	⬭	⬭	⬭	⬭
ask a family member for help with schoolwork if I need it.	⬭	⬭	⬭	⬭
ask friends for help with schoolwork if I need it.	⬭	⬭	⬭	⬭
work harder on free time activities than on homework.	⬭	⬭	⬭	⬭
wait until the last minute to start doing it.	⬭	⬭	⬭	⬭
copy someone else's work if I don't understand an assignment.	⬭	⬭	⬭	⬭
check to see whether I understand the material.	⬭	⬭	⬭	⬭
figure out what I can already do.	⬭	⬭	⬭	⬭
ask my teacher for help if I need it.	⬭	⬭	⬭	⬭
plan the steps before starting an assignment.	⬭	⬭	⬭	⬭
set things up so I can concentrate when I do my homework.	⬭	⬭	⬭	⬭
draw a diagram when I'm working on a math problem, to make it clearer.	⬭	⬭	⬭	⬭
complete an assignment without checking for mistakes.	⬭	⬭	⬭	⬭
summarize what I have learned after class.	⬭	⬭	⬭	⬭
check the teacher's comments on an assignment.	⬭	⬭	⬭	⬭
know which parts of a classroom lesson to understand.	⬭	⬭	⬭	⬭

5. **Organization** *

Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost Always
I use a planner, Google Keep, Google Classroom or check my gmail.	⬭	⬭	⬭	⬭
My school papers are disorganized.	⬭	⬭	⬭	⬭

6. **When studying for a test, I...** *

Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost Always
set words to music or a special rhythm to help me learn them.	⬭	⬭	⬭	⬭
can't seem to make sense of my notes when I try to study from them.	⬭	⬭	⬭	⬭
try to figure out which parts of the material to study most.	⬭	⬭	⬭	⬭
read study guides to prepare.	⬭	⬭	⬭	⬭
ignore the teacher's corrections on my homework.	⬭	⬭	⬭	⬭

7. **When you are taking a test I....** *

Mark only one oval per row.

	Hardly ever	Sometimes	Often	Almost Always
start to answer questions without reading the directions.	⬭	⬭	⬭	⬭
try to pace myself so i won't run out of time.	⬭	⬭	⬭	⬭
stop working on a test if I finish a test early.	⬭	⬭	⬭	⬭
complete a test without checking for mistakes.	⬭	⬭	⬭	⬭

Appendix H: Human Body Systems Pre/Post Assessment

Human Body Systems Pre Assessment

Name: ________________________
Period: _____ Team: ____ Date: ___

Part One

Directions: Please read each question carefully and answer using detailed responses and 7th grade vocabulary. The six systems are Digestive, Circulatory, Respiratory, Excretory, Skeletal, and Muscular.

1. **Choose two body systems and explain how each system helps the other system.**

   a. __________________system helps the_________________system

   ____

   ____

   b. __________________system helps the_________________system

   ____

   ____

2. **Choose two more body systems and explain how each system helps the other system.**

   a. __________________system helps the_________________system

   ____

   ____

   b. __________________system helps the_________________system

   ____

   ____

3. How would you set up an organizer to keep track of the information you will research about the Human Body Systems? Remember the six systems are the Digestive, Circulatory, Respiratory, Excretory, Skeletal, and Muscular systems.

These are the questions you will research:

What are the organs of the system and what do they look like?
What is the structure of those organs?
What are the functions of those organs?
How do all the organs work together with each other in the system?
How does this system support each of the other 5 we study. For example: If you are researching the Skeletal System; how does it support the Muscular, the Digestive, the Circulatory, the Respiratory, and the Excretory systems?
What sources did you use?

4. **Plan out how you will gather this information. Check the calendar to see what you are doing in class for 7 days**:

These are the questions you will research:

What are the organs of the system and what do they look like?
What is the structure of those organs?
What are the functions of those organs?
How do all the organs work together with each other in the system?
How does this system support each of the other 5 we study. For example: If you are researching the Skeletal System; how does it support the Muscular, the Digestive, the Circulatory, the Respiratory, and the Excretory systems?
What sources did you use?

Monday	Tuesday	Wednesday	Thursday	Friday
Science teacher introduces the system.	Science teacher continues to introduce the system	Working independently in the classroom using texts and other sources	Conducting a lab investigation with your group	Conducting a lab investigation with your group
Monday	Tuesday	Wednesday	Thursday	Friday
Working independently in the library	Working independently in the classroom using texts and other sources	The science teacher introduces a new system and the cycle begins again.		

5. **Read this information and identify the most important information to help you understand the nervous system.**

- ❑ **Underline** new vocabulary
- ❑ **Highlight** the main idea and give it a title.
- ❑ **Highlight** sub topics and give them title.
- ❑ **Summarize** in 1 or 2 sentences.

You have been wrestling for over an hour with a math problem that seems to be unsolvable. Then suddenly, while you are daydreaming about your summer vacation, the solution finally comes to you. This example is one of the many remarkable and often mysterious ways your nervous system functions. The nervous system controls all of the activities of the body. It is made up of the brain, spinal cord, and nerves that are found throughout the body.

The nervous system also allows you to react to stimuli (singular: stimulus). A stimulus is a change in the environment. At their simplest, these reactions are involuntary, or automatic. If an insect or other object zooms toward your eye, you blink without thinking. Your body reacts quickly and automatically to avoid damage to the eye. Such a response, or action caused by the stimulus, is controlled by your nervous system.

Although some response to stimuli are involuntary, such as blinking your eye, many responses of the nervous system are far more complex. For example, leaving a football game because it begins to rain is a voluntary reaction. It is a conscious choice that involves the feelings of the moment, the memory of what happened the last time you stayed out in the rain, and the ability to reason.

Attempts at understanding the human nervous system usually begin by dividing it into two parts. One part of the human nervous system is the central nervous system. It is made up of the brain and the spinal cord. The central nervous system is the control center of the body. All information about what is happening in the outside world or within the body itself is brought here.

The other part of the human nervous system branches out from the central nervous system. i tis a network of nerves and sense organs, which makes up the peripheral nervous system. Peripheral means “outer”. Included in the peripheral nervous system are all the nerves that connect the central nervous system to other parts of the body. A division of the peripheral nervous system controls all involuntary body processes, such as heartbeat and peristalsis. This division is known as the autonomic nervous system.

Summarize in 1 or 2 sentences.

____

____

____

____

Human Body Systems Pre Assessment

Name:___________________________
Period: _____ Team: ____ Date: _____

Part Two

Read the following pieces of evidence in order to answer Question #6.

6. Given these pieces of evidence can you determine whether eating right before swimming could be dangerous in terms of your ability to raise your heart rate and breathe in oxygen? Consider the six systems we study and their relationship to each other.

Evidence 1: *The effect of exercise training on oxygen consumption during digestion and swimming in catfish*

Catfish were trained for 21 days by making them swim at 60% swimming speed for 50 min and then full out for 10 minutes as if chasing prey. This 21 days of forced swimming had no effect on how much oxygen the fish could consume whether resting or moving. The ability to take in more oxygen is an indicator of better athletic performance. The trained fish could swim at faster speeds and consume more oxygen when fasting. After eating, those fish did not have an increase in swimming speed nor did they take in more oxygen. Researchers said this means that even the fish who did not go through the training could both digest and move at the same time and still get the necessary oxygen.The training seemed to be the reason for faster swimming and faster oxygen intake when the fish was not eating however this was not the effect after eating.

Fish (trained and non-trained)

Oxygen consumption at various speeds

	Oxygen Consumed			
	Non trained fish		Trained fish	
Speed (cm/s)	After eating	fasting fish	After eating	fasting fish
0	350	200	350	200
32	700	510	760	620
40	910	710	900	720
48	1100	840	1100	900
56	1400	1200	1490	1200

What does this evidence tell you about heart rate and oxygen consumption? Include evidence to support your explanation about whether eating right before swimming could have a dangerous effect on your heart rate or oxygen consumption.

____

____

____

____

____

Li, X., Cao, Z., Peng, J., & Fu, S. (2010). The effect of exercise training on the metabolic interaction between digestion and locomotion in juvenile darkbarbel catfish (peltebagrus vachelli). *Comparative Biochemistry and Physiology, Part A, 156*(1), 67-73. doi:10.1016/j.cbpa.2009.12.022

Evidence 2: *Effect of strenuous exercise on digestion and absorption of protein in young males*

The researchers studied 24 young males. Specifically they studied the effect of strenuous exercise, such as cycling and weight lifting, on protein digestion and absorption in the small intestine. Exercise can cause small injuries to the intestine and result in some loss of function. But the effects of this loss of function on digestion and absorption of nutrients are not clear. The study found that immediately after exercise the rate of protein digestion and protein absorption was not as good compared to digestion/absorption rate after resting.

Amount of phenylalanine in blood indicates protein digestion and absorption rates. A higher amount means there is more digestion and absorption.

Protein digestion and absorption after eating

	Amount of phenylalanine in blood (%)	
Time after eating (min)	Rested	Exercised
15	7.9	7.0
30	8.5	6.5
45	7.8	6.2
60	7.7	6.0
75	6.8	6.1
90	7.0	6.1
105	6.8	6.0
120	6.2	6.2

What does this evidence tell you about heart rate and oxygen consumption? Include evidence to support your explanation about whether eating right before swimming could have a dangerous effect on your heart rate or oxygen consumption.

Kim van Wijck, Bart Pennings, Annemarie A. van Bijnen, Joan M. G. Senden, Wim A. Buurman, Cornelis H. C. Dejong, . . . Kaatje Lenaerts. (2013). Dietary protein digestion and absorption are impaired during acute postexercise recovery in young men. *American Journal of Physiology - Regulatory, Integrative and Comparative Physiology, 304*(5), 356-361. doi:10.1152/ajpregu.00294.2012

Evidence 3: *The effect of eating on heart rate, blood flow and oxygen consumption in Rainbow Trout*

This study measured the effect on oxygen intake and heart rate after eating for Rainbow trout. Four hours after eating the heart rate and oxygen consumption increased. The heart rate was highest 14 hours after eating at 110% above normal. and oxygen consumption was highest after 27 hours at 96% above normal. For as long as 40 hours after eating, the oxygen consumption stayed high above normal. Most of the increase in oxygen consumption when eating is due to the ongoing digestion of proteins and absorption of nutrients.

Oxygen consumption, heart rate, and Blood flow after eating In Rainbow Trout

Time After Eating (Hour)	Oxygen Consumption (mg/kg/hr)	Heart Rate (beats/min)	Blood Flow (ml/min/kg)
10	70	52	8.0
20	70	50	6.2
30	68	36	6.2
40	64	36	6.0
50	64	34	5.8
60	63	28	5.8
70	54	36	5.6
80	58	34	5.8

What does this evidence tell you about heart rate and oxygen consumption? Include evidence to support your explanation about whether eating right before swimming could have a dangerous effect on your heart rate or oxygen consumption.

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Eliason, E. J., Higgs, D. A., & Farrell, A. P. (2008). Postprandial gastrointestinal blood flow, oxygen consumption and heart rate in rainbow trout (oncorhynchus mykiss). *Comparative Biochemistry and Physiology, Part A, 149*(4), 380-388. doi:10.1016/j.cbpa.2008.01.033

Human Body Systems Pre Assessment

Name: ___________________________
Period: _____ Team: ____ Date: _____

Part Three

7. Yesterday you were presented with 3 research articles to help you answer whether eating right before swimming could be dangerous. What problems did you find while trying to determine whether eating immediately before swimming could be dangerous?

- ____
- ____
- ____

Design an investigation to help you gather the additional data you may need.

Appendix I: Order of Data Collection

Task	Date of 2017-2018 School Year										
	9/17	January 2018				February 2018		March 2018			6/18
		1/3	1/9	1/23	1/23	2/9-2/16	2/23	3/2	3/7	3/23	
Jr.MAI and MSLS pre/post/end of study assessments											
HBS pre/post-assessments											
HBS unit											
Graphic Organizer and Metacognition instruction											
Student designed investigations.											
Prompts for use of SR strategies, and science unit specific											
Teacher interviews											
Subsequent Units											
Fading Prompts for metacognition, use of SR strategies, and science unit specific											

Appendix J: Protocols

National School Reform Faculty Harmony Education Center
www.nsrfharmony.org
Original written by Kathy Juarez, Piner High School, Santa Rosa, California
Revised by Gene Thompson-Grove, January 2003, NSRF.
Revised by Kim Feicke, October 2007, NSRF
Revised by Jeanne Weinmann April 2016 additions italicized.

Charette Teacher Work Protocol

The following list of steps attempts to formalize the process for others interested in using it.

1. A team or an individual requests a charrette when:
   a. the team/individual is experiencing difficulty with the work,
   b. a stopping point has been reached, or
   c. additional minds (thinkers new to the work) could help move it forward.

2. A group, ranging in size from three to six people, is formed to look at the work. A moderator/facilitator is designated from the newly formed group. It is the moderator's job to observe the charrette, record information that is being created, ask questions along the way, and occasionally summarize the discussion.

3. The requesting team/individual presents its "work in progress" while the group listens. (There are no strict time limits, but this usually takes five or ten minutes.) Sometimes, the invited group needs to ask two or three clarifying questions before moving on to Step 4.

   A. *Summarize student evaluation*
   B. *Summarize prior teacher evaluation*

4. The requesting team/individual states what it needs or wants from the charrette, thereby accepting responsibility for focusing the discussion. This focus is usually made in the form of a specific request, but it can be as generic as "How can we make this better?" or "What is our next step?"

Rounds:

   A. *Initial Science Rubric – What to keep/lose*
   B. *IRLA Rubric – What to keep*
   C. ***What do the students need to see - have we written it so it guides them? Will they understand what we have written?***
   D. *What else do we need?*

5. The invited group then discusses while the requesting team/individual listens and takes notes. There are no hard and fast rules here.-The emphasis is on improving the work, which now

belongs to the entire group. The atmosphere is one of “we’re in this together,” and our single purpose is “to make a good thing even better.”

6. When the requesting team/individual knows it has gotten what it needs from the invited group, they stop the process, briefly summarize what was gained, thank the participants and moderator and return to the “drawing board.

7. Debrief the process as a group.

Appendix K: Self Regulating Strategies

SR Strategies from the Middle School Learning Strategies Questionnaire

Some strategies/items from the MSLS have been deleted from this list. One behavioral was very similar to another behavioral[2], One Cognitive was nearly the same as a Metacognitive[1]. These were re-written as strategies.

Cognitive	Metacognitive	Behavioral
Pre-write by drawing a diagram	Summarize what i have learned after class	Take notes in class[2] and read them over later
Pre-write by making an outline	Try to figure how new things I learn relate to things I already know	I have strategies like using headings/Cornell method, etc I use when taking notes so that I can understand them when I look at them again
Use textbook to add to class notes	HW: I check to see if I understand the material	I look over my answers if I finish a test early
Outline what I read	Use the KWL method	Set things up so I can concentrate when I do my HW
After reading I put it in my own words	Before I start an assignment, I figure out what I can already do	If my HW is boring I think of ways to make it more interesting so I can get it done
Math: draw a diagram to make a problem clearer	When I study I figure out which parts of the material I need to study most.	I try to pace myself when taking a test so that I won't run out of time
Reading my class notes later I put them into my own words	I know which parts of a classroom lesson I understand and which parts I don't	I ask my teacher or friends or family for help with my school work when I need it
When I want to learn certain words I keep repeating them	I check the teacher's comments when I get back an assignment or test[1]	I explain what I understand to others
Organize my school papers	When completing an assignment I check to see if I've made any mistakes on it	Work with a study buddy
I set words to music or a special rhythm to help me learn them	When I do an assignment if I am confused about what to do first I ask questions of the teacher	Ask questions in class if I don't understand something
I use graphic organizers for my schoolwork		Read directions before I start answering questions on a test

		I don't wait until the last minute to start assignments

Appendix L: Introducing Metacognition to Students

Appendix M: Metacognition Journal Entry

Metacognition Passage altered from *Metacognition in Young Children*
Shirley Larkin, 2010

While working on difficult math problems, studying for a test, writing an essay….
I may think "I will stop to answer that text now", a normal thought, but if instead of immediately acting on that thought, I stop and take a little time to reflect, I might think about why I had that thought in the first place. Am I waiting for a text from a friend to help me with my work? Or is it likely the text has nothing to do with work? Perhaps the reason for my thought was not related to the text but to feeling tired or bored? Or maybe I am feeling stuck or even in need of a reward for having done some work today? From any one of these thoughts I could follow where my own thinking leads. I may become interested in planning with a friend what I will do later, or getting something to eat or drink, or looking up something on the computer that will help me do my work, or contacting a friend with a question about the work.

On the other hand I might act on this thought and make a conscious decision to stop and respond to the text. Or maybe I'll silence my phone and put it in my backpack so I don't hear the vibration and return to my work. Having considered other thoughts maybe I will look up something for reference on youtube or at school, or maybe take a walk to the kitchen, or play some video games. I might choose to ignore all these.

Becoming aware of all the different thoughts which might lie behind my initial thought means that I have shifted from the ordinary level of thinking to thinking about the thought itself; why I had that thought and how it was linked to how I am feeling right now (anxious, bored, confused, hungry).

At the same time, while considering this, I have been partially monitoring that initial thought and occasionally checking back in to see if I still really want to stop and answer the text or if the moment has passed. From the initial fairly ordinary thought, I have been on a thinking journey to make a conscious decision about what to do about the thought. What responding to the text would do for me and about whether I want to stop what I am doing to text or to wait a little while longer and then have a proper break.

Appendix N: Flex Checklist from SPED teachers

Weekly Checklist for FLEX and HOMEWORK: Executive Functioning Goals

Set up on Mondays. When first introduced, taught it/how to use it, teachers would fill in and student would share what assignment was. In the 1st column, ALL assignments for class (would need sped teachers assistance for classes that haven't had yet for homework). The student chooses which assignments they should work on in flex. In the 2nd column, assignments that still need to be completed for homework. These assignments are also transferred to agenda. In beginning of the year, teachers wrote the assignments in and initialed it. Parent was responsible to initial as well. By middle of year, student was writing, teacher would initial once agenda was written in.

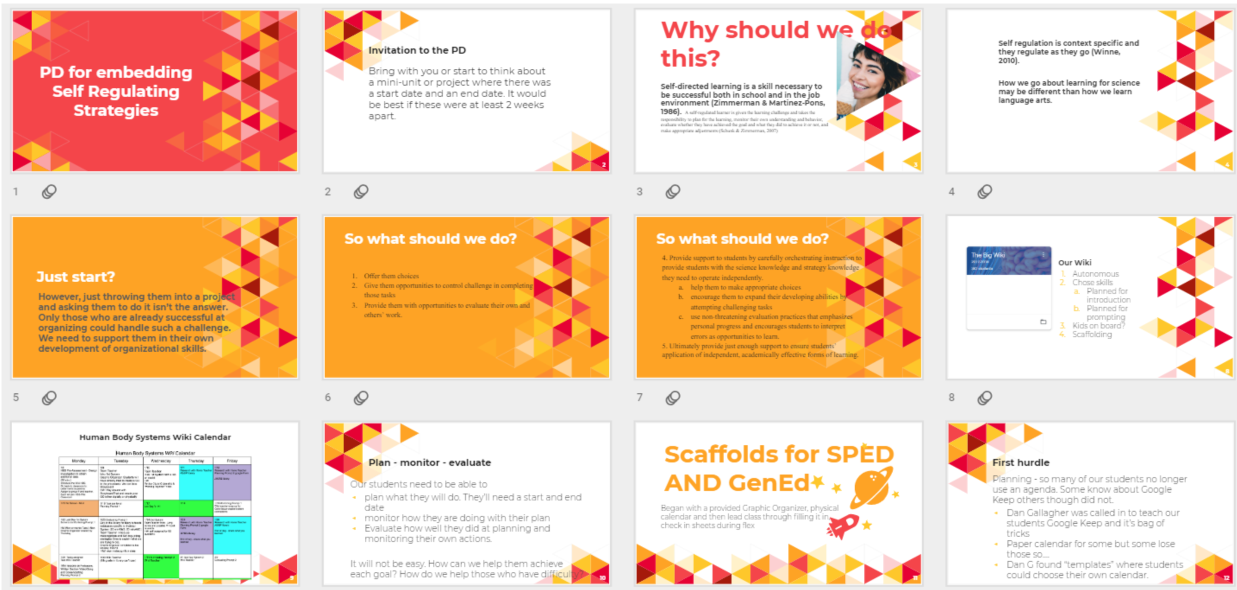
Date:	Assignments to be completed:	Assignments to complete for homework: **(should match agenda)** **homework needs to be signed off by teacher in agenda and in HW folder*
	Math: **Science**: **Social Studies**: **Spanish**: **IRLA**:	**Math**: **Science**: **Social Studies**: **Spanish**: **IRLA**:
	Math: **Science**: **Social Studies**: **Spanish**: **IRLA**:	**Math**: **Science**: **Social Studies**: **Spanish**: **IRLA**:
	Math: **Science**: **Social Studies**: **Spanish**: **IRLA**:	**Math**: **Science**: **Social Studies**: **Spanish**: **IRLA**:
	Math: **Science**: **Social Studies**: **Spanish**: **IRLA**:	**Math**: **Science**: **Social Studies**: **Spanish**: **IRLA**:
	Math: **Science**: **Social Studies**: **Spanish**: **IRLA**:	**Math**: **Science**: **Social Studies**: **Spanish**: **IRLA**:

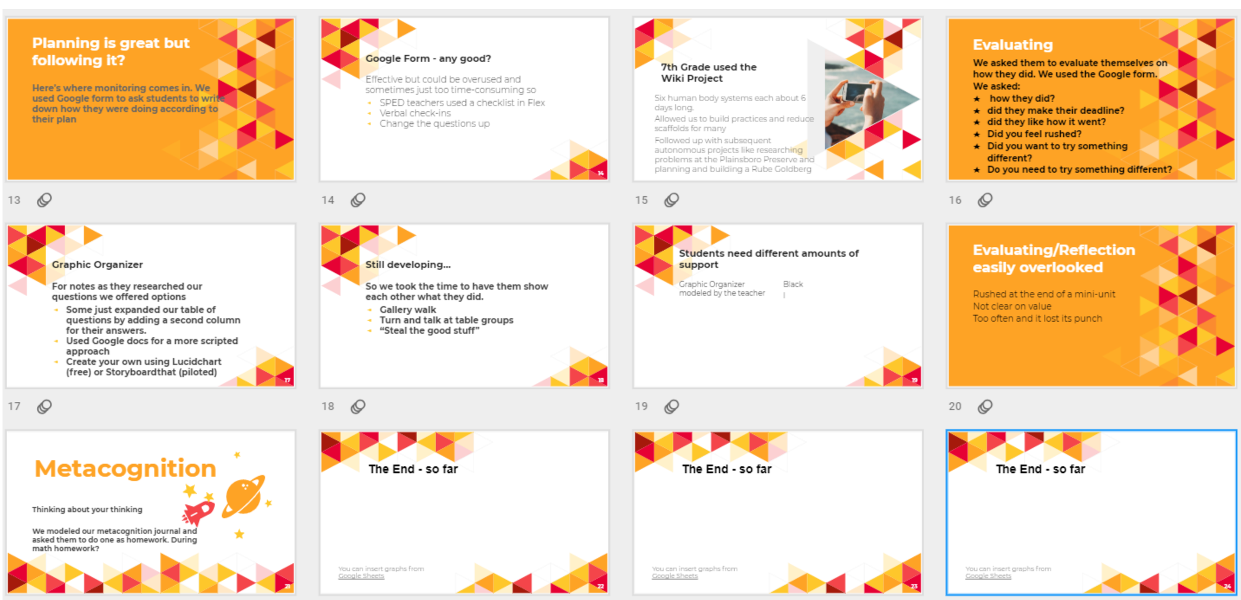
Appendix O: Training Sessions

Training Sessions 1-7			
Day Topic	Format	Activity	Goals/Objectives Addressed
Day 1 **Norms** **Introductions** **Self-Regulation and Metacognition** **Why should we do this?** **Many SR skills - choose** **Embedding into unit or project**	Lecture Discussion Video Examples of student work pre and post Teacher MAI survey List of SR skills	1. Introductions 2. Access prior knowledge 3. Intro Self-Regulation and Metacognition 4. Slides/Google Classroom intro to Prompts 5. MAI 6. Choose 4-6 skills 7. Model Calendar	Goals 1, 2, &3
Day 2 **How do you get your students to plan? Write your strategy on the papers around the room.**	Lecture Discussion Gallery Walk of techniques Guidelines checklist Modeling Review student work Design instruction Embedding Strategies	1. Slides intro of Guidelines and copy in checklist format 2. Share techniques currently used 3. Prompts in Google Classroom 4. Intro student skills assessments. JrMAI and MSLS	**Goals 3 & 4** **Objectives 1 & 2**
Days 3, 4 and 5 **How do you get your students to monitor? Evaluate?**	Lecture Discussion Gallery Walk of techniques Design instruction for students Embedding Strategies	1. Prompts in Google Classroom for Monitor and Evaluate and other skills 2. Introduce the graphic organizer with student examples 3. Review Guidelines checklist for fidelity 4. Slides to share techniques. Google Keep, Google Add-ons Template Gallery (screencast How-to), Paper calendars	**Goals 3 & 4**
Day 6 **Why should students do this? How can give extra help?**	Lecture Discussion Sharing via Padlet.com Design instruction for students Embedding Strategies	1. Slides to share techniques for SPED scaffolds 2. Metacognitive Journal	**Goal 3 &4** **Objectives 1 & 2**
Day 7 **Preparation for PLCs**	Lecture Discussion Practicing norm setting and Protocols Agenda	1. Explanation of norm setting 2. Vignettes to prompt use of protocols	**Objective 3**

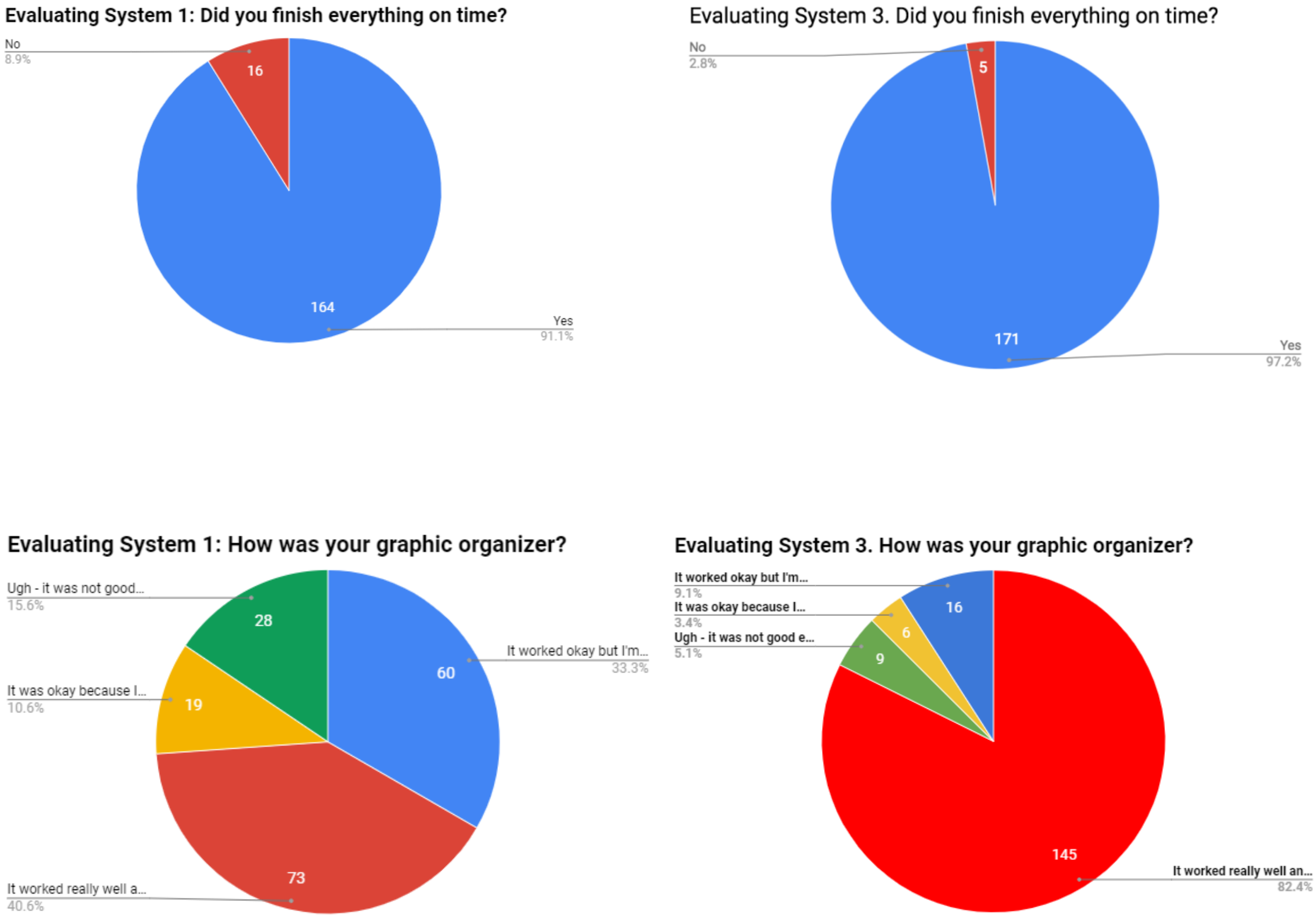
	Things to Remember slides		
Day 8 - January **Problems teachers have faced**	Lecture Discussion Review materials available for those problems Protocol *Looking at Student Work*	1. Discuss problems shared from survey of teachers 2. Teachers to bring in and evaluate student work	**Goals 4 & 5** **Objective 2**

Appendix P: Google Slides for Training





Appendix Q: Planning Data and Student Graphic organizers for comparison



Appendix R: Graphic Organizer Samples

Comparison for Student Betty

Despite including all five systems in the question she did not use them and did not answer that part of the question

Original supplied by teachers

Graphic Organizer - Digestive System

Given these questions - what can you do to create your own graphic organizer?

1. What are the organs of the system and what do they look like?
2. How do all the organs work with each other in the system? For example: Digestive: What is mechanical digestion and where in the system does it occur? What is chemical digestion and where in the system does it occur?
3. How does this system support each of the other 5 we study. For example: If you are researching the Skeletal System; how does it support the Muscular, the Digestive, the Circulatory, the Respiratory, and the Excretory systems?
4.What sources did you use?
5. An organ is made up of a tissue. Tissue is made up of cells. Pick 2 organs in this system and explain how the structure of the cell and tissue relate to the function of those organs.
6. Give an example of how this system helps another system at a cellular or tissue level.

How do all organs work with each other? A What is mechanical digestion and where in the system does it occur? B. What is chemical digestion and where in the system does it occur?	They send the food to each other and tell each other what to do with it. A. Mechanical digestion is the physical action of breaking food into smaller parts. Mechanical digestion occurs in the molar. B. Chemical digestion is the digestion of foods by by enzymes. Chemical digestion occurs in the salivary glands.
How does this system support each of the other 5 we study?	This system supports the other system because now the other systems don't have to break down foods because the digestive system already does that.
What sources did you use?	https://docs.google.com/document/d/1NypEJeR7W-PkC2ZleqwGdoD06DxY6QJSDMfZ7Z0dl_k/edit

EXTENSION

An organ is made up of a tissue. Tissue is made up of cells. Pick 2 organs in this system and explain how the structure of the cell and tissue relate to the function of those organs.	
Give an example of how this system helps	

Notice how she broke down the questions into sections within the graphic organizer on this system. She did that for each of the questions.

Muscular System

1.
 a. List the three main types of muscles.
 b. Describe their **structures**.
 c. What is the **purpose** of each type of muscle?

2.
 a. What is the **difference** between a **voluntary** muscle and an **involuntary** muscle?
 b. Which muscle types are voluntary? Which muscle types are involuntary? **Give at least one example of each.**

3. How does this system (muscular) **support** each of the other 5 we study? BE DETAILED.
 a. Digestive
 b. Skeletal
 c. Circulatory
 d. Respiratory
 e. Excretory

4. You learned the **role of mitochondria in cellular respiration** (Forget? Check your **notes!**). In the table below, look at the **number of mitochondria in each type of muscle**. Based on the table and your notes, what **conclusion** can you draw about the number of mitochondria?

Type of Muscle	# of mitochondria in each cell
Cardiac	5000
Skeletal	200
Smooth	50

5. What sources did you use? If you are using a book be sure to record the ISBN number.
*Requirement: **at least 3 sources**. You may use databases (1 book mandatory), as well as the approved sites below:*
Kidshealth.org
innerbody.com
Biology4kids.com
YouTube Crash Course

1A. List the three main types of muscles. 1B. Describe their structures. 1C. What is the purpose of each type of muscle?	1A. Cardiac, Skeletal and Smooth 1B. The cardiac muscle is an involuntary, striated muscle that is found in the walls of the heart. Skeletal muscle has a typically striped appearance. The muscle fibers are long and narrow with tapering ends. Each has an outer membrane. The smooth muscle tissue demonstrates tense and relaxation. In the relaxed state, each cell is spindle-shaped, 20-500 micrometers in length. 1C. The cardiac muscle pumps blood throughout the body. The skeletal muscle moves the body. Skeletal muscle contractions pull on tendons, which are attached to bones. The smooth muscle helps push out babies and and urine. Smooth muscles also move food through the digestive tract.
2A. What is the difference between a voluntary muscle and an involuntary muscle? 2B. Which muscles are voluntary? 2C. Which muscles are involuntary?	2A. Involuntary muscle is under unconscious control while voluntary muscle is under conscious control. Voluntary muscle tires easily while involuntary muscle does not tire out or tires out very slowly. 2B. Triceps, Biceps, Deltoids, Pectorals, Trapezius, Gluteals, Quadriceps, Hamstrings, Gastrocnemius, Latissimus dorsi and Abdominals. 2C. Blood vessels, bronchi, uterus, bladder and the cardiac.

3. How does the muscular system support each of the other 5 we study? BE DETAILED.	The muscular system supports the digestive system because the muscles in the throat move the food down to the esophagus. Muscles in the stomach also break down food for the digestive system. The muscular system supports the skeletal system because muscles connect to your skeleton and help move your skeleton. The muscular system supports the circulatory system

Graphic Organizer comparison - John

He did not answer all of the questions actually posed for this system. He did not copy them from the question sheet to his graphic organizer. His fix seems to be that he just used the question sheet and built into it his own tables for the answers.

Muscular System

1.

a. List the three main types of muscles.
- Smooth muscles
- Cardiac muscles
- Skeletal muscles

b. Describe their **structures**.

• Skeletal muscles	A cylinder shaped muscle made of hundreds or thousands of muscle fibers that is covered by connective tissue
• Cardiac muscles	It's similar to the skeletal muscles but instead of being covered by connective tissue its covered by intercalated discs.
• Smooth muscles	Made of myosin and actin which takes the whole structure making it contract and expand the smooth muscles

c. What is the **purpose** of each type of muscle?

Cardiac muscles-it is muscles that help to pump blood throughout the body.
Smooth muscles- in side hollow organs to push food down through our body
Skeletal muscles- it helps our bones move by contracting and releasing tendons

2.

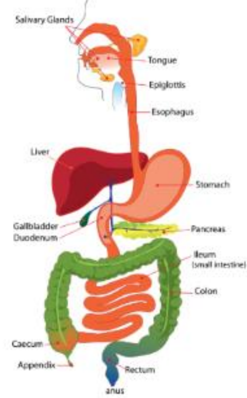
a. What is the **difference** between a **voluntary** muscle and an **involuntary** muscle? Voluntary is the muscles you can control and Involuntary muscles is the ones that move on their own to keep you alive everyday

b. Which muscle types are voluntary? Which muscle types are involuntary? **Give at least one example of each.**

Voluntary	Skeletal muscles and some cardiac muscle an example is the biceps
involuntary	Smooth muscles an example like this is the stomach

3. How does this system (muscular) **support** each of the other 5 we study? BE DETAILED.

A. Digestive- using the muscles we have we grind the food in our stomach which is a smooth muscles
B. Skeletal-our skeleton can't move without our skeletal muscles in work
C. Circulatory- blood vessels and arteries have muscles inside of them which pushes the blood through the body
D. Respiratory- in order for our body to move we need oxygen which is provided in the respiratory system since you take in air
E. Excretory-

Digestive System of the Human Body	
What are the organs of the system and what do they look like?	The organs of the digestive system are the esophagus, the liver, the gallbladder, the pancreas, the large intestine, the small intestine, the appendix, and the rectum. 
How do all the organs work with each other?	Mechanical Digestion: The teeth first grind down onto the food and breaks down the food. The tongue moves the food around and helps in the crushing of the food. The food is then pushed down by the esophagus, into the stomach. From the stomach, it travels into the small intestine, where it is churned by the small intestine for seven days. Then it travels to the large intestine for absorption by the large intestine. It is then produced as feces. Chemical Digestion: The saliva helps to break down the food in the mouth, and is then pushed down the esophagus into the stomach. This is where the stomach acids (pH of 1) mix the food with enzymes, to turn it into chyme. It then travels into the small intestine and into the large intestine, and then out of the rectum,

Digestive System - Nancy

	Circulatory	Respiratory	Excretory	Digestive	Skeletal	Muscular
What are the organs of the system and what do they look like?				The mouth  Small intestine: Long and thin Large intestine: Shorter and thicker Esophagus:A tube that connects the stomach to the rest of the system Stomach: a balloon like figure		
How do all the organs work with each other in the system?				All of the organs are connected and help the next digest the food better. For example the mouth chews the food so it goes down the esophagus easier		
How does this system support each of the other 5 we study.				The digestive system help the rest of the systems by taking part of the workload off. For example, the digestive system help digest food and gives energy to the muscles whose job is to keep the body running.		
An organ is made up of a tissue. Tissue is made up of cells. You will pick 2 organs in this system and explain how the structure of the cell and tissue relate to the function of those organs.				Stomach: The cells in the stomach are specialized, meaning they only have one job. In the stomach all it has to do is squeeze the food to make it easier for the next organ. Small intestine: The small intestine also is made up of specialized cells. The small intestines job is to take the nutrition out of liquids. It's cells only has one job. That is to move the liquids down through the small intestine to the large intestine. The peristalsis move the food through the small intestine.		
Give an example of how this system helps another system at a cellular or tissue level.				Cellular respiration in the body needs the oxygen which comes from the respiratory system. The energy comes from the digestive system.		
The sources				Life science book Pg 263-309 ISBN= 0-13-713991-8		

Graphic Organizer - Nancy

	Muscular Systen
List the three main types of muscles. Describe their structures. What is the purpose of each type of muscle?	Skeletal muscle Structure: They are attrac Purpose: They contract th Smooth muscle Structure: Organized into Purpose: Help control the digestive system. Cardiac muscle Structure: The fibers wea Purpose: They contract to
What is the difference between a voluntary muscle and an involuntary muscle? Which muscles are voluntary? Which muscles are involuntary? Give at least one example of each.	A voluntary muscle is a m movements too. For exan is something that you can involuntary muscle is the I For example, Blinking can action that helps to protec
How does this system support each of the other 5 we study? BE DETAILED. Digestive Skeletal Circulatory Respiratory Excretory	The muscular system help muscles help the body mo the body into use. Withou use for the bones that are muscles. The muscular sy smooth muscle that helps of the digestive system. It the cardiac muscle that cc them, the circulatory syste respiratory system is also providing muscles to help dioxide out. The muscular by being in all of the orgar example, the kidneys hav muscles in them they wou

Appendix S: Middle School Learning Strategies Survey

Middle School Learning Strategies Scale, MSLS (Liu, 2009)
For each question the answer choices are Hardly ever, Sometimes, Often, or Always

When learning something new in class, I.....	
	take notes in class and read them over.
	use headings in my notes so I can find information when I look through them again
	ask questions in class
	find that taking notes in class isn't helpful
	have strategies I use when taking notes so that I can understand them when I look at them again.
When learning something new, I....	
	use a textbook or website to add to my notes.
	use graphic organizers.
	relate new things to things I already know.
	avoid asking for help even when I need to.
	read over my class notes and put the teacher's lesson into my own words.
	use the KWL method (what I already Know, what I Want to know, what I have Learned).
	like certain words, I keep repeating them.
	offer help to classmates.
When you are reading or writing something new I ...	
	pre-write by drawing a diagram.

	pre-write by making an outline.
	outline what I read.
	put things I read into my own words.
When doing homework I ...	
	adjust music or TV to concentrate on homework.
	do homework in a place hard to concentrate.
	only do as much work as I have to.
	think of ways to make homework more interesting so I can get it done.
	ask a family member for help with schoolwork if I need it.
	ask friends for help with schoolwork if I need it.
	work harder on free time activities than on homework.
	wait until the last minute to start doing it.
	copy someone else's work if I don't understand an assignment.
	check to see whether I understand the material.
	figure out what I can already do.
	ask my teacher for help if I need it.
	plan the steps before starting an assignment.
	set things up so I can concentrate when I do my homework.
	draw a diagram when I'm working on a math problem, to make it clearer.
	complete an assignment without checking for mistakes.

	summarize what I have learned after class.
	check the teacher's comments on an assignment.
	know which parts of a classroom lesson to understand.
Organization	
	I use a planner, Google Keep, Google Classroom or check my gmail.
	My school papers are disorganized.
When studying for a test, I...	
	set words to music or a special rhythm to help me learn them.
	can't seem to make sense of my notes when I try to study from them.
	try to figure out which parts of the material to study most.
	read study guides to prepare.
	ignore the teacher's corrections on my homework.
When you are taking a test I....	
	start to answer questions without reading the directions.
	try to pace myself so i won't run out of time.
	stop working on a test if I finish a test early.
	complete a test without checking for mistakes.

Appendix T: Prompt Planning Sheet

Prompt Planning Sheet					
Task	Google form prompt questions for Planning	Daily prompts - Will you use...			Specific Prompt questions
		Checklist?	Rubric?	Daily reminders?	