USING GRAPHIC ORGANIZERS TO DEVELOP AND BUILD UPON PRIOR KNOWLEDGE

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study was implemented with a transitional-level Experimental Methods in Physics (EMP) class. The course was made up of students with individualized education plans and students who struggle with reading and/or math. The students often struggle with accessing and building upon prior knowledge between courses and within the EMP course. The major focus of this study addressed how the use of graphic organizers affects transitional-level student understanding of physics. Along with this main focus, the teacher also explored: how students' confidence levels are affected by the use of graphic organizers, how the use of graphic organizers affects students' ability to access and build upon prior knowledge, and how the use of graphic organizers affects the teacher's awareness of student progress. The methods used to answer these questions involved pre- and post-tests, interviews, reflective journals, student work samples, surveys, and daily quizzes. Two main graphic organizers were utilized to address these questions: the four corners and a diamond (FCD) organizer to aid in problem solving and the Six Step Topical Guide (SSTG) to aid in accessing and building on prior knowledge. After qualitative data analysis, it was determined that although the FCD organizer did not have a positive effect on all students, it is a good resource for students when starting out the in the problem solving process and for those who struggle with mathematical processes. It was also determined that the SSTG organizer is a strong resource for helping students draw upon their prior knowledge and build connections moving forward.

INTRODUCTION AND BACKGROUND

Maine South High School is situated on the northwest side of Chicago about five minutes from O'Hare airport in Park Ridge, Illinois. It is the largest of three high schools in the Maine Township School District, with a student population of roughly 2,600 students. Of those students, a majority are Caucasian (88.7%), with small, but increasing number of Asian (2.8%), Hispanic (7.6%), and African American (0.3%) students. Most students come from families that are well-off, but the recession has made some economic changes in the community for most families. Eight percent of students come from low income families ("Illinois interactive report," 2011).

The students that this study will focus on are those in the transitional level physics class called, "Experimental Methods in Physics" (EMP). The course is a one semester introduction to physics for students in between the regular track and special education track. In this course, generally, a considerable number of students are main-streamed special education students with an Individualized Education Plan (IEP), and students with skills sets ranging from being proficient with math, but poor with reading and vice versa to very poor with both reading and math.

Out of the five years of teaching at Maine South, two of them have been spent teaching the EMP course. Experience has shown that many of the problems that EMP students have with being successful in science stem from struggling to use prior knowledge and build connections. In a typical semester, many students will need to learn how to convert between units, graph data, calculate slope, and solve problems all over again in each unit of study throughout the semester. Even if the students learned how to do all of the aforementioned tasks in classes taken prior to or concurrently with EMP, to many of them, they are brand new skills in EMP. In a typical semester the dimensional analysis method of converting will need to be re-taught in each unit (as with calculating slope). The students struggle to identify, access, and utilize the prior knowledge they bring to the course.

Often times, it is very difficult for these students to apply concepts learned in this course. Students, with practice, become very good at reciting facts. For example, if students are asked, “what is Newton’s 1st law?,” by the third day of repeating it, most of them can repeat it back, word for word, without looking at notes. The issue arises when students are asked to apply or explain Newton’s 1st law. By intentionally having students determine what prior knowledge they have to understand concepts better, hopefully they will be better equipped to apply and explain the concept.

As a result of these issues, this study will address how to aid students in accessing prior knowledge and building connections through the use of graphic organizers.

The research question for this study is how will the use of graphic organizers affect transitional-level student understanding in physics? Along with this main question, four sub-questions will also be addressed. One will look at how students’ confidence levels are affected by the use of graphic organizers. Another will investigate how the graphic organizers affect the students’ ability to access existing prior knowledge. The third sub-question will address how the use of graphic organizers affects the students’ ability to build upon prior knowledge by carrying over skills into future units. The final sub-question will determine how the use of graphic organizers affects the teacher’s awareness of student progress.

CONCEPTUAL FRAMEWORK

Developing knowledge in students is a topic with many viewpoints and varying procedures depending on the ability level and previous experiences of a student. With such a variety of students coming into a classroom everyday, it can be a challenge to determine what prior experiences the students have had, how the students learn best (if they even know), and how well they are able to build connections. Marzano (2007) and Gil-Garcia & Villegas (2003) cite that there are two major types of knowledge that govern how we learn: declarative and procedural. Declarative knowledge has to do with knowing facts and definitions, whereas procedural knowledge has to do with knowing how to complete a task (Gil-Garcia & Villegas, 2003). In order to build up one’s procedural knowledge, it is imperative that the appropriate declarative knowledge already be in place. The development of both of these types of knowledge requires that one must regularly use and apply what has been learned. For example, if a physics student is learning about terminal velocity, he cannot simply read the definition once and expect to retain the declarative knowledge. Instead he would need to work to understand what terminal velocity is and understand when it occurs. As an example of procedural knowledge, if a student is to become proficient with the scientific method, it is not enough for them to try to memorize each step. Instead, the student should complete experiments in which she regularly goes through the scientific method.

For the students in the previous examples to become fluent in their declarative and procedural knowledge, it is important for them to connect the new information to something that they already know or have experience with; their prior knowledge. This understanding comes from the idea of schema theory. According to Dye (2000), “schema theory states that new information must be linked to preexisting knowledge" (p 72). Marzano (2007) expands on this idea as he discusses Piaget's theory of assimilation and accommodation that allow students to develop knowledge. In assimilation, students use what they already know as a knowledge base and slowly build the new knowledge into that base, making connections between the two along the way. Accommodation involves a deeper level of change in that students must alter their prior knowledge base to fit the new information. Marzano breaks these ideas down into three methods of schema development. The first two, accretion and tuning, go along with Piaget's idea of assimilation in that students add knowledge onto their prior knowledge base and adjust or refine it as the learning process continues. The last method is restructuring, which would be similar to Piaget's accommodation in that students need to rearrange and adjust their prior knowledge to fit the new learning and move forward.

In all of this, the teacher plays a key role, especially with low-achieving, special education students. According to Dye (2000), "the teacher's task is to ensure that the child has prior knowledge related to the concept and to provide a means to assist the child in making the necessary connections between what is being taught and the child's prior knowledge" (p. 72). In courses with low-achieving, special education students, it is important to pay special attention to how information is presented and ensure that it is organized and focused on the important points, so that the students can more easily make the connections needed.

The Illinois State Science Learning Standards for education also emphasize the importance of students being able to make connections between prior and new knowledge in one of the main sections, "Making Connections." The section states:

> Recognize and apply connections of important information and ideas within and among learning areas.
>
> Science has many disciplines, all interrelated. Understanding the functioning of living things depends on knowing chemistry; understanding chemistry depends on knowing physics. In the same way, science itself is highly dependent on mathematics—and it also relates strongly to medicine, geography, physical development and health, social trends and issues, and many other topics. Science, at its best, provides knowledge and skills that improve the understanding of virtually all subjects. (Illinois learning standards, n.d., para. 13-14)

Based on these Illinois learning standards, the idea of students building up connections moves from a best practice and theoretically sound idea to a state mandated practice, which begs the question of what is the best way to build connections in students?

The methods available for assisting students in making connections vary slightly, but many of the ideas can be summarized by Marzano. Marzano (2007) explains a process for introducing students to new information that involves previewing, grouping, chunking, questioning, drawing conclusions or summarizing in a nonlinguistic manner and reflecting. Previewing involves students drawing out what knowledge they already have about the topic and introducing students to some of the main ideas that will come out in the lesson, book, video, etc. Grouping involves separating students into small groups to facilitate the learning and organization of information. Chunking requires the teacher to break the new information up into smaller pieces for students to process based on available prior knowledge, so that their working memory does not get overloaded. Questioning requires students to dig deeper into the new content and explain their understanding or make inferences based on their understanding. Students representing their knowledge non-linguistically, requires them to utilize a means other than verbal communication to demonstrate their understanding: writing, drawing, acting, etc. Finally, reflection involves the students looking back on the learning experience and processing it as a whole to identify what was learned and how confident they are in the new information/process.

One major tool that teachers can use to develop new knowledge in students that has an overwhelming amount of research support is the graphic organizer. The graphic organizer can be used in many of the ways that Marzano indicated previously. Egan (1999) defines graphic organizers as "a visual representation of knowledge, a way of structuring information, and of arranging essential aspects of an idea or topic into a pattern using labels" (p. 641). The graphic organizer allows the students to see the process of organizing information and further aids in their ability to properly learn and store the necessary information (Gil-Garcia & Villegas, 2003). From the teacher's perspective, the graphic organizer allows the teacher to easily recognize how students make their connections and identify gaps in the learning process (Greenstein, 2010). In addition, Marzano, Pickering, and Pollock (2001) discuss "dual-coding" theory, in which there are two major ways of storing knowledge: linguistically (verbal and text-based) and non-linguistically (sensory and image-based). The majority of what is done in the classroom is linguistic-based and students must, on their own, develop the nonlinguistic portion, if so inclined. Marzano, Pickering and Pollock argue that if instead teachers offer assistance, possibly in the form of graphic organizers, the results will show higher student achievement.

Kooy, Skok and McLaughlin (1992) performed a study to test the effect of two types of graphic organizers on math and science quiz scores for special education students in high school. The first type of organizer was a teacher generated organizer and the second was a student/teacher generated organizer. There was not a significant difference found in student achievement based on the type of graphic organizer used, but there was a significant difference in the use of a graphic organizer as compared to not using a graphic organizer at all. The students also responded positively to the graphic organizers in a survey and found them to be useful, easy to use and indicated that they would try them in other classes. Teachers did not find that students actually used them as often as students indicated that they intended to, and as such Kooy, Skok and McLaughlin recommend training students in how to apply the organizers regularly.

A study done by Zollman (2009) also indicated that the use of graphic organizers in math classes to be beneficial. Zollman utilized the four corners and a diamond graphic organizer (FCD) as depicted in Figure 1, to determine the effects on learning disabled and non-learning disabled middle school students ability to solve open-ended response problems dealing with math knowledge, strategic knowledge and math explanation problems. In his study, Zollman identified a problem that is not only relevant to middle school math students, but also low-level high school students. He indicated that, "typically low-ability students do not attempt to show any work in one or more response categories, while average-ability students often have disorganized responses. Higher-ability students sometimes skip steps in their explanations" (p. 7). The hope was that the non-hierarchical layout of the organizer would allow students to solve the problem naturally without worrying about needing linear thinking. Through the use of pre and post tests Zollman found that the use of the graphic organizer on math problems significantly improved performance for all levels of students (learning disabled and non-learning disabled). The low ability level students were at least trying and showing some work. Middle ability level students had more organized work and high ability level students were better able to communicate the way in which the problem was solved.

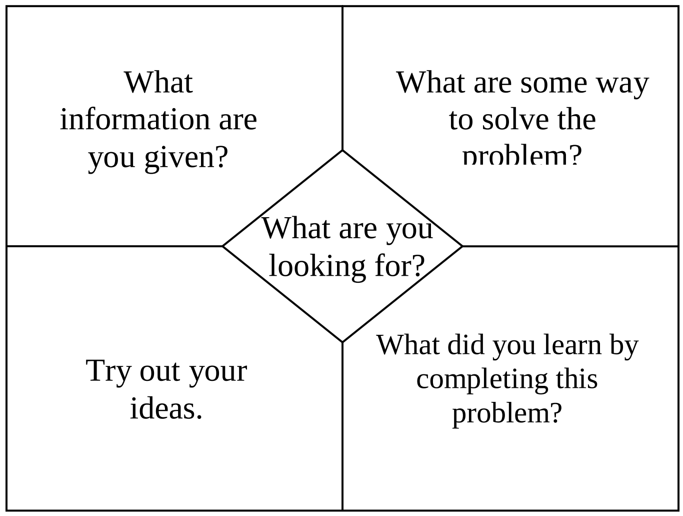

Figure 1. Four Corners and a Diamond Graphic Organizer (Adapted from Zollman 2009).

As the previous studies have implied, the benefits of using graphic organizers are not only found in the assessment scores, but also in student perceptions. The study done by Gil-Garcia & Villegas (2003) explored the undergraduate and graduate student and faculty perceived value and usefulness of graphic organizers. In this study students were interviewed about how graphic organizers aid in processing and acquiring knowledge. The teachers were interviewed about the value of graphic organizers and how they develop advanced thinking skills. The consensus of students was that graphic organizers help students process the concepts being learned, aid in making connections with prior knowledge, allow needs to be met on a more individualized basis, help teachers effectively plan, allow students to more easily remember and relate the information learned, and despite all of these benefits, still are not for all learners (there is no such thing as a one size fits all solution). The faculty who were interviewed identified two major benefits to the graphics organizers: they enhance higher level thinking skills and are useful for introducing conceptual framework. The idea that graphic organizers are a useful learning strategy to carry through college gives more urgency for the need to use them with high school students.

Based on the theory behind, the purpose of, and the studies done about graphic organizers, it is apparent that they are a very effective to help students organize information, identify prior knowledge and build on that prior knowledge. At the end of their study, Gil-Garcia and Villegas (2003) go so far as to say that, “the advance organizers may be the answer to enhance authentic, active, and dynamic teaching that in retrospect would lead to higher comprehension of complex curriculum and content” (p. 6).

Marzano, Pickering and Pollock (2001) break graphic organizers down into six major categories: descriptive patterns, time-sequence patterns, process/cause-effect patterns, episode patterns, generalization/principle patterns and concept patterns (see Appendix A for images of these graphic organizers). Descriptive patterns entail linking facts or details to a topic. Time-sequence patterns involve placing events in chronological order. Process/cause-effect patterns require students to fill in causes that lead up (in order) to the effect. Episode patterns help students keep track of the major details of a specific event. Generalization/principle patterns allow students to structure examples under the heading of a major idea. Concept patterns allow students to organize details, examples, facts and dates around a central idea. While this is an extensive list of graphic organizers, it does not encompass all organizers. A graphic organizer could be as simple as a KWL (know, want to know, learned) chart and as complex as a comprehension matrix for a lab.

Egan (1999) discusses her adapted KWL graphic organizer called the “Six-Step Topical Guide” (SSTG) and its uses for reading assignments or lecture (see Table 1). Egan points out that for this, or any graphic organizer, to be effectively used, it should be used after the teacher has tried it herself, allow for students to interact about the content at some point (in this case during the verify stage), used with caution to ensure that the organizer is maintaining its value (not used too often), and used for circumstances other than just reading (notes, videos, class discussion).

Table 1
SSTG Graphic Organizer (Adapted from Egan, 1999)

A **What I definitely know**	**B** **What I am pretty sure I know**	**C D** **Read & Verify**	**E** **Questions from the reading/notes**	**F** **Where to find answers**
1. ___________ 2. ___________ 3. ___________ etc.	1. ___________ 2. ___________ 3. ___________ etc.	May discuss with group/partner **+** means statement is correct **-** means statement is not correct ? means there is not enough information given to decide	1. ___________ 2. ___________ 3. ___________ etc.	1. ___________ 2. ___________ 3. ___________ etc.
List the information that you are certain you know about the topic	List the information that you think you might know about the topic	After reading or completing notes check whether the information in columns A and B was correct with a plus (+), minus (-) or question mark (?)	What questions do you still have about the topic? What questions have developed out of the reading/notes?	What sources could you use to find the answers to your questions?

The focus of using a graphic organizer must be to enhance the students' learning by connecting to or building upon prior knowledge. As Merkley and Jefferies (2000) identify in their paper, teachers must be cautious to avoid two common graphic organizer implementation errors. The first is that a graphic organizer is not a tool to lecture from – it requires student participation. The second is to find the proper balance when constructing the graphic organizer that it is detailed enough for the students to glean an overview of the material, but not so detailed that it replaces a lecture or portion of the text.

As teachers, it is our job to find ways to help low-achieving and special education students succeed. By implementing graphic organizers into the classroom, students gain more guidance and organization in identifying their existing prior knowledge and building upon their knowledge effectively. The teacher will gain more insight into where gaps reside in student prior knowledge and how to fill those gaps, as well as be able to identify gaps in developing knowledge. This study will investigate the use of graphic organizers for these purposes with low-achieving and special education students.

METHODOLOGY

This study used a class of transitional-level students to determine the effect of graphic organizers on the understanding of physics. The methods developed also addressed the effect of graphic organizers on student ability to access prior knowledge, student ability build upon prior knowledge by carrying knowledge to the next unit of study, student confidence levels, and teacher awareness of student understanding.

Participants

There were fifteen students involved in this study. All of the students were in a one semester “Experimental Methods of Physics” course, which is the transitional level physics course at the high school. These students fall between the special education and regular level track for science. Many students in this course struggle not only with science, but also with math and/or reading. Three students had individualized education plans (IEPs) that identified them as having low ability levels in reading, writing, and/or math. Three students were in the guided study program, which provides students one period per day to focus on getting work done and developing study skills. The course was made up of six female students and nine male students. The majority of students were sophomores. There was one student with freshman standing due to lack of credit earned.

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

Intervention

This study began with the start of the new semester, and therefore the start of the course. The research spanned three units of study and lasted from late January to mid-March. The three units used were the Introductory unit (conversions, graphing, scientific method, and experimental procedures), the Electricity unit, and the Motion unit.

Within these three units there were two main graphic organizers that were implemented. The four-corners and a diamond (FCD) organizer was used to develop problem solving abilities and observe the students' problem solving process as applied through different units (Appendix B). The standard problem solving method that was implemented involves identifying the given and unknown information, converting units if necessary, identifying which equation to use, rearranging the equation and plugging in numbers, and then solving and recording the answer with units. The FCD was used alongside the problem solving method. The Six Step Topical Guide (SSTG) organizer was utilized during reading and verbal introduction of new material to monitor student ability to access and build upon prior knowledge. The SSTG was altered slightly from Egan's (1999) initial form to be able to implement the organizer with both reading and class lecture/discussion (Appendix C, D, E).

The first unit of study was the Introductory unit which introduces students to conversions, the scientific process, experimental procedures and graphing. All of the students in this course took Experimental Methods of Chemistry the semester prior and learned all of this material in that course. This provided a good starting point for observing their ability to access and build upon prior knowledge. In this unit, the focus was on establishing a baseline of student ability to convert between units and draw out the information they learned in chemistry about the scientific process, experimental procedures and graphing. Early on in the unit, students took notes using any method that they wanted on a selected reading about the scientific process. On the next reading, which was a current science article, students used an SSTG organizer to aid in their note-taking.

The second unit of study was the Electricity unit, which involved a considerable amount of reading, applying concepts and using applied math. During this unit, students demonstrated their prior knowledge through completing an SSTG organizer during textbook reading about electrostatics and electricity along with a reading guide to help them with taking notes (Appendix D, E). When the students learned to apply Ohm's Law they were first given problems to solve on their own. Then the teacher introduced the FCD graphic organizer to solve the remaining problems given. Some of these problems involved conversions and called upon students to remember what they learned in the prior unit to solve the problem appropriately. The first assignment given required students to use only the organizer. On subsequent assignments students were either allowed to choose whether or not to use the organizer or used it on a limited number of problems.

The third and final unit of study was the Motion unit, which involved applied math and note-taking. In this unit, students were expected to complete an SSTG organizer when learning speed and acceleration when taking notes in class. When students were ready to solve problems related to speed, they were to solve problems and were required to use the FCD graphic organizer on some of the problems and then could decide whether to use the organizer or show work using the standard problem solving method. Many of the problems in this unit involved conversions and similar processes to those that were used in the units prior.

Data Collection

To assess the effect of graphic organizers on student performance, the teacher administered pre- and post-tests for each unit, conducted interviews with students, collected samples of student work, used Likert scale surveys, gave daily quizzes, and kept a reflective journal (see Table 2). The triangulation matrix indicates how the questions of the study were addressed by these methods. The data collection focused on noting the progress that students made and how results changed, rather than on any one individual survey, interview, work sample, etc.

Table 2
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3	Data Source 4
Primary Question: 1. How will the use of graphic organizers affect transitional-level student understanding in physics?	Interviews	Student work samples	Likert Scale Survey	
Secondary Questions: 2. How are students' confidence levels affected by the use of graphic organizers?	Interviews	Likert Scale Survey	Pre- and post-tests (comparing results with Likert survey)	
3. How do graphic organizers affect students' ability to access prior knowledge?	Interviews	Student work samples	Likert Scale Survey	
4. How does the use of graphic organizers affect students' ability to build upon prior knowledge by carrying over skills into future units?	Pre- and Post-tests	Student work samples	Daily quizzes	Likert Scale Survey
5. How does the use of graphic organizers affect the teacher's awareness of student progress?	Interviews	Student work samples	Reflective journal	

As can be seen in the table, some of the methods were used for multiple purposes and each question was answered based on data from at least three different sources so as to give an increase in validity to the analysis.

Student Work Samples

In assessing the students' abilities to access prior knowledge, build connections, and determine if using graphic organizers affects the teacher's awareness of student progress, it was integral for the teacher to view student work samples throughout the study. In Zollman's (2009) study, he was able to identify differences in student progress based on observing work samples from students before being introduced to graphic organizers and after. Using these samples of the four corners and a diamond organizer he was able to see what students understood and where students got stuck. In a similar fashion for this study, the teacher collected samples from students of how problems were solved prior to using the four corners and a diamond organizer and then during the process of using the organizer to assess progress made. The teacher also collected samples of notes taken by students in their ordinary fashion and then notes taken using the SSTG organizer to assess any differences in prior knowledge accessed or new knowledge gained.

Likert Scale Surveys

To assess student confidence levels about accessing prior knowledge and building connections it was important to implement Likert scale surveys that could keep track of how student confidence progressed through the study (Appendix F, G). Kooy, Skok and McLaughlin (1992) used Likert scale surveys to assess student and teacher perceptions of graphic organizers. By using this survey with pre- and post- tests they were able to determine whether student perceptions matched the performance change. In a similar fashion, this study utilized a Likert scale survey similar to the survey that Kooy, Skok, and McLaughlin used. The survey given to students not only assessed the students' perceptions and use of the graphic organizers, but also how the graphic organizers affected their confidence level and perceptions of their abilities. Just as Kooy, Skok, and McLaughlin did, the survey results were compared with pre- and post-test results to assess whether or not confidence matched the performance.

Pre- and Post-Tests

Students were given a pre-test at the start of each unit to see what they remembered or knew already, and then a post-test at the end of the unit to see what they had learned and how their knowledge had developed (Appendices J-O). When used in conjunction with the other methods mentioned, the pre- and post-tests helped the teacher determine how the graphic organizers were affecting student confidence levels and student ability to carry information over into the next unit. Conversions were on each test and allowed for the teacher to see if students were becoming more or less proficient in converting units after using the SSTG organizer and the four corners and a diamond organizer. The tests also allowed the teacher to assess the students' ability to solve problems using the four corners and a diamond organizer, and determine if problem solving ability improved after use of the organizer.

Interviews

In order to determine the effect that graphic organizers had on the students' understanding of physics, confidence, ability to access prior knowledge, and teacher awareness of progress, the teacher conducted interviews with students to gain more detailed insight into their thought process. Student interviews occurred twice throughout the course of the study, once at the beginning and once at the end (Appendix H, I). There were a total of four students interviewed. Two of the students were male and two were female. One male and one female were above average students. One male and one female were below average students. The students chosen to be interviewed were ones who gave the impression that they were willing to speak honestly and openly about their perceptions. These interviews took place out of class, during a common break.

Daily Quizzes

Daily quizzes were given to students approximately every other day during the Motion Unit to help students assess what they know and need more practice with, and to allow the teacher to see which topics require more time. By giving daily quizzes during this unit, the teacher was able to assess the progress that was made toward carrying over prior knowledge into future units.

Reflective Journal

By keeping a reflective journal the teacher was able to track her observations of student progress throughout the study and determine whether or not she was more aware of student progress through the students' use of graphic organizers. She recorded observations of class discussions that took place during use of the graphic organizers and observations of students using the graphic organizers on a daily basis.

DATA AND ANALYSIS

Over the course of this study, various observations, interviews, surveys, assessments and work samples were collected to determine responses to the focus and sub-questions of this study.

How Does the Use of Graphic Organizers Affect Transitional-level Student Understanding in Physics?

As with all teaching practices, there is no one size fits all solution for improving student learning. At the transitional level, the standard teaching methods do not work for the majority of students, which requires teachers to be more innovative in how content and skills are presented.

Four Corners and a Diamond Graphic Organizer

The four corners and a diamond graphic organizer proved to be a useful tool for most students to refer to at the start of solving new types of problems and a good resource for students who struggled more than others with mathematical procedures.

All four of the students who were interviewed indicated that they found the word problems in class easier to solve than they were at the start of the study. All of the students also indicated that the organizer was most helpful for organizing the information. Three of the students indicated that they only liked to use the organizer at the beginning of learning how to solve a problem until they had a better understanding of the process. One of the female students stated, “I like it because it (FCD) is easier to organize the information. It’s helpful to use at the beginning when you are learning the problem.” Another student who didn’t like to use the actual organizer for solving the problem explained, “I mean, like it (FCD) helps at the beginning cuz like now, even though I write on my paper I do things step by step and like, I list like what I know and stuff, but like, the only part that I don’t do is like, at the end… where you have to give all the information like what you did step by step so…” The process of students needing to write out how they solved a problem was something that all students were resistant to, but would need to do every so often on worksheets regardless of using or not using the organizer. Through using the graphic organizer and the explanation portion of the organizer, students' problem solving skills not only improved, but their ability to explain how to solve a problem increased as well.

The idea of using the organizer as a guide, but not actually writing on the organizer was a common theme throughout students in the class as well. When talking with the class as a whole, multiple students indicated that, while the questions helped them think through the problem, they did not want to write out the information on the sheet and would rather use the original worksheet.

The lowest achieving student who was interviewed said that the organizer was helpful to him and made the problems easier to figure out. Even with that said, he still did not use it often in class. Unfortunately, he was under the impression that if he used the organizer he needed to write the work out on the organizer and the original worksheet. When the teacher and student discussed that only one was necessary, he explained that he probably would have used it even more.

Student work samples also indicated that the students who used the organizer were those who struggled the most with the mathematical problem solving process. More students used the organizer on the first test after learning about the organizer (electricity) than the second test (motion). On the first test, eight of fifteen students used the organizer, whereas, on the second test only three used the organizer. Two of those three students were ones who have typically had more trouble with the math processes in the past. Of the two who used it on the second test that typically struggle, one of them improved his score on the problems by 20%. The other student’s score decreased by 11% on the problems. One of the students who used the organizer on the first test and not the second ended up with a decrease in his score of 45% when he did not use the organizer for problems. While the graphic organizer cannot be the sole source of success or failure on problem solving, it appears that it is a tool that can help struggling students be more successful. To determine the complete effect of the FCD, the study would need to continue through more than just two tests to determine the full effect on students who struggle with problem solving.

When using the organizer in class, more students opted to use the organizer at the beginning of the unit or learning to solve a new problem than at the end. By the end of a unit, only one or two students used the organizer on homework, but at the beginning, five or six students would choose to use the organizer.

According to the pre- and post-surveys that all students completed at the beginning and end of the study, the majority of students felt that their confidence in being able to solve a problem had increased since the start of the semester (Figure 2). The cause of that increase however, was not clear for all students. One-third of the students found the organizer to be helpful and one-third said they used the organizer when solving problems. In interviews and class discussion, some students indicated that simply having more practice helped them get better at solving problems, while still others did indicate that the graphic organizer was helpful in their growth.

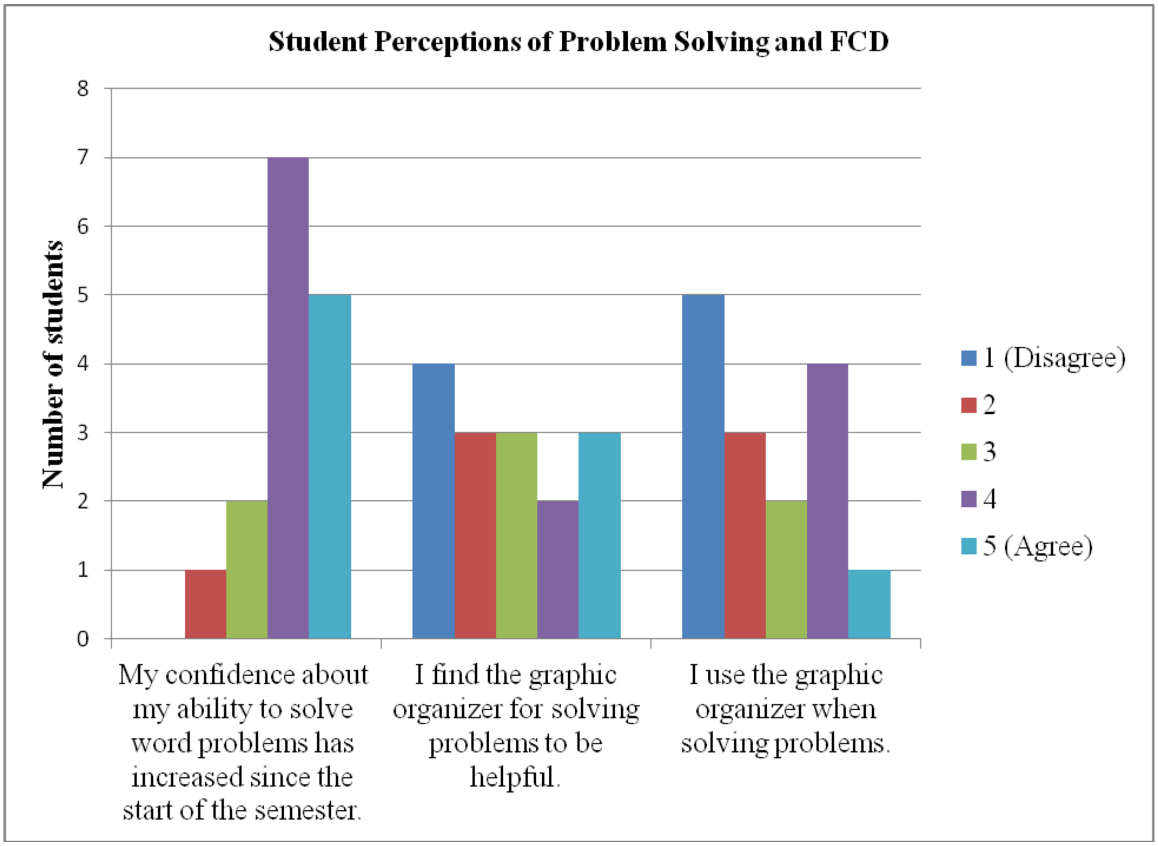

Figure 2. Student Perceptions of Problem Solving and FCD, (*N* = 15).

Based on the data, although the FCD graphic organizer will not be helpful to all students, it should still be introduced and demonstrated for all students. Once students have tried both the standard problem solving method and graphic organizer, then they should be given the opportunity (with teacher insight and encouragement) to decide whether or not to use the organizer. In interviews, two of the students noted that the FCD helped organize their information and acted as a guide for solving problems. The other two students stated that they liked that the FCD provided what to do step by step. The standard problem solving method also provides a step by step approach, but the organizer allows for students who may be less linear in their thinking to follow whatever order they desire, while still having the questions to guide them. Further investigation needs to be done into the long term effects of the organizer and the cause of some students not using the organizer even though they say that it helps.

SSTG Organizer

When learning new information the SSTG organizer allows the teacher and students to identify and clarify misconceptions at the beginning of the unit of study.

Both of the female students that were interviewed thought that the SSTG guide, know/think you know sections helped when learning new material. One of the students said, "(it) proves when you're wrong and shows a depth of what you know… (it) helps learn longer term." The other female student stated, "(it) helps find what relates…helps get better knowledge." Both of these students identified key components to any deep learning. Both students recognized that in order to retain knowledge and understand a new concept, it must be connected to something that is already known by the learner. The two male students that were interviewed also said that the connections to what you already know were helpful (especially if you don't understand something), but could not identify why it was helpful.

By looking through student work samples and recording observations from class, it was clear that when students were able to properly connect new material to something they already learned, the students learned the information better and were able to overcome misconceptions faster. In the Electricity unit, students struggled quite a bit to think of what they knew already. Most students referred to voltage, current and circuits all as "electricity" and could not identify what the differences were between them. Many students struggled with differentiating the concepts of voltage, current and circuits because for so long they had been thought of as the same. By knowing that this was where the weakness resided, the teacher was able to step in to provide extra supports, labs and examples for the students to more clearly see the differences.

As the students moved on to the Motion unit, they started to have an easier time determining what they knew and thought they knew on the SSTG. By using the organizer as a class the teacher and students were immediately able to identify that all except for two people thought that acceleration had something to do with only either changing speed, starting speed, final speed, etc., but most missed the fact that it was a rate or needed time to be considered. Rather than students proceeding based on their prior knowledge of acceleration and then later correcting their definitions, the class was able to discuss examples of different accelerations (high and low) and eliminate the misconception that acceleration only has to do with speed. By the end of the class, all students demonstrated that they understood that acceleration must consider not only changing speed, but also time through examples.

How are Students' Confidence Levels Affected by the Use of Graphic Organizers?

In the process of learning, it is important for students to feel confident in their ability to succeed and accomplish the tasks required. It is equally important that the students' assessment of their confidence match their performance.

Problem Solving

While students communicated on their post-treatment surveys that they felt more confident in their problem solving abilities, not all of the increases in confidence matched up with assessment results and it is not clear in this study as to whether the cause of the increase in confidence is completely due to the FCD organizer or simply more practice.

Given the survey data, it is clear that the majority (80%) of students felt more confident in their ability to solve word problems than they did at the beginning of the semester (Figure 3). To start the semester, only 33% of the students felt confident in their problem solving abilities. Over the course of this study, a significant improvement was made in student confidence in problem solving, but the direct cause of the increase is not yet clear.

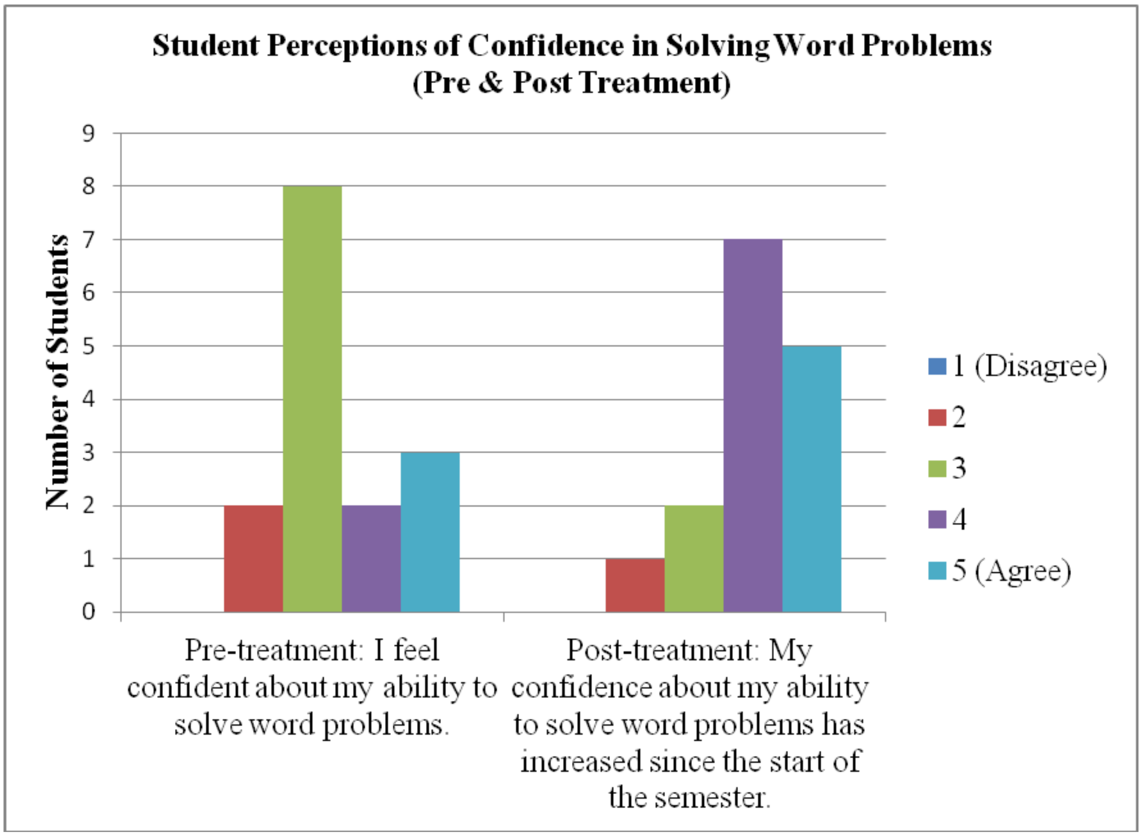

Figure 3. Student Perceptions of Confidence in Solving Word Problems, (*N* = 15).

In the interviews, three of the four students indicated that the problems that needed to be solved in physics were easier now and all four indicated that they felt more confident in their ability to solve the problems. Of these students, three of them not only felt that they increased in their confidence and abilities, but their test results matched their opinions. The only students whose results did not match was the lowest achieving male student, he was also the student that did not say that problems were easier to solve.

Of the three lowest achieving students in the class, two of them accurately pointed out that their confidence had not changed. The other student indicated that he did feel more confident, despite test results not agreeing with that statement. After the study was completed, the student did start to perform better on problem solving once he started doing homework and applying himself more, which leads to the revelation that he was always capable, but not putting forth enough effort.

On all three unit tests given during the treatment period, the majority of questions demonstrated an increase in student understanding (Appendix P). All pre-tests had one less student than the post-tests because a student was absent on the day they were given. On the last two tests given, students had the opportunity to use the FCD graphic organizer to solve problems on the test. On the electricity test, seven students used the organizer. Of those seven students, four of them used it to check answers (solved problems on paper and used the organizer), one of them used it only for the problem requiring an explanation and two used only the organizer. On the motion test, only three students used the organizer and it helped two of them in that they improved their score on the problem solving portion of the test as compared to the test prior.

Note-taking and New Material

Over the course of the study, most students experienced an increase in confidence in their ability to take notes and learn mew material.

In the interviews, all four students said that they felt more confident in their ability to learn new information than they did at the start of the semester, but most had a hard time identifying why. Three of the four students said that they felt more confident in their ability to read and take notes than they did at the start of the semester. All three students indicated that the use of the SSTG and reading guide were an important part of their progress. All three of them explained that the reading guide helped them figure out what was important and two even said that it helped them get in the habit of what to look for when reading in our class and other classes.

To start out the semester, the majority of students already felt somewhat confident in taking notes and they were already trying to connect what they learned to what they already knew (Figure 4). Over the course of the study, it was clear that while students said they knew how to take notes, the majority of notes taken were a list of bullet points without headings, indentations or even section labels. Also to start the semester, when students were asked to identify what they knew and thought they knew about a topic, they struggled to identify any prior knowledge.

In the post Likert scale survey of all students, 53% (eight out of fifteen) of the students indicated that their confidence in note-taking had increased since the start of the semester. In addition 67% of the students felt more confident in being able to build connections between the new information being learned and what they already knew. Both note-taking and building connections between new and prior knowledge are not things that students do automatically well on their own. They take teaching and practice (otherwise these students would already have been good at them!). By the end of the study, students' notes contained headings, indentations (outlines) and were also shorter than they were at the start of the study. Most students were also better able to identify any existing prior knowledge that they had about a given concept.

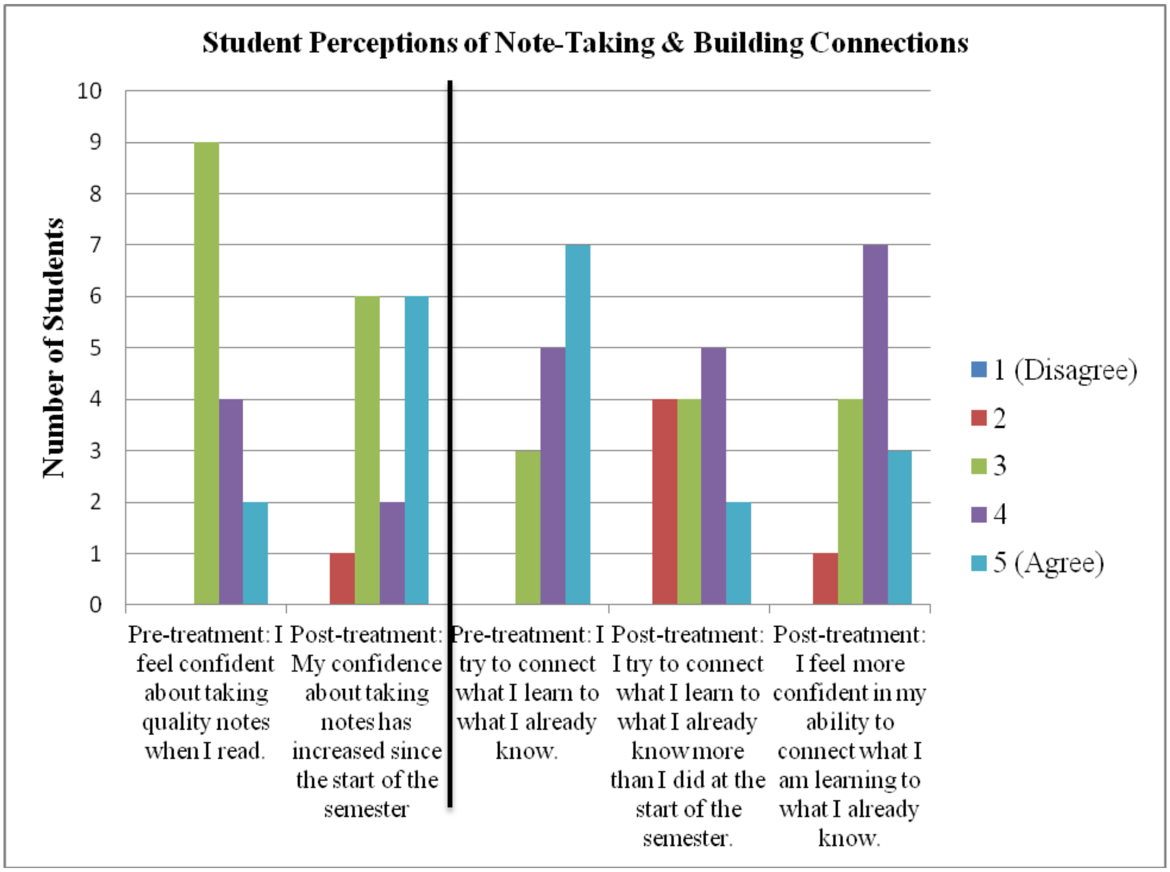

Figure 4. Student Perceptions of Note-Taking and Building Connections, (*N* = 15).

It could be argued that students' confidence in problem solving increased due to extra practice. However, the importance that students put on using the organizer when solving new problems does show that the increase is not only due to practice. It also shows that the organizer gives most students a boost of confidence at the start of the learning process. Some students (in this case, the lower achieving students) can benefit from the organizer through the entire problem solving process.

How do Graphic Organizers Affect Students' Ability to Access Prior Knowledge?

The process of learning new information is made much easier by having prior knowledge to build upon. It is important that students understand how this process works so that they can grow in their ability to learn.

Increase in Relevant Information Identified

As students continued to use the SSTG organizer over the course of the study, they grew in their ability to determine what information they knew that was relevant to what was being learning. Initially, students identified many irrelevant pieces of knowledge from material that was going to be read, rather than material that would address concepts to be learned. For example, when first learning about electrostatics, students turned the section headers into questions and then determined what they knew or thought they knew about each question. The information identified at that time was very surface level and general (Table 3). While some things listed were correct and deep, many were also either irrelevant or wrong. When making the class list, the teacher only listed each item once, but many students chose to focus on energy, lightning and gravity.

Table 3

Electrostatics Class "Know-Think We Know" chart from SSTG

Know	Think we know
- Lightning is electricity - Positive and negative attracts together - They are powerful (strong) - Has to do with gravity - Conductors such as power lines attract energy - Insulators do not attract energy - Electricity comes from many things - Negative, negative; negative, positive; positive, positive - Atoms have electrons and protons - Electrons are transferred - Electricity is conducted - Electrons transferred - Charge can travel - Positive and negative attracts together - Electricity is like lightning - It is used to help aid technology - Conductors can help transfer electricity - Gravity attracts you to the earth - Conductors flow through very long wires - All electrons are identical - Atoms have no net charge	- Static builds up in clouds when it storms - Electricity transfers through electricity - Electrons are transferred - Conductors easily transfer electricity - Dragging your feet across the ground is creating friction - Involved gravity - Made up of energy - Friction can cause a shock of electricity - Negative and positive ions are present - Bodies can make energy for electricity - Friction - Positive and negative = shock - Static electricity - Conservation is to put aside - Charges come together - Force of gravity - Conservation - Charge polarization - Positives are attracted to negatives - Charge can move from or travel - Insulators keep electrons neat inside of it. - Static electricity - Positive + negative = shock - Negative can't be together with another negative

As the students continued to use the organizer, the lists started to become less random and more focused. By the time the Motion Unit started, the students were able to focus on the objectives and spent less time going off on tangents to the information (Table 4). Even though the students were still incorrect about some of the ideas listed, the lists were focused on trying to determine what they knew about speed and acceleration more specifically and their examples came out of where they have experienced the concepts (cars, driving, etc).

Table 4
Motion Unit Class "Know-Think We Know" lists from SSTG

Speed Know/Think we Know	Acceleration Know/Think we Know
- Cars travel in speed - How fast it is going and the distance it's travel - Measured in mph - How fast something is traveling - Speed is how fast you go - Involved with motion - How fast - Speed is measured by how fast the wheels are moving - Speed can measure velocities - How far you go in a certain amount of time	- How fast something goes from stop to start - How fast something starts - Acceleration is how fast something is getting - Increase in speed is part of acceleration - Changing speeds (rate) - It gets faster/to go faster - Has to do with speed - Determines the speed of an object - When speed increases the acceleration increases - Motion of an object when falling downward - Motion of object when falling at same speed - All things fall at the same speed - To add up and keep track how fast you go - Monitor keeping track of speed - Acceleration is applying pressure to a pedal to move forward

At the beginning of the semester, most students said that they did try to connect what they learn to what they already know (80%). As can be seen from the tables, while students tried to make some of these connections to start with, they were often only surface-level or obvious. By the end of the study, students were able to make less obvious and deeper connections. During the post-treatment survey, 67% of students said that they felt more confident in their ability to make connections.

Students Need to Be Taught to Use Prior Knowledge

Even though 80% of students claimed that they tried to connect what they learn to what they already know on the pre-treatment survey, when the class started using the SSTG organizer, it became clear very quickly that they had a hard time determining the information that was relevant to the content. Referring back to Tables 3 and 4, the students' lists became more focused on the objectives and they were able to interpret the objectives given.

When the class started using the SSTG for the know-think we know lists, the teacher had the students turn section headings into questions to draw out their prior knowledge. When giving notes in class, the teacher would give her students the objectives that were to be learned from the lesson. What the teacher quickly noticed was that students were having a hard time understanding what an objective or question meant and how to determine what information they knew. When this was discovered, the teacher decided to spend more time discussing and explaining purpose of the objectives with the students before they made their lists. The teacher also gave more specific and limited objectives on which to focus.

At the end of the study, based on the post-treatment survey, 67% of the students understood how the different concepts that they studied connected and related to each other. One of the female students that was interviewed explained that, "every time we learn something there's a piece of what we learned last time, so that helps." Two of the students interviewed indicated that being able to relate and connect content to previously learned material helped to give a deeper understanding of the material.

As with many other topics, students need to be taught how to learn and how various methods of learning can be helpful to them. Students often struggle to explain their reasoning or identify what they might know, so guiding them along in the process is vital. The SSTG organizer, when explained and used appropriately, is one tool that can help students successfully build on their prior knowledge and make connections that allow them to learn content at a deeper level.

How Does the Use of Graphic Organizers Affect Students' Ability to Build Upon Prior Knowledge by Carrying Over Skills into Future Units?

Students often see different units of instruction as completely separate. When students are asked about a concept or skill from a prior unit they often fail to see why it is relevant. Therefore, the helping students use similar skills throughout units can improve their abilities.

Consistency in Learning

By using the same graphic organizers in each unit, students were able to find consistency in processing information which allowed them to carry forward the note-taking and problem solving skills that were used in each unit.

In a typical semester prior to using the graphic organizers, the teacher would need to re-teach students how to convert SI units in each unit of study. Through using the FCD graphic organizer, students only needed reminders that, during the "brainstorm" portion of the FCD, they may need to consider converting values. On each homework assignment and test, the number of students that had trouble converting values decreased. Also, over the course of the semester, students demonstrated growth in their note-taking abilities and had notes that were better organized and more thorough than at the beginning (Appendix Q).

When students first learned how to convert units and calculate slope, the goal was only to accomplish those two tasks. In the following units (Electricity and Motion), students needed to identify when to find slope or convert within a problem. For example, in the Electricity unit, a student would be asked to calculate the current through a circuit, but also need to convert the voltage before doing so. Also, in the Motion unit, students were asked to determine how fast a person was going based on a graph, which requires the students to connect that slope on a distance vs. time graph is equal to the speed of the person or object. Given this information, progress in understanding was not as much determined by an increase in performance, but rather maintaining performance. When students needed to convert a single unit (i.e. meters to miles), the performance decreased by fifteen percent on the electricity unit test, primarily due to forgetting to convert prior to solving the problem (Figure 5). By the time students got to the motion unit test, more students remembered to convert and converted properly. In terms of fraction unit conversions, (i.e. mi/hr to m/s) there was a fairly significant decrease in performance from the introductory unit to the motion unit, but all students who were ranked as a "1" on the chart forgot to convert the SI units before solving the problem. When students needed to calculate slope, there was an increase in students who fully understood how to calculate slope, and most of those who did it completely wrong, did not attempt to calculate slope, which implies that they did not connect speed to slope.

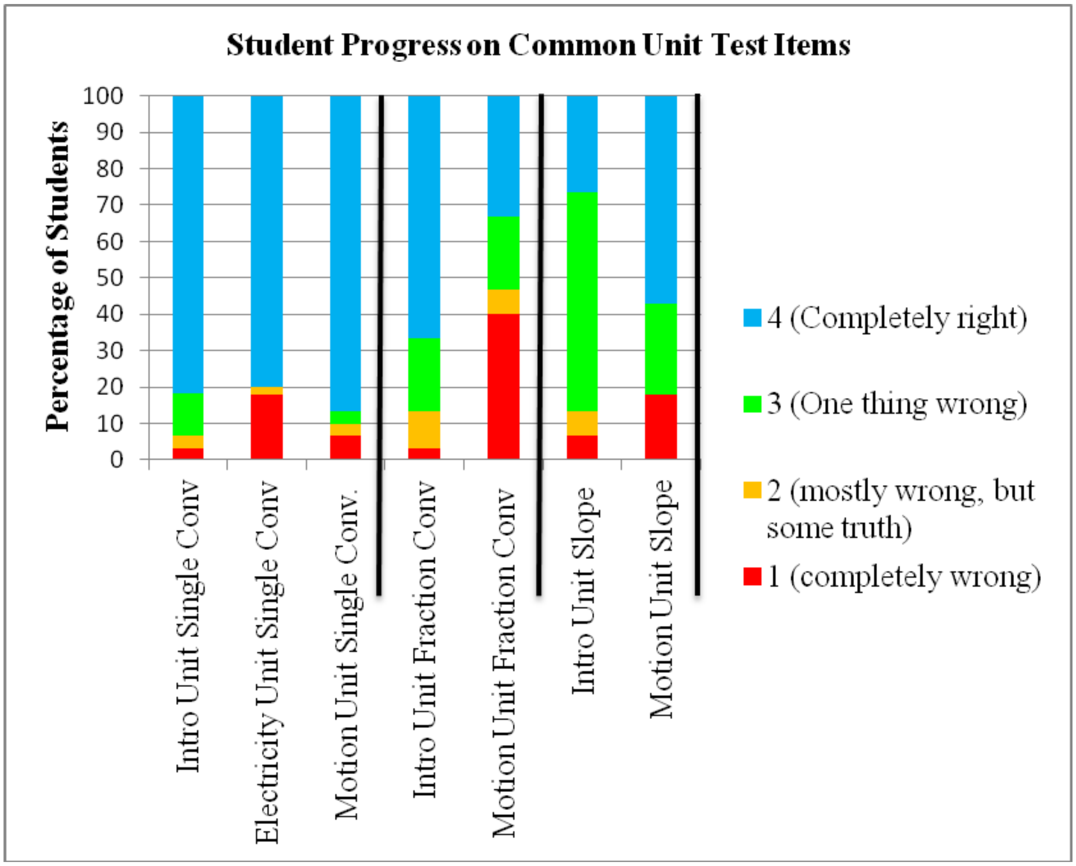

Figure 5. Student Progress on Common Unit Test Items, (*N* = 15).

Over the course of the Motion unit, students were given quizzes every other day to review material being learned. Over the course of the unit, twelve out of the fifteen students improved in their ability to use the speed equation (s=d/t), convert units, interpret graphs and calculate slope.

It could be argued that students simply have more practice with material and therefore perform better as time goes on. However, the repetition and familiarity of the graphic organizers allows students to have a common starting point for each unit to build up their skills and make connections.

How Does the Use of Graphic Organizers Affect the Teacher's Awareness of Student Progress?

Good teachers are constantly assessing student progress and finding ways to help students be successful. It is important for the tools that teachers use to not only help the students, but also inform the teacher of the students' progress.

Awareness of Who Needs Attention

By using the FCD graphic organizer, the teacher is more aware of students who need assistance than by students only filling in a worksheet. Since the students who tended to use the organizer were ones who struggled with the mathematical processes, the teacher was able to focus in on those students. The use of the graphic organizer also allowed the teacher to more quickly and clearly see the steps that the students were taking in solving the problem and together identify where the student was hitting road blocks. Over time, the amount and quality of work that students showed improved (Figures 6 & 7).

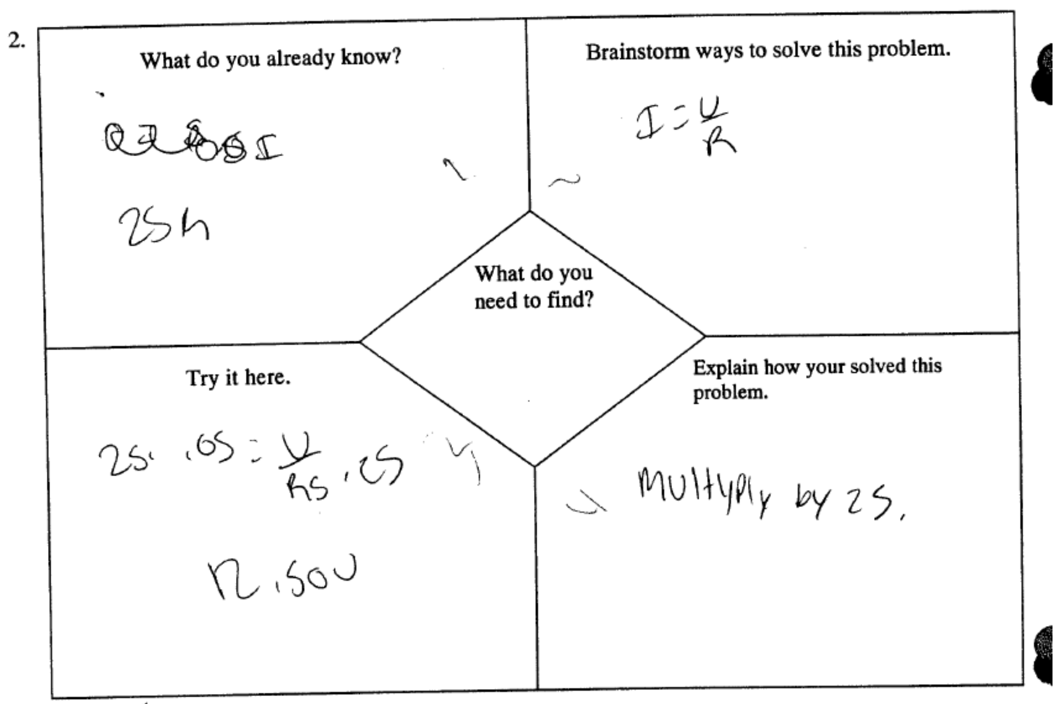

Figure 6. Initial FCD student work sample.

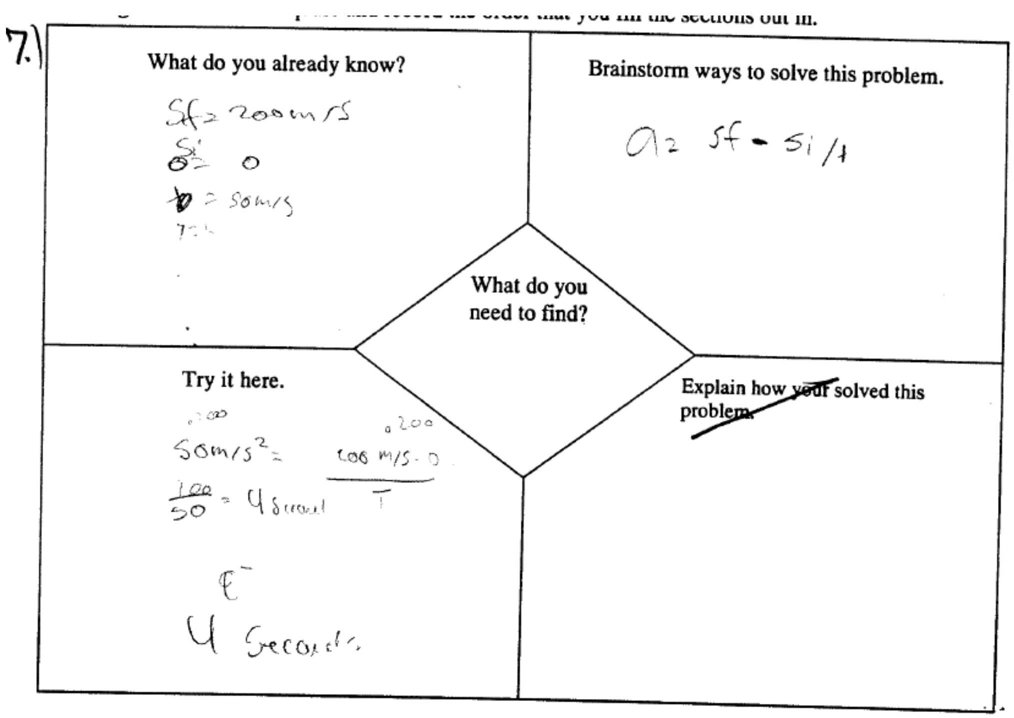

Figure 7. Later FCD student work sample.

The students who used the FCD organizer in class were students that tended to have a harder time with the math or just needed some extra checks in place to complete the problems. As time went on however, students became resistant to using the organizer unless the teacher forced them to use it for certain problems. The reasons behind this are not clear, but from the teacher's reflective journal on March 16th, she notes that "only four students did the assignment as required. Three additional students did the problems, but didn't use the organizer. This is becoming a larger problem. I'm finding that some students find the organizer helpful, but refuse to use it because it is different or takes a little more time…" On this given day, the students had been given four new problems to complete on acceleration and they needed to use the graphic organizer on at least two of them. Some other reasons why students may not have wanted to use it could be because the majority of the class was not using it, so in class they did not want to seem different.

The teacher spoke with two of the students who have a great deal of trouble with mathematical processes to determine why they were not using the organizer and they were not able to give a reason. The teacher tried to encourage the students to use the organizer because both students indicated that it was very helpful to them.

Even though the FCD organizer can be of great value to a teacher in determining what students do and do not understand or where they are struggling, more needs to be done to determine the roadblocks that are keeping students from using the organizer and how to combat these issues.

SSTG Organizer and Misconceptions

By using the SSTG organizer, the teacher gained a better awareness of how much information the students knew going into a unit and was also made more aware of the misconceptions that students had.

As the students gained more practice with using the SSTG organizer, the knowledge that they were able to draw out (right or wrong) increased. When first using the organizer, the information that students were identifying as “know or think we know” was very random and often unrelated. Even though this may not have given the teacher as much information as she hoped for pertaining to the unit, it did give the teacher insight into how the students learn and process information. It informed the teacher that she would need to spend more time addressing building connections with her students.

Even with the somewhat scattered list from the Electricity unit, the teacher was able to identify where she needed to do the most clarifying for students. As the study went on, the teacher noted in her journal,

> Today we started acceleration. I wrote the objectives up on the board for what students were supposed to know and had the students record what they knew/thought they knew about the objectives. I then had students pair up (as usual) and share their lists. I didn't have students write on the board this time, but instead just told each pair to pick just one thing to share out loud as a class. This method seemed to work the best yet. I'm not sure if students just finally felt more comfortable with the organizer or if they felt more comfortable with the method of giving information.
>
> As we discussed the organizer I found some very interesting information. Students had some interesting misconceptions about acceleration. Most of the students thought it was just a change in speed (like most students), but a couple of groups mentioned thinking that acceleration was just the starting or ending speed. By using the organizer I was able to see what my kids thought right away and address the differences between their thinking and what is correct.

By using the SSTG organizer the teacher was able to more quickly identify misconceptions that needed to be addressed immediately, some that could be addressed later in the unit, and also gain insight into what background information her students already had.

In the interviews, the students also echoed the thoughts the teacher had in class about establishing what is known before learning. One of the female students said that, "(SSTG) proves when you're wrong and shows a depth of what you know."

While other methods besides the SSTG organizer could be used to determine student prior knowledge and help them build connections, this organizer was a powerful tool for allowing the teacher to see misconceptions, accurate prior knowledge and progress in developing their skills to identify prior knowledge.

Both the FCD and SSTG organizers are tools to help students build connections, grow in their abilities and carry knowledge over into future units. While not all students will benefit from the structure of both of them, they are resources that can help students who have not been successful with more traditional methods.

INTERPRETATION AND CONCLUSION

This study sought to determine the effects of two specific graphic organizers on transitional level student learning. The SSTG organizer had a more broad reaching effect over all students, while the FCD organizer had a more limited effect on students.

On the whole, students felt more confident by the end of the study in their ability to make connections, take notes, and solve problems than they did at the start of the study. While one would hope for and maybe even expect those outcomes over the course of a semester or school year, the triangulation of data with interviews, pre and post surveys and pre/post tests, indicates that the SSTG and FCD organizers had a significant impact on increasing students' confidence. Multiple students alluded to the idea that connecting what you learn to what you know at the start of a unit helps to identify holes in knowledge and deepen existing knowledge. Even though not all students used the FCD organizer, those who were interviewed did state that the organizer was helpful when starting to learn a new problem or good to refer to if one got stuck.

At the start of the study, students had a hard time focusing in on the knowledge that they already had pertaining to the current topic of study. When filling out the SSTG alone and with a partner, students would identify any piece of information that they thought could even remotely relate to the section headings. By the end of the study, students had progressed and were able to focus in on what they knew about the specific objectives and section headings. It also was very apparent that the majority of students do not automatically have the ability to successfully identify and connect prior knowledge to a new content area being learned and that the teacher needs to take time to teach and model this process for students.

By using the same organizers for each unit, students were able to continually build upon and add to their skills. Because students were able to use the SSTG and FCD organizers through the entire study, they had consistency in how to process and connect new information as well as solve problems. Even though new information was added into each unit, the triangulation of data shows that most students were able to successfully build up their skills and apply them in the next unit of study. The teacher needed to do much less re-teaching of the information than she had done in the past.

Not only did the teacher have to do less re-teaching, but she was also more aware of where students stood in the class. Being able to see and hear students processing their relevant prior knowledge allowed the teacher to focus in on key areas that needed to be addressed and correct some misconceptions earlier than she had been able to in the past. The FCD organizer allowed her to identify which students were struggling and where they were struggling more easily than before, but it also raised some questions of why more students weren't taking advantage of the benefits of the FCD.

As with all studies, this investigation had some limitations and issues in its implementation. Perhaps the most significant limitation was the timing of the study. EMP is a one semester course and this study started about one week into the new course. While this did allow the teacher to get a true baseline of her students, she had the disadvantage of not having established a rapport with her students by the start of the study. Had the study occurred later in the semester, the teacher could have evaluated the students' needs better and altered how the data collection instruments were administered. In addition to the teacher not knowing the students very well, the students also didn't know the teacher yet. In EMP, trust is a very big deal for the students; if the students trust that the teacher has their best interests in mind, they will do just about anything asked. Because of the time limitations, the teacher was not able to establish this trust prior to the study and had to work the trust into the study. The greatest effect of these limitations is not having more definite results. Many of the results were dependent on other factors because the study could have used more time and more knowledge of the student's needs. The investigator still believes that the results are credible, but could have been solidified further with the removal of some of these limitations.

VALUE

The implementation of this study has made significant contributions to the classroom and how material is considered by the students and me. The students that this study targeted are known to have difficulty processing new information and carrying skills over to different units.

Through this study, I recognized that even though not all students used the FCD organizer, the questions that the FCD asks students while they process how to solve a problem can have a profound impact on student success. Multiple students in interviews commented that even though they did not use the organizer, the steps to the organizer helped them. These steps are the same as the typical problem solving method that we use, but they are worded as questions rather than statements. In the future, I will try out the two methods combined to see if there is any additional impact.

In future courses, using the “know/think we know” portion of the SSTG will continue in a similar capacity. The largest change will be in how it is introduced. More time will be spent modeling how I identify prior knowledge and then moving on to having the students try.

New questions have been raised that need to be addressed with these organizers and the transitional level students as well. More investigation needs to be done into why students are resistant to trying out a new method of learning (FCD) and how to successfully encourage students who find it helpful to use the method. Another issue to be addressed in the future is how to help students identify prior knowledge when the topic involves vocabulary that students are not familiar with.

For students who have been unsuccessful in the traditional methods of teaching and learning, organizers such as the SSTG and FCD can have powerful effects on changing the way that they think about and interpret content. These organizers allow students to realize that there is more than one way to think about learning and problem solving, and embrace the difference in needs that students bring into the classroom.

This action research study has not only given me insight into how my students build connections and access prior knowledge, but has also shown me the importance of being transparent with students about why they are being asked to do various tasks. Before using the SSTG and FCD organizers, I explained to students the purpose of the organizers. This was not done with the intent to skew data, but rather to answer the "why do we have to do this?" question that is so often asked.

Through this study, I have also become more aware of areas that I need to improve upon in my classroom and teaching. It is now easier for me to pinpoint what needs tweaking and then look to educational research and methodology for what could help in those situations. For example, in my regular level classes, students sometimes struggle to work successfully in groups and I know that is an area that I need to improve upon and use cooperative learning with more frequency.

Finally, I have always been passionate about professional growth opportunities and building up my toolbox for teaching strategies. This study has helped me focus my professional growth and seek more proof for what is and is not working in my classroom through data and student feedback. Next school year, I will be participating in an action research study in our district that involves cooperative learning in the classroom. I look forward to more opportunities to examine and improve upon my teaching of students.

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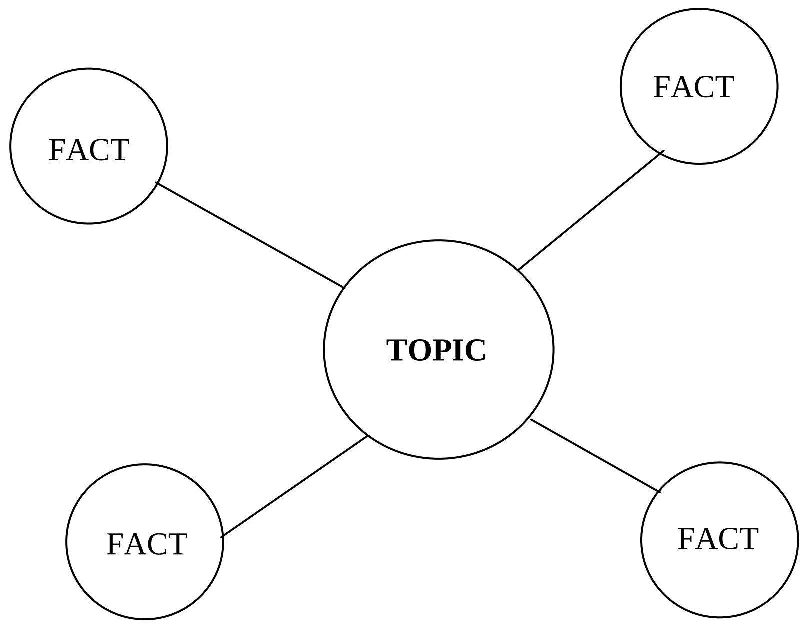
APPENDICES

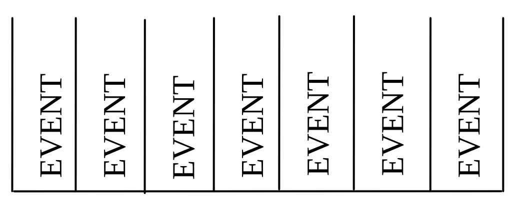
APPENDIX A

MARZANO GRAPHIC ORGANIZER FIGURES

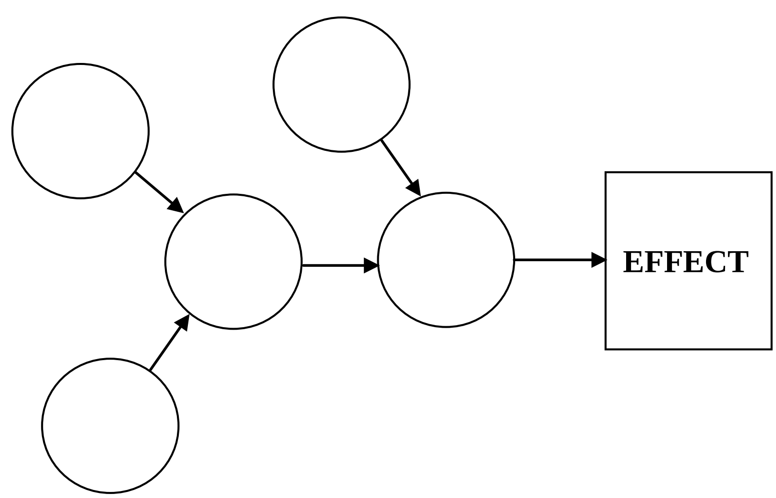
Descriptive Pattern Organizer (Marzano, 2007, p. 75)



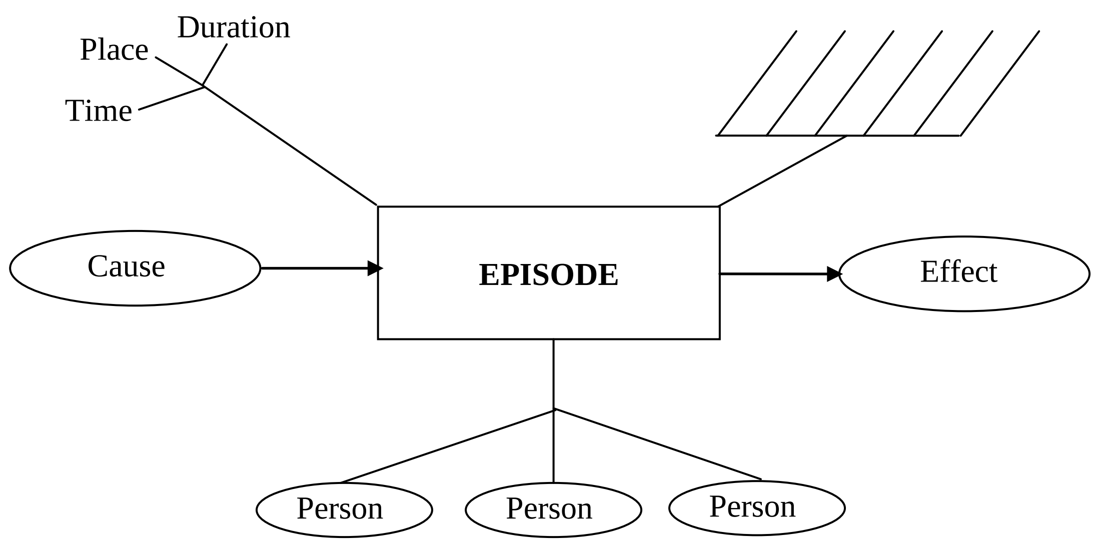
Time Sequence Pattern Organizer (Marzano, 2007, p. 76)



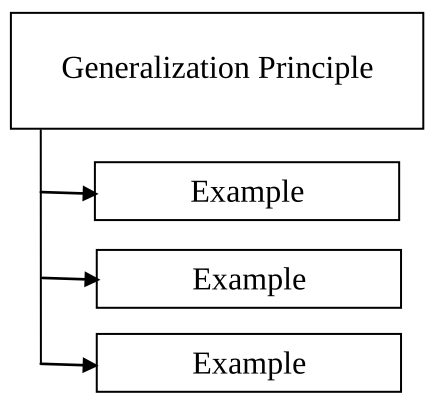
Process/Cause-Effect Pattern Organizer (Marzano, 2007, pg. 76)



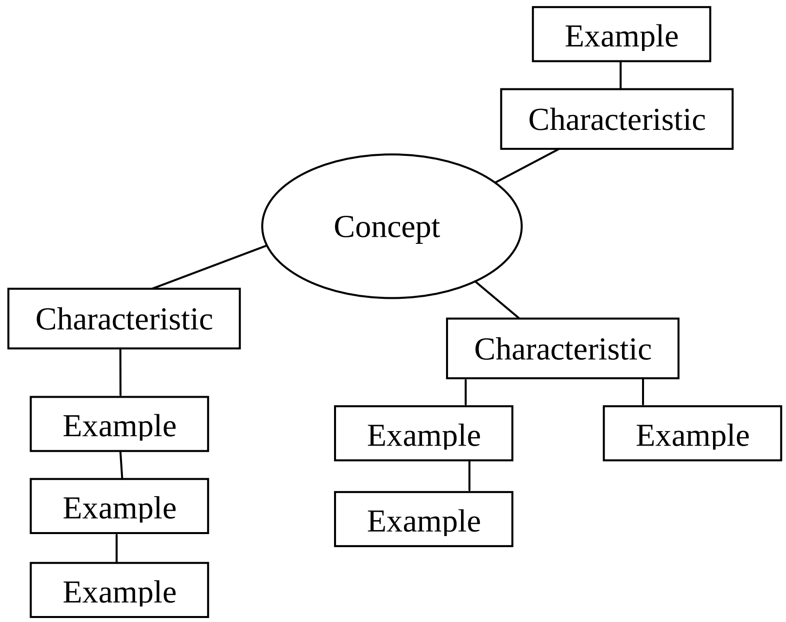
Episode Pattern Organizer (Marzano, 2007, p. 77)



Generalization/Principle Pattern Organizer (Marzano, 2007, p. 77)



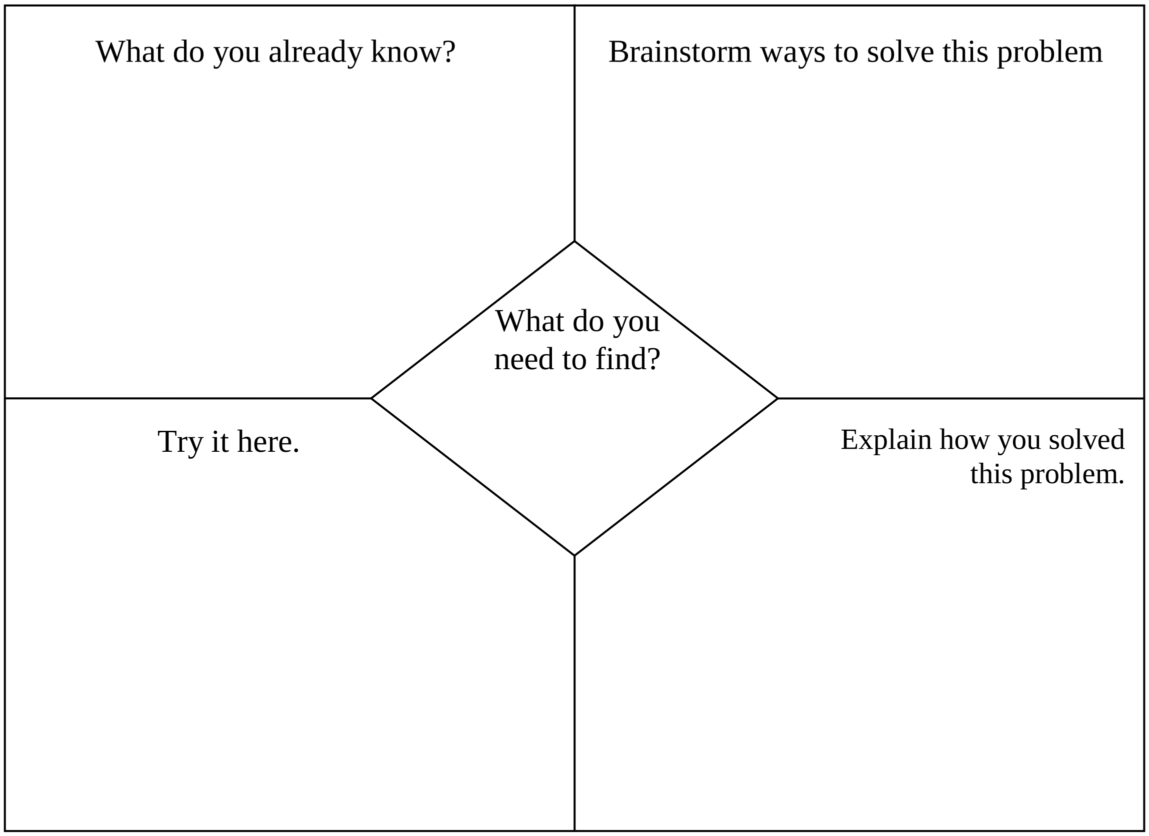
Concept Pattern Organizer (Marzano, 2007, p. 78)



APPENDIX B

FOUR CORNERS AND A DIAMOND GRAPHIC ORGANIZER

Directions: Use the organizer below to solve the problem given. You can complete the boxes in any order, but you need to put numbers in the boxes (1-5) of the order in which you complete them. (Adapted from Zollman 2009).



APPENDIX C

SSTG GRAPHIC ORGANIZER

Directions: As you read/take notes fill in the SSTG reading guide. (Adapted from Egan 1999)

A **What I know definitely**	**B** **What I think I know**	**C D** **Read / Verify**	**E** **Questions about the reading/notes**	**F** **Where to find answers**
1. ___________ 2. ___________ 3. ___________ etc.	1. ___________ 2. ___________ 3. ___________ etc.	May discuss with group/partner **+** means statement is correct **-** means statement is not correct **?** means not enough information is given to decide	1. ___________ 2. ___________ 3. ___________ etc.	1. ___________ 2. ___________ 3. ___________ etc.
Before reading or completing notes. Preview the reading. List the information that you definitely know about the topic	**Before reading or completing notes.** Preview the reading. List the information that you think you might know about the topic	**After reading or completing notes**. 1. Verify the whether the information in columns A and B was correct with a plus (+), minus (-) or question mark (?) 2. Add any new information that you learn to your first two lists in a different colored writing utensil.	**After reading or completing notes.** What questions do you still have about the topic? What questions have developed out of the reading/notes?	**After reading or completing notes.** Identify which sources can be used to find the information to answer your questions.

Record the answers to your questions when you find them below.

APPENDIX D

SSTG: ELECTROSTATICS

Name: _______________________________________

SSTG Organizer: Electrostatics

Directions: Pre-read to fill in columns A and B. While reading, use the outline to take notes. After reading, complete columns C/D, E and F. (Adapted from Egan 1999).

A **What I know definitely**	**B** **What I think I know**	**C D** **Read / Verify**	**E** **Questions about the reading/notes**	**F** **Where to find answers**
		May discuss with group/partner **+** means statement is correct **-** means statement is not correct **?** means not enough information is given to decide		
Before reading or completing notes. Preview the reading. List the information that you definitely know about the topic	**Before reading or completing notes.** Preview the reading. List the information that you think you might know about the topic	**After reading or completing notes**. 1. Verify whether the information in columns A and B was correct with a plus (+), minus (-) or question mark (?)	**After reading or completing notes.** What questions do you still have about the topic? What questions have developed out of the reading/notes?	**After reading or completing notes.** Identify what sources can be used to find the information to answer your questions.

Record the answers to your questions from column E when you find them below.

1. 32.1 – Electrical Forces and Charges (What are electrical forces and charges? What causes them?, etc)
    a. Main Idea(s):
    b. Definitions:
    c. Important ideas/concepts:
    d. Examples:
    e. Other:
2. 32.2 – Conservation of Charge (What is conservation of charge? What does it mean? Etc)
    a. Main Idea(s):
    b. Definitions:
    c. Important ideas/concepts:

d. Examples:

e. Other:

3. 32.4 – Conductor & Insulators (What are conductors & insulators? What do they do? Etc)
    a. Main Idea:

    b. Definitions:

    c. Important ideas/concepts:

    d. Examples:

    e. Other:

4. 32.5 – Charging by Friction and Contact (What is charging by friction & contact? How is it done? What are the results? Etc)
    a. Main Idea:

    b. Definitions:

c. Important ideas/concepts:

d. Examples:

e. Other:

5. 32.7 – Charge Polarization (What is charge polarization? How is it done? What are the effects?)
    a. Main Idea:
    b. Definitions:
    c. Important ideas/concepts:
    d. Examples:
    e. Other:

APPENDIX E

SSTG: ELECTRICITY

Name: ____

SSTG Organizer: Electricity

Directions: Pre-read to fill in columns A and B. While reading, use the outline to take notes. After reading, complete columns C/D, E and F. (Adapted from Egan 1999).

A **What I know definitely**	**B** **What I think I know**	**C D** **Read / Verify**	**E** **Questions about the reading/notes**	**F** **Where to find answers**
		May discuss with group/partner **+** means statement is correct **-** means statement is not correct **?** means not enough information is given to decide		
Before reading or completing notes. Preview the reading. List the information that you definitely know about the topic	**Before reading or completing notes.** Preview the reading. List the information that you think you might know about the topic	**After reading or completing notes**. 1. Verify whether the information in columns A and B was correct with a plus (+), minus (-) or question mark (?)	**After reading or completing notes.** What questions do you still have about the topic? What questions have developed out of the reading/notes?	**After reading or completing notes.** Identify what sources can be used to find the information to answer your questions.

Record the answers to your questions from column E when you find them below.

1. 33.5 – Electric Potential (What is electric potential? What does it do?)
   a. Main Idea(s):
   b. Definitions:
   c. Important ideas/concepts:
   d. Examples:
   e. Other:
2. 34.1 – Flow of Charge (What is flow of charge? What does it do?)
   a. Main Idea(s):
   b. Definitions:
   c. Important ideas/concepts:

d. Examples:

e. Other:

3. 34.2 –Electric Current (What is electric current? What does it do?)
    a. Main Idea:

    b. Definitions:

    c. Important ideas/concepts:

    d. Examples:

    e. Other:

4. 34.3 – Voltage Sources (What are voltage sources? What do they do?)
    a. Main Idea:

    b. Definitions:

c. Important ideas/concepts:

d. Examples:

e. Other:

5. 34.4 – Electric Resistance (What is electric resistance? What does it do?)
   a. Main Idea:

   b. Definitions:

   c. Important ideas/concepts:

   d. Examples:

   e. Other:

APPENDIX F

PRE-TREATMENT LIKERT SCALE SURVEY

Survey of Learning

*** Participation in this survey is voluntary and participation or non-participation will not affect your grades or class standing in any way.**

Rank the items below based on how much you agree or disagree with each statement.

	Disagree				Agree
1. Doing well in school is important to me.	1	2	3	4	5
2. I try to connect what I learn to what I already know.	1	2	3	4	5
3. I can explain to someone else how I solve problems easily.	1	2	3	4	5
4. I feel confident about taking quality notes when I read.	1	2	3	4	5
5. I feel confident about my ability to solve word problems	1	2	3	4	5

APPENDIX G

POST-TREATMENT LIKERT SCALE SURVEY

Name: ____________________

Final Survey of Learning

*** Participation in this survey is voluntary and participation or non-participation will not affect your grades or class standing in any way.**

Rank the items below based on how much you agree or disagree with each statement.

	Disagree				Agree
1. My confidence about taking quality notes has increased since the start of the semester.	1	2	3	4	5
2. My confidence about my ability to solve word problems has increased since the start of the semester.	1	2	3	4	5
3. I still understand how to convert units.	1	2	3	4	5
4. I understand how the different concepts that we study connect together.	1	2	3	4	5
5. I try to connect what I learn to what I already know more than I did at the start of the semester.	1	2	3	4	5
6. I feel more confident in my ability to connect what I am learning to what I already know.	1	2	3	4	5
7. I find the graphic organizer for solving problems to be helpful.	1	2	3	4	5
8. I use the graphic organizer when solving problems.	1	2	3	4	5

Comments:

APPENDIX H

PRE-TREATMENT INTERVIEW QUESTIONS

Preliminary Interview Questions

1. How is your semester going? What is going well?
2. What do you do (if anything) to prepare for reading?
3. What do you typically do to solve a mathematical problem?
4. How do you learn new information?
5. When you learn new information do you ever try to connect it to something you already know? If so, how?
6. What difficulties typically come up when trying to learn new information?
7. How confident are you in your ability to take notes in class and/or from a reading? Explain.
8. How confident are you in your ability to solve a word problem? Explain.
9. Anything else you want me to know?

APPENDIX I

POST-TREATMENT INTERVIEW QUESTIONS

Post Treatment Interview Questions

1. How have your learning habits changed since the start of the semester? Explain
2. Has formally connecting new information to something you already know helped you improve your learning? Explain yes or no.
3. Have you changed the way that you read and process new information in other classes as a result of this class?
4. Have you changed the way that you solve problems in math class as a result of this class?
5. What difference does it make (if any) to have a guide when you read or take notes?
6. What difference does it make (if any) to have the four corners and a diamond graphic accessible when solving problems?
7. Has your confidence in learning new material changed since the start of the semester?
8. What benefits do you see with connecting what you are learning to information you already know or learned in the class?
9. Has your confidence in your ability to take notes in class and/or from a reading changed since the start of the semester? Explain.
10. Has your confidence in your ability to solve a word problem changed since the start of the semester? Explain.
11. Anything else you want me to know?

APPENDIX J

INTRODUCTORY UNIT PRE-TEST

Name: ____________________
Date: ___________
Per: ______

Introductory Unit Pre-test

Directions: Answer each question as completely as possible. When even minimal mathematical work is necessary, show all work.

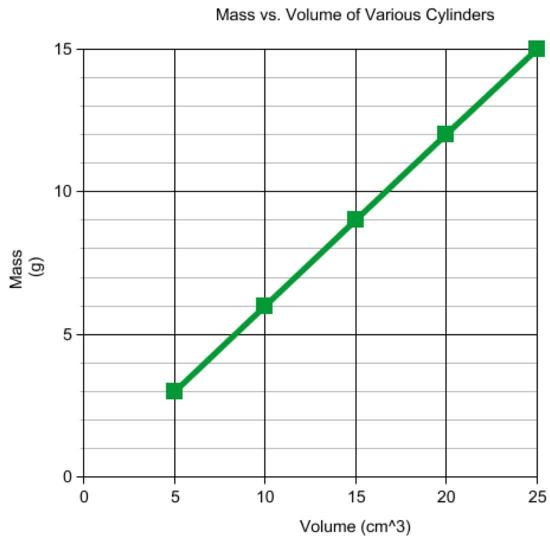
1. Convert 50 milligrams to grams.

2. Convert 10 feet into inches.

3. Convert 20m/s into mi/hr.

4. The city of Chicago is trying to determine if there is a more effective way to keep the streets from staying slippery than the standard salt that is used. They are comparing the usual salt (group A) with the sand (group B) as is used in Michigan.
    a. What are three things that the city needs to keep controlled to perform the experiment scientifically?
    b. What is the control group?
    c. What is the independent variable?
    d. What is the dependent variable?

5. Calculate the slope on the line on the graph below.



6. Describe the scientific process that scientists use to perform an experiment.

APPENDIX K

INTRODUCTORY UNIT POST-TEST

Name: ___________________________
Date: ___________________
Per: ___________

EMP: Introductory Unit Quest
(v1112.A)

Directions: Answer/solve each problem completely. Make sure that all work is shown (including fraction form work for conversions) and units are included on answers to receive full credit. Fully explain all responses to receive full credit.

1. If someone walks 200 fathoms, how far have they walked in feet?
   Path:

   Work:

   Answer: ___________________

2. Convert 65 grains to kilograms.
   Path:

   Work:

   Answer: ___________________

3. Convert 50 m/s to mi/hr.
   Path:

   Work:

   Answer: ___________________

4. Convert 150,000mg/barrel to kg/gallon.
   Path:

   Work:

Answer: ___________________

5. How many weeks are there in 1500 hours?
   Path:

   Work:

Answer: ___________________

6. 70 Calories of energy is equal to how many Joules?
   Path:

   Work:

Answer: ___________________

For problems 7-11 identify <u>the next step</u> that the scientist should take in the scientific process. *<u>Explain your reasoning</u>* for your answer completely and use complete sentences.

7. Cory just completed and analyzed the very first trial of her experiment, what should she do next?

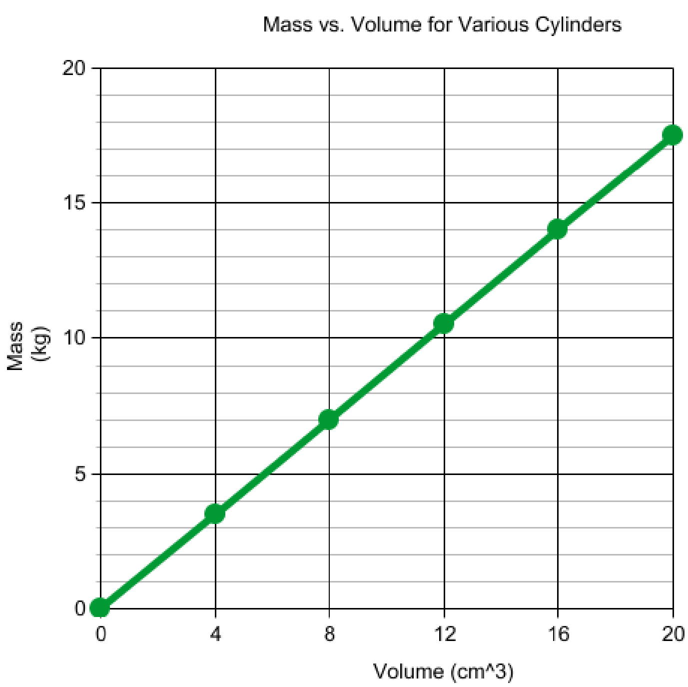
8. Annie has completed years of research on predatory animals and has hypothesized that the lower the body-mass index of an animal, the faster it can run. What should she do next?

9. A scientist's experiment has been repeated by hundreds of people and the results are always the same, what should he do next?

10. Karen wants to know if organic food really is better for your body. What should she do next?

11. Jordy just presented his findings from an investigation into extraterrestrial life at a national space conference, what should he do next?

12. Calculate the slope of the line on the graph below.



Work:

For problems 13-15 read the experimental information and respond to the questions.

13. Kayla is planting a garden and notices that the plants come with sunlight recommendations. She wants to know if these recommendations actually affect plant growth. She decides to test one type of plant. She uses three plants and places one in full sun (based on the directions), one in partial sunlight and one in the dark.
    a. What is the independent variable?

    b. What is the dependent variable?

14. Connor wants to know if ethanol gas makes a car more fuel efficient than regular gas. He drives the same car on one tank of ethanol gas and one tank of regular gas.
    a. What are **three** things that he needs to make sure are controlled (kept the same throughout the experiment)?

    b. What is the control group?

    c. What is the independent variable?

    d. What is the dependent variable?

15. Mrs. Statema read a new study about homework completion having no effect on student test performance. She decides to test if students who never do homework perform the same on tests as students who always do their homework. She monitors two groups of 30 students each. Group A does their homework every night and Group B does not do any homework. She finds that the students in group A scored 10% higher on the test than the students in group B.
    a. What is the independent variable?
    b. What is the dependent variable?
    c. What should Mrs. Statema conclude? Defend your answer.
    d. What should Mrs. Statema do next? Defend your answer.

16. In honor of the last question….. (this is not for graded points, but MUST be answered)
    a. How well did you feel that you understood the material coming into the test? (1-10, 1=understood nothing and 10= understood everything)
    b. How did you prepare for the test and for how long did you prepare? Be specific.
    c. How do you think you did on the test (please give a grade letter and explain).

APPENDIX L

ELECTRICITY UNIT PRE-TEST

Name: ______________________________

Pre-test: Electricity

Directions: Answer each question to the best of your ability.

1. What is voltage?

2. What is current?

3. What is resistance?

4. What powers a circuit?

5. What is a circuit?

6. What is an open circuit?

7. What is a closed circuit?

8. How much voltage is applied to a circuit with 10A of current going through a resistor of 30 Ohms?

APPENDIX M

ELECTRICITY UNIT POST-TEST

Name: __________________________
Date: _______________
Per: _______

Electricity Unit Test
EMP 1112.1

Directions: For any **multiple choice questions**, circle the ONE correct response and then explain your reasoning behind choosing the response (you will receive credit for both parts). For any problems **requiring explanation**, completely explain your response. For any problems requiring even **minimal mathematical work, all work must be shown to receive credit (in the manners indicated below).**

You must either use the steps below to solve the problem OR use the graphic organizer attached.

1. **Record givens & unknown(s)**
2. **Show fraction work for converting when necessary**
3. **Record equation to be used (with variables included)**
4. **Plug in numbers**
5. **Record answer with proper units.**

Good luck!!

1. List what three subatomic particles are found in an atom and what their charge is.

	Particle	Charge
1.		
2.		
3.		

2. Which of the following can move most easily from atom to atom?
   a. Protons   b. Neutrons
   c. Electrons

   Why did you choose the answer that you did?

   ____
   ____
   ____

3. The pie tins flew off the Van de Graaff generator because it was charged by which method?
   a. Conduction   b. Induction
   c. Friction   d. Polarization

   Why did you choose the answer that you did?

   ____
   ____
   ____

4. When you rub your feet with socks on the carpet to shock someone, you are charging yourself by which method?
   a. Conduction
   b. Friction
   c. Induction
   d. Polarization

   Why did you choose the answer that you did?

   ____
   ____
   ____

5. In problem number 4, if your feet end up with a negative charge, what is the charge of the carpet?

6. Fully state the law of conservation of charge.

7. When we used the electroscope and brought the charged rod near, the pin moved. When we took the rod away the pin went back to normal. Which of the following would explain what happened?
   a. Conduction
   b. Friction
   c. Induction
   d. Polarization

   Why did you choose the answer that you did?

   ____
   ____
   ____

8. Which of the following is an example of a conductor?
   a. Pure water
   b. Salt water
   c. Plastic
   d. Glass

   Why did you choose the answer that you did?

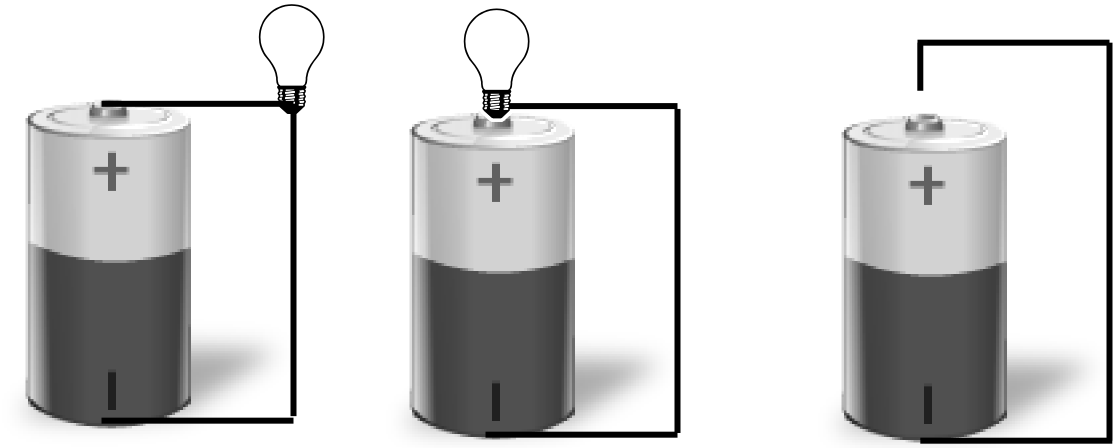
   ____
   ____
   ____

9. What can harm you about a circuit?
   a. Voltage
   b. Current
   c. Resistance

   Why did you choose the answer that you did?

   ____
   ____
   ____

10. Circle which of the diagrams below would actually cause the light bulb to light up.



Why did you choose the answer that you did?

____
____
____

11. What potential difference would cause a 50 mA current to pass through a circuit with a resistance of 1.7 Ω?

12. How much current would result if a voltage of 500 kV is applied to a circuit with a total resistance of 12,900 Ω?

13. A 5.8 Amp current passes through a wire. If the wire is hooked up to a 9 volt battery, compute the resistance of the wire?

14. How much voltage is causing a 0.050 amp current to pass through a lamp with a resistance of 1.5 kΩ? In words, completely explain how you solved this problem (as though you were explaining how to solve it to a friend).

15. What is the purpose of a circuit breaker in a circuit?

16. If I increase the resistance of a circuit and keep the voltage constant. What will happen to the current?

17. If I increase the voltage of a circuit and keep the resistance constant, what will happen to the current?

18. What is voltage?

19. What is current?

20. What is resistance?

21. What powers a circuit?

22. What is a circuit?

23. What is an open circuit?

24. What is a closed circuit?

Reflection

On a scale of 1-10 how well did you understand the material coming into today's test? (1 = not at all, 10 = very well)

What did you do to prepare for this test? How long did you prepare?

What grade do you think you earned on the test?

APPENDIX N

MOTION UNIT PRE-TEST

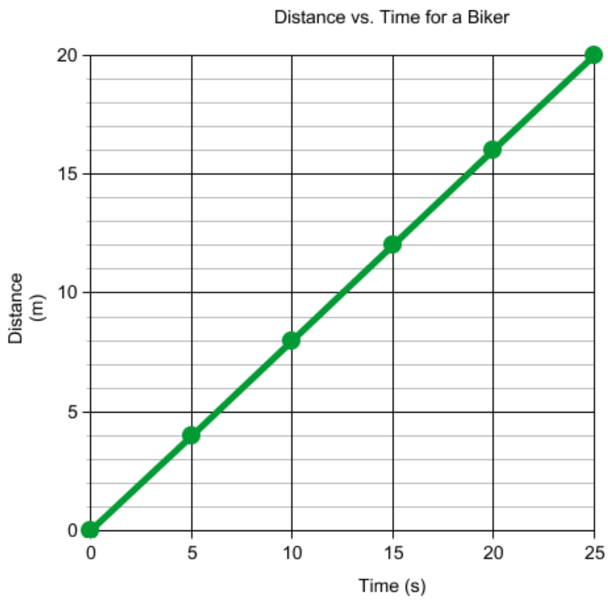
Name: ___________________________
Date: ___________________

Motion Unit Pre-test

Directions: Answer each question to the best of your ability. Show work where needed.

1. Define speed.

2. Find the slope of the graph below.



3. How fast is a person traveling if they run 15 meters in 3 seconds?

4. How far did someone travel if they ran at a speed of 7m/s for 2 seconds?

5. How long will it take someone driving 15 m/s to go 100m?

6. Convert 15m/s to mi/hr. (1 mi = 1609.344m; 3600s = 1hr)

APPENDIX O

MOTION UNIT POST-TEST

Name: ____________________________
Date: ________________
Per: _________

Motion Unit Test

EMP: s1112v.1

Directions: Answer each question completely. To receive full credit you must show **ALL** work. Answers must be rounded appropriately and in decimal form.
For any problems requiring even minimal mathematical work, you **MUST** either follow the steps below OR use the graphic organizer attached to receive full credit:

6. Record givens & unknown(s)
7. Convert and show work in fraction form (if necessary)
8. Record equation to be used (with variables included)
9. Plug in numbers
10. Record answer with proper units.

Good luck!!

1. Sally drove to the store 10 miles away in 3 minutes. What was her speed in miles/minute?

   Givens & Unknown: **Conversions:**

   Equation & Work:

   Answer:____________________

2. Convert Sally's speed from problem #1 to miles per hour.

   Path:

   Work:

   Answer: _____________________

3. How fast was a car initially travelling, if it is going 50m/s after accelerating at a rate of $3.5 m/s^2$ for 6.5s?

   Givens & Unknown: **Conversions:**

   Equation & Work:

   Answer:____________________

4. How far does a horse trot in 15 minutes at a speed of 5 mi/hr?
Givens & Unknown: **Conversions:**

Equation & Work:

Answer:____________________

5. A rock is dropped off of a tall cliff. How fast will it be falling after 25s? AND fully explain how you solved this problem.
Givens & Unknown: **Conversions:**

Equation & Work:

Answer:____________________

6. How long will it take a car to travel 50 miles at a constant speed of 30mi/hr?
Givens & Unknown: **Conversions:**

Equation & Work:

Answer:____________________

7. How long will it take for a plane to accelerate from rest to 200m/s at a rate of $50m/s^2$?
   Givens & Unknown: **Conversions:**

   Equation & Work:

   Answer:____________________

8. What is the rate of acceleration of a car that accelerates from 11m/s to 60m/s in 7.8s?
   Givens & Unknown: **Conversions:**

   Equation & Work:

   Answer:____________________

9. A train accelerates at a rate of 7m/s/s for 5s. If the train starts a speed of 15mi/hr, how fast is it going at the end of the 5 seconds?
   Givens & Unknown: **Conversions:**

   Equation & Work:

   Answer:____________________

10. "The fastest that an object can fall through air" would be a good definition for which term?
    a. Speed
    b. Acceleration
    c. Terminal velocity

11. If an object's speed changes from 30 mi/hr to 150 mi/hr it has a…
    a. Low acceleration
    b. High acceleration
    c. Not enough information was given to finish the sentence.

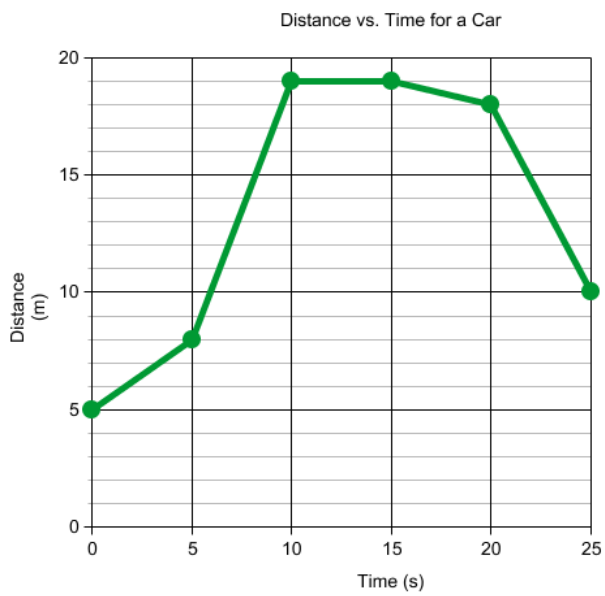
    Explain why you believe that the answer you chose is correct.

    ____

    ____

    ____

12. Use the graph below to answer the following questions.



    a. How far does the car travel from 5-20s?

    b. During which time interval is the car stopped? How do you know?

    c. During which time interval is the car traveling the fastest? How do you know?

    d. During which time interval is the car traveling the slowest, but still moving? How do you know?

    e. How fast is the car traveling from 20-25s?

    f. How fast is the car traveling from 0-5s?

13. Define acceleration:

____
____
____

14. Define speed:

____
____
____

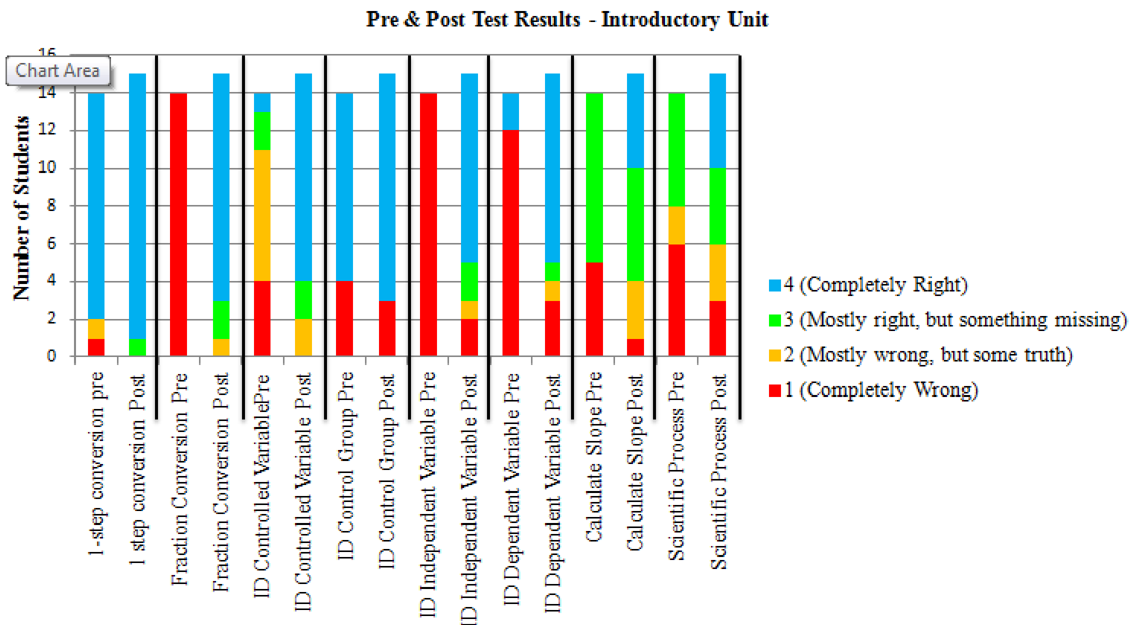
15. As an object falls, it…
    a. Travels at the same speed the entire time
    b. Speeds up
    c. Slows down
    d. Stops

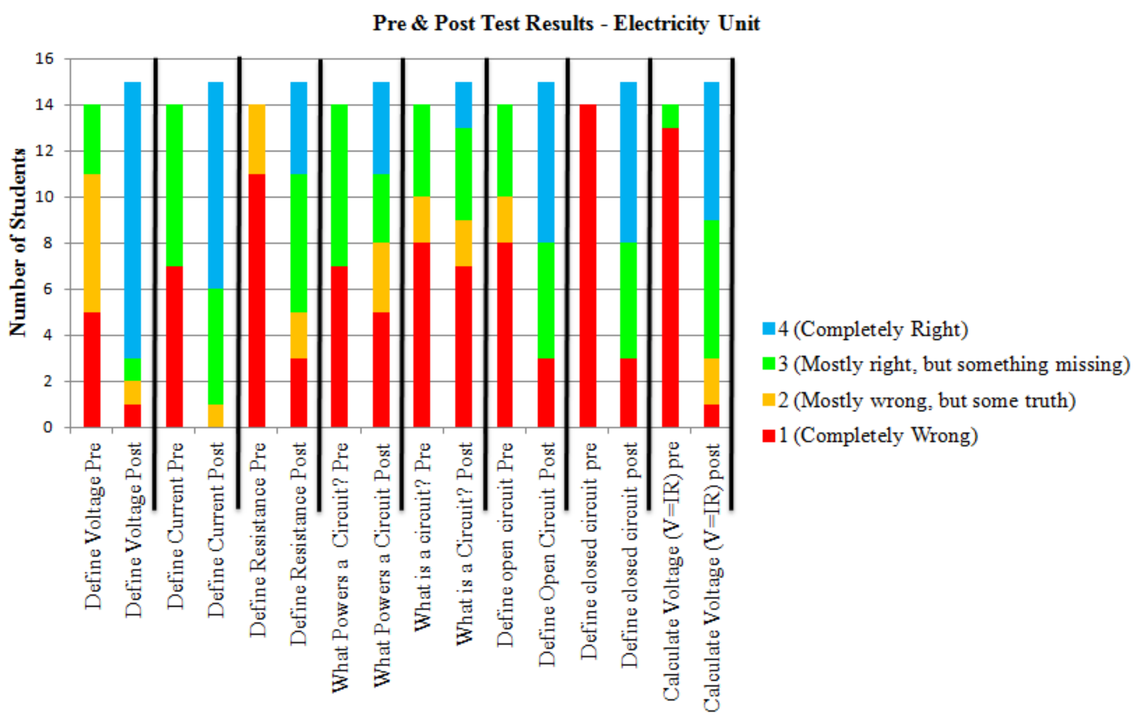
16. For Mrs. Statema's information…
    a. How well did you feel you understood the material coming into this test? (Scale 1-10, 1=not at all, 10=fully) EXPLAIN.
    b. How did you prepare for today's test? How long did you prepare? BE SPECIFIC. A response of "I studied" is not acceptable…what did you do to study?
    c. What grade do you think you earned on the test?

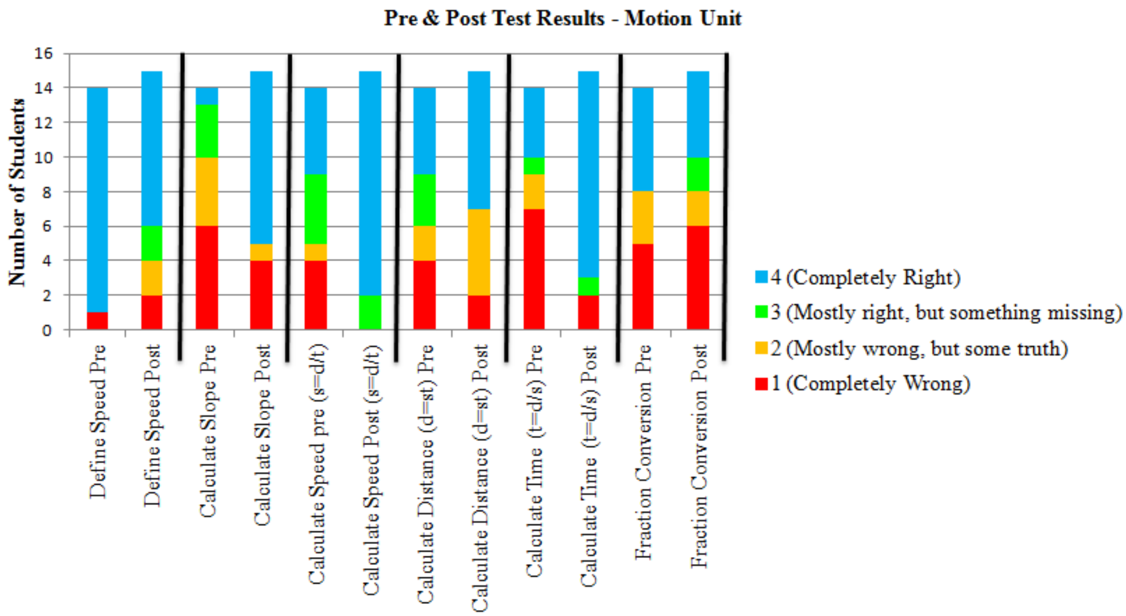
******DON'T FORGET TO CHECK TO MAKE SURE YOU SHOWED ALL WORK AND INCLUDED ALL UNITS!!!!*****

APPENDIX P

PRE- & POST-TEST RESULTS


Pre & Post Test Results - Introductory Unit
Chart Area
Number of Students
0
2
4
6
8
10
12
14
16
1-step conversion pre
1 step conversion Post
Fraction Conversion Pre
Fraction Conversion Post
ID Controlled VariablePre
ID Controlled Variable Post
ID Control Group Pre
ID Control Group Post
ID Independent Variable Pre
ID Independent Variable Post
ID Dependent Variable Pre
ID Dependent Variable Post
Calculate Slope Pre
Calculate Slope Post
Scientific Process Pre
Scientific Process Post
4 (Completely Right)
3 (Mostly right, but something missing)
2 (Mostly wrong, but some truth)
1 (Completely Wrong)


Pre & Post Test Results - Electricity Unit
Number of Students
0
2
4
6
8
10
12
14
16
Define Voltage Pre
Define Voltage Post
Define Current Pre
Define Current Post
Define Resistance Pre
Define Resistance Post
What Powers a Circuit? Pre
What Powers a Circuit Post
What is a circuit? Pre
What is a Circuit? Post
Define open circuit Pre
Define Open Circuit Post
Define closed circuit pre
Define closed circuit post
Calculate Voltage (V=IR) pre
Calculate Voltage (V=IR) post
4 (Completely Right)
3 (Mostly right, but something missing)
2 (Mostly wrong, but some truth)
1 (Completely Wrong)


Pre & Post Test Results - Motion Unit
Number of Students
16
14
12
10
8
6
4
2
0
Define Speed Pre
Define Speed Post
Calculate Slope Pre
Calculate Slope Post
Calculate Speed pre (s=d/t)
Calculate Speed Post (s=d/t)
Calculate Distance (d=st) Pre
Calculate Distance (d=st) Post
Calculate Time (t=d/s) Pre
Calculate Time (t=d/s) Post
Fraction Conversion Pre
Fraction Conversion Post
4 (Completely Right)
3 (Mostly right, but something missing)
2 (Mostly wrong, but some truth)
1 (Completely Wrong)

APPENDIX Q

NOTE-TAKING EXAMPLES

Pre-treatment notes

Notes on Scientific Method

-scientific method = 4 steps
· hypothesis
· experiment
· analysis
· conclusion.
- all science begins with a single focused question/problem example - "which enzyme makes a reaction go faster.
- the question searches to find the relationship between cause and effect (x→y)
- the next step is doing the research.
- after reasearching and learning everything the next step is to make a hypothesis.
· Hypothesis is an "educated guess"
· the most fun part is the expiermental design.
· Experiments must be designed and planned.
- doing the experiments is very expensive because some material costs billions of dollars in that case scientists have to find alternative ways to experiment.
- Safety is critical.
- there are rules for the use of live animals in experimentation.
- Making observations or gathering data can take lots of time.
- The expirement must be reproducible.
- Phenomena such as this lie outside of science cannot be falsified.

- Experiments should be repeated many times by the reaserer in order to get the correct results.
- the # of times that an experiment is repeated depends on a number of factors.
- Experiments can be altered while they are being run if the scientists decides it is flawed or not really measuring to whats though it was measured.
- careful process which is analysis.
· Graphing the data becomes an important tool in analys
- the analysis should and will be the end end products which leads to the conclusion.
- the conclusion is the answer to the problem.
- if the hypothesis and experiment don't match up the scientist has to go back and say that his or her hypothesis was wrong.
- If the hypothesis is correct the scientist must communicate these findings
- a journalis a proffesical magazne which scientists use to publish their work.
- Publication is important because it determines who gets credit for the experiment,
- Peer view is when another scientist does your experimentand see's wheter or not your hypothesis is correct
- a scientific theory, as hopefully is a powerful statement.

Post-treatment notes

3. 34.2 –Electric Current (What is electric current? What does it do?)
   a. Main Idea:
   Electric current is simply the flow of electric charge.
   b. Definitions:
   conduction electrons - electrons that are free to move throughout the atomic network.
   ampres - eletric current measured.
   c. Important ideas/concepts:
   - In a solid conductors the electrons carry the charge through the cricuit. because they are free to move through the atomic network. SI units is "A"
   d. Examples:
   In fluids, such as the electrolyte in a car battery, positive and negative ions.
   e. Other:

4. 34.3 – Voltage Sources (What are voltage sources? What do they do?)
   a. Main Idea:
   Charges do not flow unless their is a potential diffrence.
   b. Definitions:
   voltage source - something that provide a potential diffrence.
   c. Important ideas/concepts:
   - a sustained current requires a suitable electric pump to provide a sustained potential diffrence.
   - If a charge a large sphere positively, and another negatively, you develop a large voltage between them.
   d. Examples:
   e. Other: