THE EFFECT OF GUIDED INQUIRY ON MIDDLE SCHOOL STUDENTS' UNDERSTANDING OF SCIENCE CONCEPTS

by

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STATEMENT OF PERMISSION TO USE

In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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ABSTRACT

This project focused on the utilization of the 5E method on student understanding of middle school physical science. The 5E model of instruction has shown to be a valid method for students to gain understanding through an active participation in their own learning. When compared to a traditional method of learning, such as using lecture, note taking, and annotating this study showed the 5E method can yield positive results in student understanding, long-term memory, student motivation and teacher motivation. The traditional method, however, can prove to be effective in increasing student understanding and long-term memory as well.

INTRODUCTION AND BACKGROUND

The focus of this action research project was to determine if students learn best, and are able to retain that which is learned better, using guided- inquiry methods compared to a more traditional model. The guided-inquiry method I used was the 5E model. The 5E model developed by the Biological Sciences Curriculum Study included the steps Engagement, Exploration, Elaborate, Explain, and Evaluate (Bybee et al., 2006). When combined, these steps offer a potentially powerful tool to help students learn effectively. From experience, I understand that when students get involved in their own learning, it allows them to learn more, to have more motivation to learn and to retain the information learned longer. Guided- inquiry is a tool that helps students explore new science content and develop a conceptual understanding of the new material learned. The students are then able to apply what has been learned to other situations. My motivation for doing this project stemmed from my students' apathy for their education. In the past few years I felt as if students simply came to school looking to fulfill a social instead of an academic need. More and more I have noticed a drop in grades and interest in my science students. My hope was to use this 5E method as an intervention to get my students motivated to learn.

The middle school where I teach physical science has about 1200 students in sixth, seventh, and eighth grades. There is a high population of free and reduced lunch students with a mix of Latino and Caucasian students with an equal amount of boys to girls, which is similar to my class demographics. In my classes one third of the students are special needs.

My project focus question was: What are the effects of using guided- inquiry lessons that utilize the 5E method on student understanding of middle school physical science? My project subquestions were: what are the effects of guided inquiry lessons with the 5E method on long-term memory of concepts?; what are the effects of guided inquiry lessons and activities on middle school students' motivation?; and what are the effects of using guided- inquiry lessons on my attitude and my motivation as a science teacher?

The support team that I have for this project includes Phyllis Atkinson, fellow science teacher, who did my proofreading, Terrill Paterson who volunteered to be my reader, and Jewel Reuter, Ph.D. was my advisor.

CONCEPTUAL FRAMEWORK

The effectiveness of a particular learning method on student understanding has to start first with an understanding of how students think. John Dewey wrote on the subject of critical thinking. Critical thinking allows for a student to reflect on his own thinking about a topic. Dewey encouraged the student not to be judgmental, but to be skeptical and to keep an open mind. Dewey also maintained that students must be taught how to question, examine and reflect. Ultimately, success comes from learning from ones mistakes (Dewey, 1910).

In regards to how students learn Jean Piaget adds that students at differing age levels learn material in different ways. All students, however, must build upon previous knowledge. If there is no previous knowledge about a particular concept a student must assimilate or use existing knowledge to be able to make connections to the new material.

Students will at times need to change or accommodate existing knowledge to fit the new information they are learning. In this process students find equilibrium where they are in balance and are able to make connections to the new material being learned (McLeod, 2009).

Lev S. Vygotsky also looked into how students learn. He found that students learn in settings where students work together helping to construct new ideas and mannerisms. Vygotsky described this as social constructivism. Students work together to construct their reality through meaningful learning scenarios where students are engaged in social activities such as team or group learning (Vygotsky, 1978).

From Piaget's work Robert Karplus was able to reveal a learning cycle method. Karplus describes this cycle as having three phases including the Explore, Introduction of Concepts, and the Application of Concepts phases. The learning cycle method allowed for students to explore a science concept during an activity. From the exploration phase students would be introduced to vocabulary of the concept as well as be involved in a discussion of the students' discoveries. The third phase has students apply that which they had learned to new situations (Karplus, 1977). The 5E model of instruction stems from these practices. Balci et al. (2005) showed that when students were engaged in guided-inquiry activities implementing the 5E model they were unable to explain phenomena that they experienced by their background knowledge. This produced disequilibrium in the students. After reflection and discussion students were able to find connections with the activities they engaged in and build knowledge and understanding.

Research shows that students learn more using an inquiry approach. Guided-inquiry allows students a way to make connections between new material being learned

and their background knowledge that they have when they arrive in class (Owens, 2009). From the literature that I investigated, a common theme emerged: active learning is more productive than traditional teacher led, lecture style, teaching and instruction (Bybee et al., 2006) (Owens, 2009) (Hinde & Kovac, 2001) (Hanson and Wolfskill, 2000). Guided inquiry allows for students to be actively engaged in their learning which encourages increased understanding.

In my research of the literature on the effectiveness of guided inquiry, I focused on the 5E learning cycle model. I then considered each topic of my project questions and the methods that would help me to design and implement my capstone project.

The 5E model, developed by the Biological Science Curriculum Study (BSCS), led by Rodger Bybee , uses a five step process to get students to actively learn in a guided- inquiry setting (Bybee et al., 2006). The model utilized an engagement method to illicit students' background knowledge and helped to focus the student on the content of study. Then, the model employed an exploration strategy allowing for the student to investigate a problem. The explanation stage followed. Here students were able to explain their understanding and also allowed for a teacher to share a concept that related to the students' findings. Next, the elaboration phase took place, and a teacher challenged his students to apply their newly learned knowledge to new situations. Finally, the evaluation stage allowed for both student and teacher to assess the learning that had occurred.

Bybee (2006) and his fellow researchers found that science education is enhanced with an active learning approach. When the 5E method is used, students' understanding of science concepts increases as well as does their retention of these concepts over time.

In an active learning model it is best that a teacher takes the role as facilitator, helping students formulate ideas and science concepts and helping the students correct their misconceptions. This is done by posing a question that the students work to answer through investigation and exploration and attempting to steer students away from inaccurate conclusions and misconceptions.

In regards to student understanding, research on guided-inquiry shows that students that participate in guided-inquiry lessons have greater understanding when compared to traditional learning methods. Chemistry students at the university level performed better on tests after active learning lessons were used especially when coupled with high attendance rates (Hinde & Kovac, 2001) and short focused lectures (Hanson and Wolfskill,2000). One study done on eighth- grade science students, studying genetics using a 5E learning cycle model, demonstrated that the students had a significantly higher understanding of concepts when compared to that of a traditional teaching model (Dogru-Atay & Tekkaya, 2008) . Another study on 8th grade students' understanding of photosynthesis concepts was done by Balci et al. (2005) and found that student understanding also improved significantly by using the 5E method of instruction but found that students still held onto certain misconceptions about photosynthesis and respiration (Balci et al., 2005). Not only does the 5E model increase knowledge and understanding of college students and teens but of children also. Lin et al. (2013) designed a project to test the effectiveness of the 5E model on 4th grade students and found that by using the 5E method of instruction strategies students' understanding and knowledge of aquatic plants increased.

A study of college level chemistry students, demonstrated that when students are in the active learning setting where guided-inquiry is being utilized test results showed improvement on long-term memory. It was also found that when students were taught using active learning methods classes, they did better in subsequent chemistry classes (Phillips & Grose-Fifer, 2011). The results of a study on introductory engineering students done by Kvam (2000) show that there is an increase in long-term memory with the students that have average and below average scores who participated in active learning methods. Kvam states that, "By its nature active learning should encourage deeper learning, thus enhance long-term memory" (p.136).

Students' attitude and motivation can also be positively affected by using the 5E model of instruction. Fourth grade students using the 5E model of guided inquiry demonstrated that they loved using such methods for learning about aquatic plants and also really enjoyed sharing their discoveries (Lin et al., 2013) In regards to student motivation Hanson and Wolfskill (2000), using a guided-inquiry method, reported that in their study of college science students 83% of the students tested felt that active learning helped them to learn and understand the course material more thoroughly than alternative methods. When student's see that a method helps them understand it will increase the students' motivation to learn as well as positively affect the students' attitudes. One study done on college students indicated that having been involved in an active learning setting, found that students were much more motivated and engaged in their learning (Cano et al., 2011).

With respect to teacher motivation, Tessier demonstrated that guided- inquiry lessons taught to preservice college students in teacher programs showed a result that

participants are more comfortable with a guided -teaching method when they have had experienced it in numerous occasions (2010). This impacts teacher motivation in a positive way helping teachers to have an amiable attitude for the content as well as the methodology they are to be using to teach science (Tessier, 2010). Bybee's study also indicates a positive attitude from teachers who utilize such methods (Bybee et al., 2006).

Teachers have to learn how to write 5E method lessons properly to increase student learning. Instead of simply teaching students the scientific method to learn science, the 5E model should be implemented in the classroom to help students' understanding increase as they combat against misconceptions (Bilica, 2011). Goldston et al. (2012) developed a method to help teachers tailor lessons to fit the needs of their individual classrooms by utilizing rubrics to assess teacher's lesson plans using the 5E model and to assess the validity of each portion of the 5E model and how it is visualized in the classroom. This study aids the instructor in identifying each phase of the 5E model in a lesson and to properly transition between them.

As a method of guided –inquiry the 5E model, when used properly, it can affect student learning at the middle school science level positively. These methodologies positively impact teacher and student motivation as well as long-term retention of science concepts and skills.

METHODOLOGY

Project Intervention

This research project included one nonintervention and three intervention units for comparison. The nonintervention unit, on heat energy, took one and a half weeks to

accomplish. Each of the three intervention units, sound energy, electricity, and kinetic and potential energy, took one and a half weeks to accomplish. During the non-intervention unit, I taught lessons on heat energy in a lecture fashion. I used PowerPoint presentations while students copied notes onto guided note takers. Most of the sections of the unit were taught using modeling and demonstrations while students copied notes and observations. An example of the nonintervention lesson is found in Appendix A**.** The instruments I used to collect data for student understanding were pre and postunit assessments, pre and postunit interviews, and pre and postunit surveys. These were used to measure the students understanding, while delayed tests, interviews and surveys were used to determine long- term memory and motivation. During the nonintervention unit, the students were limited to very few group activities keeping them in a teacher centered style of learning and instruction. The nonintervention unit started with a preunit assessment on content given to every student. An example of the nonintervention unit pre, post and delayed assessments on heat energy used are found in Appendix B. The assessments students took on heat energy at all stages were exactly the same. The five questions on the assessment focused on the properties of heat including conduction, convection and radiation. The students explained their understanding of the concepts as a constructed response. All students took a preunit survey on content used to get data to measure the students' motivations and understanding of concepts. The survey used a Likert scale response method which allowed students to rate their level of understanding. An example of this survey is found in Appendix C.

Instructor field observations were collected on student's motivation during classes. The observation instrument I used allowed for me to rate students based upon

perceptions of their attitude, desire and engagement. An example of the sheet used for collecting data on field observations is found in Appendix D. Six students, based on high, medium, and low- achievement levels, were interviewed after school to collect data on the student's motivation and understanding. Interview questions allowed for me to access students' understanding and attitude about heat energy in a setting where I could have them expound upon or clarify a particular concept if necessary. An example of the interview is found in Appendix E. After the unit on heat energy, a postunit assessment was given to all students and data were collected. These data were used to measure understanding of concepts. A delayed assessment was given to the students two weeks after the completion of the unit to measure for long-term memory and retention of concepts.

To measure long-term memory postunit surveys and interviews were given at the end of the unit 14 days later. The same six students were interviewed and all students took the survey. The post and delayed surveys and interviews were the same as the pretreatment surveys and interviews. During the nonintervention unit, I reflected in a journal using prompts that had me rate my attitude about students and the activity that we had just finished. Prompts also had me rate how well the strategies were used and if the intervention goals made an impact on students learning and if goals were met. A peer observer made observations using a review sheet with a checklist about my attitude and motivation as the instructor. The peer reviewer would look for overall enjoyment of the students and teacher during the lesson. She also rated the engagement of the students throughout the lesson as well. An example of the journal prompts is found in Appendix F. An example of peer observer checklist is found in Appendix G. I also took pre and

postunit Intervention teacher surveys on my attitude and motivation. These surveys had me rate my motivation and attitude using a Likert scale response method. An example of these teacher surveys is found in Appendix H. These data were qualitative and compared to the intervention units.

During the intervention units, the 5E guided -inquiry methods were used throughout the lessons. Like the nonintervention unit, student data were assessed using instruments to collect data on understanding concepts, motivation, and long-term memory. The intervention preunit, postunit, and delayed unit assessment for sound energy can be found in Appendix I. Students were assessed on their ability to give an example of sound interference, ability to make a concept map using sound vocabulary and then on their ability to describe the relationship between amplitude, frequency and wavelength. The intervention preunit, postunit, and delayed unit assessment for kinetic energy is found in Appendix J. Students were assessed on their ability to describe the difference between kinetic and potential energy, make a drawing of an example of energy transfer and explain the transfer of energy at different points found on a diagram. The intervention preunit, postunit, and delayed unit assessment for electricity can be found in Appendix K. Students were assessed on their ability to define and explain certain vocabulary dealing with electricity including circuits, batteries and conductivity.

The 5E model uses a method of engagement, exploration, elaboration, explanation, and evaluation. During the intervention students were given a problem that they had to investigate. For instance, during the sound unit students were engaged by being asked how they thought sound works. Students had five minutes in order to try to answer the question. After a quick discussion, students then worked to answer the

question through exploration. Students explored the sounds of different musical instruments. Students were able to strike a drum, blow air over bottles with water of varying levels and or without water, tap bottles with different amounts of water or strum a guitar. I monitored each student, questioning them about what caused the sounds. Students were then able to explain what they thought caused sound. We then tried to elaborate on our understanding of pitch and frequencies made by having the students extend what they had discovered with the instruments to the use of tuning forks and the vibrations they give off when struck. Students shared their findings as a class. All students heard and saw the results that each team of students had. I used a formative assessment at the end of class to evaluate students understanding.

During the kinetic energy unit I posed an investigable question, “what happens to the energy of an object when it is released from a certain height?” Five minutes were allowed for the students to ponder the question and write down any possible answers that they might have about it. This elicited students’ background knowledge and had the students focused and engaged on the topic. The exploration portion allowed for the students to use lab materials to plan and prepare a way to explore the question. I allowed students to have a large portion of the class time to plan and explore. I gave students materials to use to conduct their investigations after they made their plan. During the explanation step, learners shared their experiences and tried to explain a particular concept learned. Here, an explanation of energy transfer was added to offer a deeper understanding for the learning. Next, during the elaboration phase, I extended the students experience of the concept being investigated by allowing more activities of the same concept to be explored. Finally, the evaluation section allowed for me to evaluate

the learners' progress and also allowed for the students to assess their understanding of the concepts they investigated. The evaluation consisted of students being questioned and having to respond on white boards with dry- erase markers. This allowed for me to have 100% mandatory engagement as well as a quick assessment of classroom performance. Students responded to my questions in silence by lifting their whiteboards up so only I could see their responses. I then discussed the responses students made and corrected any misconceptions.

During a particular intervention lesson taught on electricity, a guided- inquiry approach, the 5E model of instruction , was utilized which consisted of a five minute warm up question, the engagement, which asked students to explain electricity. This warm up was based on background experiences. This was followed by quickly going over any questions and answers students had on the warm up. After the students had been introduced to the topic, electricity, the students moved to the explore portion of the lesson. Here students had a chance to explore different properties of electrical circuits. Students did this by working in small groups and using materials to explore the concept. The students then formed a question to investigate such as comparing the difference between parallel and series circuits.

At first, I helped students come up with investigable questions. Then they planned an investigation with the given materials; wires, batteries light bulbs and switches. The students started their exploration. I checked student's plans and then allowed them to investigate their question. Students then shared their findings and through discussion explained what they had found. The class then took the findings and looked for errors or misconceptions found in the learning and then compared it what

others had found. The elaboration portion of the 5E model had students use the new information found about the model and used it to explain a real phenomenon such as when a light goes out on a strand of Christmas lights. After students heard others' explanations about what was discovered they came up with a new questions that interested them to explore, like, what happens to a bulb's brightness when another bulb is removed from a parallel circuit? Once these explorations were finished students then took an assessment at the end for accountability and evaluation. An example of two lesson plans for the intervention unit is in Appendix L.

The intervention was effective because students explored an idea and worked to find meaning to a concept. Once the students deliberated and shared their findings, we challenged and or modified student perceptions using classroom conversations. Then as a class a general consensus was reached and the students were then assessed. 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.

Data Collection Instruments

The students in this action research project were eighth graders from Carson Middle School, Carson City, Nevada. Carson City is a town of 50,000 people, where the biggest attraction to the city is tourism. Of the two public middle schools, the larger one I teach at has a population of approximately 1200 students and 66 teaching staff. The student population consists of a high number of free and reduced lunch and English as a Second Language learners and is considered an at risk school. The class in this study consisted of 50% Latino students and 50% Caucasian students. About one third of my

classes were students with special needs. One class I chose was my fourth period science class. In this class there was a diverse level of learners. There were 24 students enrolled and of those four were special needs. There were 11 girls and 13 boys. Four students had attendance issues and their data were not used in this study.

I collected various data for each of my project questions to allow for triangulation. Table 1 shows the data triangulation matrix which I used to show an appropriate mix of perspectives to help me answer my project focus question of how guided- inquiry effects middle school student understanding. By triangulating the data and not using only one source, I was able to consider if my action research methods were effective. It is important to use both qualitative data which are data that cannot be measured but can be observed and then also to use data that can be tallied and measured as quantitative data for analysis. The table shows that I used pre, post, and delayed surveys, interviews, and assessments for both student understanding and long-term memory. Pre and postunit student interviews, surveys and observations were used to measure student motivation. My own attitude and motivation was triangulated using reflective journaling, taking teacher surveys and by observations made from a colleague. I used student interviews as part of my triangulation of data and I conducted the interviews at the end of each unit. The student interview for sound is found in Appendix M. The questions were the same for the preunit, postunit and delayed unit interviews. Students were asked about properties of sound, what they enjoyed learning about sound and if there was anything still unclear to them.

Table 1
Data Triangulation Matrix

Research Questions	Data Source		
	1	2	3
Increased understanding	Pre and postunit assessment with concept questions	Pre and postunit interviews	Pre and postunit survey
Long-term memory	Post and delayed unit student surveys	Post and delayed unit interviews	Post and delayed assessments
Student motivation	Pre and postunit student interviews	Pre and postunit student surveys	Instructor field observations
Teacher attitude and motivation	Instructor weekly reflection journaling with prompts	Pre and postunit teacher surveys	Nonintervention and intervention peer review

The student interviews for kinetic energy are found in Appendix N. Students were asked to explain and describe kinetic and gravitation potential energy , explain and justify the relationship between kinetic and potential energy, describe what they enjoyed learning about kinetic energy and then if there was anything still unclear about kinetic energy. The student interview for electricity is found in Appendix O. Students were asked what they knew about electricity including its properties, how it works, how it is related to batteries, and if there was anything they really enjoyed learning about electricity and if there was anything still unclear. The questions I asked of the students focused on understanding of concepts and things that they perceived to help their learning. I selected six students and orally interviewed them after school. There were two high-achieving students, two medium-achieving students and two low- achieving students that were selected for the interviews based upon their grades they had scored in class.

Students with a 100- 90 percent range were considered high, students with a class score of 89-70 were considered medium, and students who score below a 69 percent were considered low. The same students were used with each set of interviews. There were concept and nonconcept questions given during the interviews.

The survey I administered used a Likert scale which focused on student motivation. This survey was given at the end of a unit to all students. The surveys for the treatment units are found in Appendices P, Q, and R. The interview and survey are important to my action research because they allowed for data on student motivation to be assessed and used to form a conclusion about the effectiveness of guided inquiry on student motivation.

To measure my motivation and attitude I used surveys, journal entries that used reflection prompts, and peer observations. I also used teacher observations during the treatment unit. These instruments were used to collect data on my motivation and attitude as the teacher during the action research project. These data were triangulated to demonstrate how guided -inquiry affected my attitude and motivation about guided -inquiry. In measuring student long-term memory, I used the same test given for the pre and postunit assessments as for the delayed test 14 days after the postunit test. It was important to give some time after the treatment lessons were taught to determine the effectiveness on long- term memory. I administered the surveys and interviews after each unit and then gave a delayed unit test two weeks after the units had been taught. The timeline of the project is Appendix S.

DATA AND ANALYSIS

Data from assessments, surveys, and interviews were used to determine the effects of the 5E model of instruction on students' understanding of concepts. Table 2 compares the class averages of the intervention and nonintervention scores from the preunit and postunit assessments. From the normalized gain score these data suggest that the intervention was more effective for students to understand concepts than was the nonintervention.

Table 2
Average Scores of the Unit Preunit Assessments and Postunit Assessments (*N*=20)

Unit Data	Nonintervention Unit- Heat	Intervention Unit 1- Sound	Intervention Unit 2- Kinetic	Intervention Unit 3- Electricity
Preunit Assessment	7	13.75	27	23.75
Postunit Assessment	44	69	64	65
Percent Change (%)	528.6	401.8	137	173.7
Normalized Gain Score	0.40	0.64	0.51	0.54

The data showed that students learned using the 5E model with overall higher normalized gain than the nonintervention strategies. The normalized gain was used to determine student progress. There is a lower percentage change for the intervention phase when compared to that of the nonintervention unit on heat. This suggested that students' possible beginning knowledge of these science concepts on heat were lower for the nonintervention and that the students had more to learn than when compared to the beginning scores for the topics of the intervention units. The percentage change is lower

for the preunit assessments and the postunit assessments suggesting that the students beginning knowledge increased a smaller amount compared to when the percentage change was higher. A higher percentage change implied that the students' possible beginning knowledge had increased during a unit. Figure 1 below demonstrates the normalized gain for the high, medium, and low- achieving students.

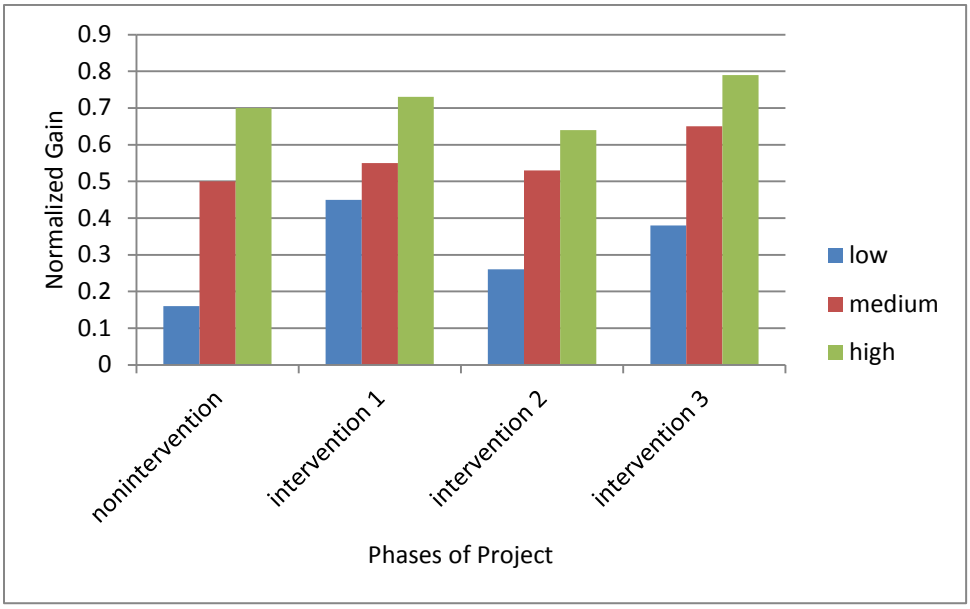

Figure 1. Normalized gain by achievement group, high-achieving (*n*=5), mid-achieving (*n*=9), and low-achieving (*n*=6) for preunit assessments and postunit assessment, (*N*=20).

High-achieving student progress showed a drop during intervention 2 with an increase in progress during intervention 1 and 3. Medium-achieving learners showed consistent progress, while the low-achieving learners showed intermittent progress throughout the intervention units. Compared to the nonintervention normalized gain the gain for the intervention was higher.

During the nonintervention students took a preunit assessment on heat energy concepts and the data showed a high percentage of students had very low scores. According to the nonintervention preunit assessment results, most students did not

understand heat and temperature concepts. Students were evaluated on their ability to compare convection and conduction concepts and most students knew that conduction dealt with the transfer of energy, but they had inaccurate ideas about convection. The students did not do very well on the preunit assessment for intervention unit 1 on sound. The majority of the students answered only few of the assessment questions correctly, scoring a class average of 13.75%. Most students had a low knowledge of frequency, amplitude, wavelength, or what interference was, though there were a few students that did have some knowledge of these concepts. Students used the 5E learning method to investigate particular concepts on sound energy. Student average scores increased on the postunit assessment after the unit to an average of 69%. However, the main concepts that the students did not understand on the preunit assessment, still seemed a little unclear for the students when they took the postunit assessment. The normalized gain of 0.64 for intervention unit 1 on sound showed greater progress than the nonintervention unit on heat.

Student data on the intervention unit 2 on kinetic energy demonstrated that there was an association between the increase of the students' scores and the intervention strategies. Student normalized gains for the intervention units were greater than that of the nonintervention unit on heat. The intervention unit 2 preunit assessments on kinetic energy demonstrated that students were more familiar with the concepts in that unit than they were on the previous units. On the postunit assessments most students had a grasp of kinetic energy being associated with motion and potential energy affiliated with energy being stored or at rest. The assessment showed a problem in student understanding of the transfer of energy involved when an object goes from either kinetic to potential or from

potential to kinetic energy. Postunit assessment scores showed an increase in the students' understanding for intervention unit 2. The normalized gains indicated that students had more progress with the 5E strategies than with the nonintervention.

The last unit of the intervention, unit 3, was on electricity. These data from the intervention unit 3 on electricity showed that the students who took the preunit assessment scored an average of 23.75%. Most students did not know what electricity was and left the question blank. Students knew what sort of materials conducted heat and electricity fairly well, however, were quite uncertain of what circuits were and how they worked. Most students had a basic understanding of batteries, but could not explain how batteries function. The postunit assessment scores showed an increase of the class average to 65%. Students still needed a better understanding of why objects conducted electricity, of why batteries allowed for objects to have power, and of being able to describe electricity. Again, the percentage change helped to give perspective about the knowledge starting point and ending point for the students and the normalized gains helped to put the assessment scores and percentage changes into perspective. The normalized gain of students' assessment scores indicated that students had the greater knowledge growth with the 5E strategies.

Table 3 demonstrates the breakdown of high, medium, and low achieving students' progress on the preunit and postunit assessments for both nonintervention and intervention units. Again, student progress was measured using normalized gain. Student starting and ending growth was measured using percent change. The high-achieving students scores were relatively close in range for both non-intervention and intervention units.

Table 3
Average Scores by Achievement Group, High-Achieving (*n*=5), *Mid-Achieving* (*n*=9), *and Low-Achieving* (*n*=6) *for Preunit Assessments and Postunit Assessments (N*=20*)*

Group	Description of Data	Nonintervention (%)	Intervention 1 (%)	Intervention 2 (%)	Intervention 3 (%)
High	Preunit Assessment	20	25	44	30
	Postunit Assessment	76	80	80	85
	Percent Change	280	220	81.8	183
	Normalized Gain	0.7	0.73	0.64	0.79
Medium	Preunit Assessment.	5	16.7	31.4	28.6
	Postunit Assessment	52.5	62.5	67.5	75
	Percent Change	950	274.3	115	162.2
	Normalized Gain	0.5	0.55	0.53	0.65
Low	Preunit Assessment	1	2.9	15	20
	Postunit Assessment	16.7	46.4	36.7	50
	Percent Change	1570	1500	144.7	150
	Normalized Gain	0.16	0.45	0.26	0.38

The percent change was greatest for the nonintervention unit and the normalized gain scores were overall higher for the intervention units, however, not greatly. These data suggest that the high-achieving students can possibly learn science concepts quite similarly using both intervention and nonintervention strategies. Medium –achieving students showed a greater increase in percent change for the nonintervention unit while the normalized gain scores for the intervention units were higher for the intervention units. The difference in normalized gain between the nonintervention and intervention

units is not great. The low-achieving student's percent change for the nonintervention were very high, however the normalized gain demonstrated very low progress for the nonintervention unitOn the other hand, the normalized gain was greater for the intervention unit for the low-achieving learners.

Figure 2 compares the data for the intervention surveys with the nonintervention surveys concerning student perceptions. These data demonstrate how students perceived their own understanding during nonintervention and intervention strategies. Students perceived that they had most a neutral perception of their understanding. There is a greater percent change and a great normalized gain for the nonintervention unit compared to the intervention units.

Among other variables students' perceptions can be affected by stress, confidence, interest and ability. Ultimately though, there is a measure of increased perception of understanding for both intervention and nonintervention units.

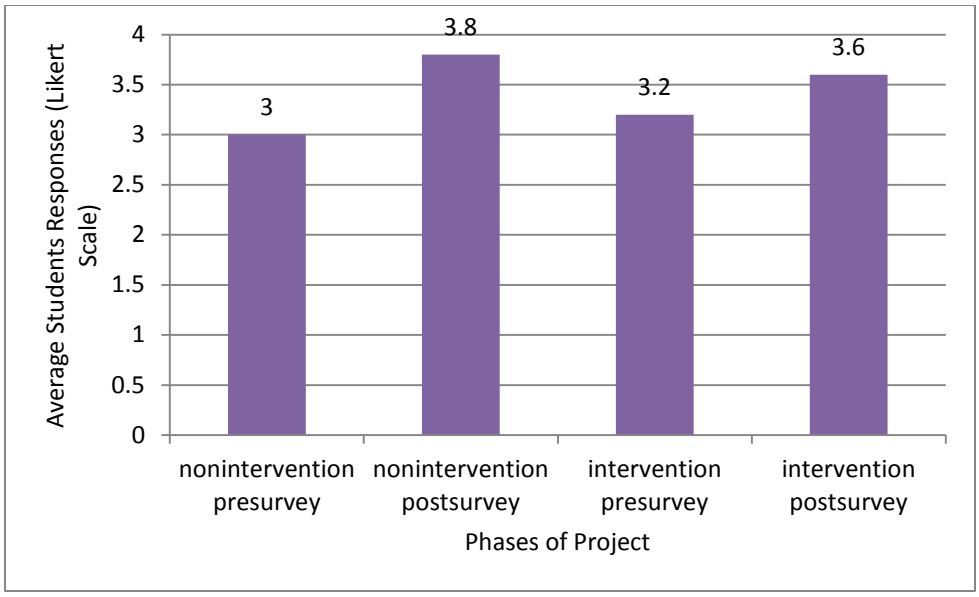

Figure 2. Student perception results for pre and postunit survey for nonintervention and intervention phases, (*N*= 20). *Note.* Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1.

However, the students' perception of their knowledge was greater after the nonintervention unit according to the data in Figure 2. Nonintervention strategies consisted of note taking, annotating during lecture, and observations during demonstrations. In addition to assessments and surveys, interviews were used to measure student understanding. Table 4 shows the results and indicates that postunit data for both nonintervention and intervention showed growth. The progress shown by the normalized gain demonstrates that the students in each achievement group for the intervention units increased their scores more greatly compared to the nonintervention unit. The results are positive for the intervention units. The low- achieving learners had a greater normalized gain during the intervention phase. The normalized gain indicates the high-achieving students had the greatest progress.

Table 4
Pre-unit Interview and Post-unit Interview Scores for the Nonintervention and Intervention Units for Understanding (*N*=6)

Student Achievement Level and Unit	Preunit Interview	Postunit Interview	Percent Change	Normalized Gain
Low Nonintervention Unit	0.1	0.5	400	0.004
Medium Nonintervention Unit	0.1	0.5	400	0.004
High Nonintervention Unit	0.1	1	400	0.004
Low Intervention Unit	0.1	2.5	2400	0.02
Medium Intervention Unit	1	3.11	211	0.71
High Intervention Unit	1	3.44	244	0.81

Note. Scores are out of 4.

The nonintervention unit showed that the low, medium and high-achieving learners all had the same percentage change and normalized gain. However, the intervention normalized gain scores were greater than those of the nonintervention unit demonstrating a positive association with the 5E strategies. During the preunit interview for the nonintervention unit on heat, students would simply say that they did not know an answer and were unable to elaborate on any of the questions. Students showed that they still had not grasped heat properties concepts yet. During the intervention unit interview

data were similar to those of the nonintervention unit in that students had very little understanding of either concept on the preunit interviews except on the kinetic energy unit. Few students had had some knowledge of these concepts. Table 5 shows the comparison of intervention and nonintervention preunit and postunit interviews. When the intervention units were compared to the nonintervention unit, students showed more success on the postunit interviews for the overall score on the intervention units. The six students that were interviewed were selected based on their achievement levels. The six scores were averaged for each preunit and postunit interview to obtain the percent change and normalized gain.

Table 5
Pre-unit Interview and Post-unit Interview Scores for the Nonintervention and Intervention Units for Understanding (*N*=6)

	Low	Low	Medium	Medium	High	High	Average	Percent Change	Normalized Gain
Heat-Pre	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
Heat-Post	0.1	0.1	0.5	0.5	1	1	0.53	430	0.004
Kinetic-Pre	0.1	0.5	0.1	1	0.5	0.5	0.45		
Kinetic-Post	2	2	1	2	2	2	1.83	306.7	0.014
Sound-Pre	0.1	0.1	0.5	1	0.5	1	0.53		
Sound-Post	1	0.5	1	2	2	2	1.42	167.9	0.009
Electricity -Pre	0.5	0.1	0.5	1	0.5	1	0.6		
Electricity -Post	0.1	1	0.1	2	1	2	1.1	83.3	0.005

Note. Scores were out of 2.

Figure 3 demonstrates the distinction between high, medium, and low- achieving students during the preunit and postunit interviews .The scores from the preunit interview content questions for both nonintervention and intervention phases were quite low and

demonstrated that the students had little background knowledge beginning all units. Figure 3 demonstrates that the low-achieving students did poorly on both the pre and postunit interview for the nonintervention unit and intervention units.

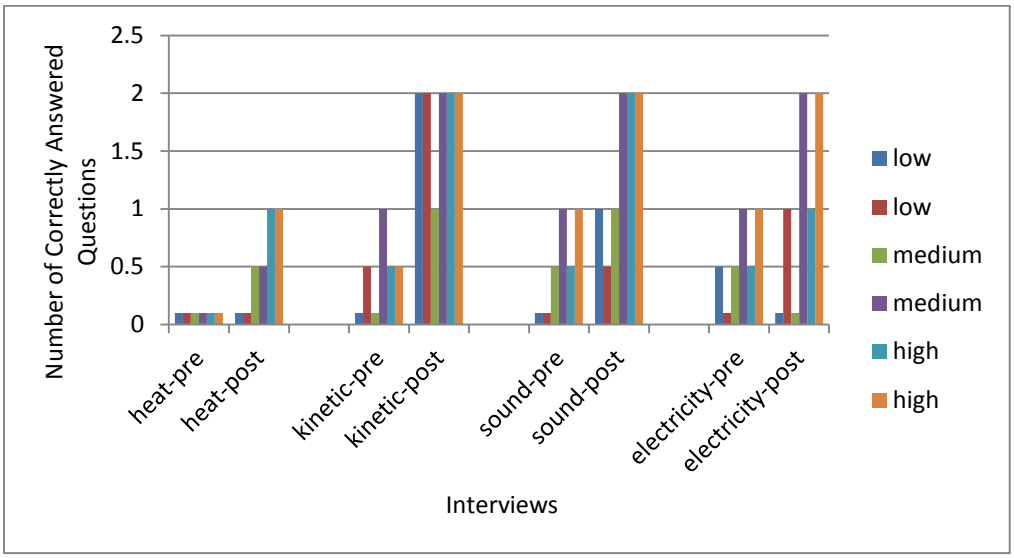

Figure 3, Student pre-unit and post-unit interview for the nonintervention and intervention units by achievement group, high-achieving students (n=2), Mid-achieving students (n=2), and low-achieving students (n=2), (N= 6).

The medium-achieving students scored better during the intervention postunit interview compared to the nonintervention unit. However, one of the two medium-achieving students did more poorly during the electricity postunit interview. For the high-achieving students there were greater increases of scores during the intervention compared to the nonintervention.

When the assessments, surveys, and interviews were triangulated the data demonstrates that there was a more positive association with students' ability to understand concepts using the 5E method compared to the traditional method, though only by a small margin.

To triangulate the data on students' long-term memory of concepts I used a comparison between the postunit and delayed unit assessments, interviews, and surveys. The post and delayed unit assessments are portrayed as averages in Table 6.

Table 6
Average Scores of the Postunit Assessments and Delayed Assessments for Long-term Memory (*N*=20)

Unit Data	Nonintervention Unit	Intervention Unit 1	Intervention Unit 2	Intervention Unit 3
Postunit assessment	44	69	64	65
Delayed assessment	48	68.1	66.4	75
Percent Change (%)	9.1	-1.45	3.25	15.4
Normalized Gain Score	0.07	-0.03	0.06	0.29

To demonstrate recall students' scores on the delayed assessments should either remain the same as the postunit score or show an increase in the score. A student's score that has dropped after a delayed unit assessment did not show great recall ability. The results in Table 6 showed that the intervention phase had a positive impact on student's long-term memory on the unit 3 about electricity. For unit 1 there was a reduction in recall abilities for high-achievement students. For unit 2 the intervention units showed students were able to recall science concepts keeping the same percentage as they had for the postunit assessment. Table 7 demonstrates the breakdown of scores for the high, medium, and low-achieving students.

Table 7
Average Scores by Achievement Group, High-Achieving (n=5), Mid-Achieving (n=9), and Low-Achieving (n=6) for Postunit Assessments and Delayed Unit Assessment (*N*=20)

Group	Description of Data	Nonintervention (%)	Intervention 1 (%)	Intervention 2 (%)	Intervention 3 (%)
High	Postunit Assessment	76	80	80	85
	Delayed unit Assessment.	92	75	80	100
	Percent Change	21.1	-6.25	0	17.65
	Normalized Gain	0.67	-0.25	0	1
Medium	Postunit Assessment	52.5	62.5	67.5	75
	Delayed Unit Assessment	40	62.5	74.3	57.1
	Percent Change	-23.81	0	10.07	-17.9
	Normalized Gain	-0.26	0	0.21	-0.72
Low	Postunit Assessment	16.7	46.4	36.7	50
	Delayed Unit Assessment	23.7	20.8	34.3	42.9
	Percent Change	41.92	-55.2	-6.54	-15
	Normalized Gain	0.08	-0.48	-0.038	-0.15

Overall, the data from Table 7 shows that the high-achieving students demonstrated recall abilities on two of the three intervention units, while showing regression on unit 1 of the intervention. High-achieving students demonstrated recall after the nonintervention strategies. Medium-achieving learners also demonstrated recall on two of the three intervention units. However, they showed regression on the intervention unit 3 and also on the nonintervention unit. The low-achieving learners did not

demonstrate recall on any of the intervention units. They did, however, show recall for the nonintervention unit.

Figure 4 compares students' perception of their recall abilities. To obtain these data the students took delayed surveys on the nonintervention and the intervention units in which I compared to the postunit surveys. These data demonstrate that the students had a relatively moderate view in regards to their own recall abilities for all units.

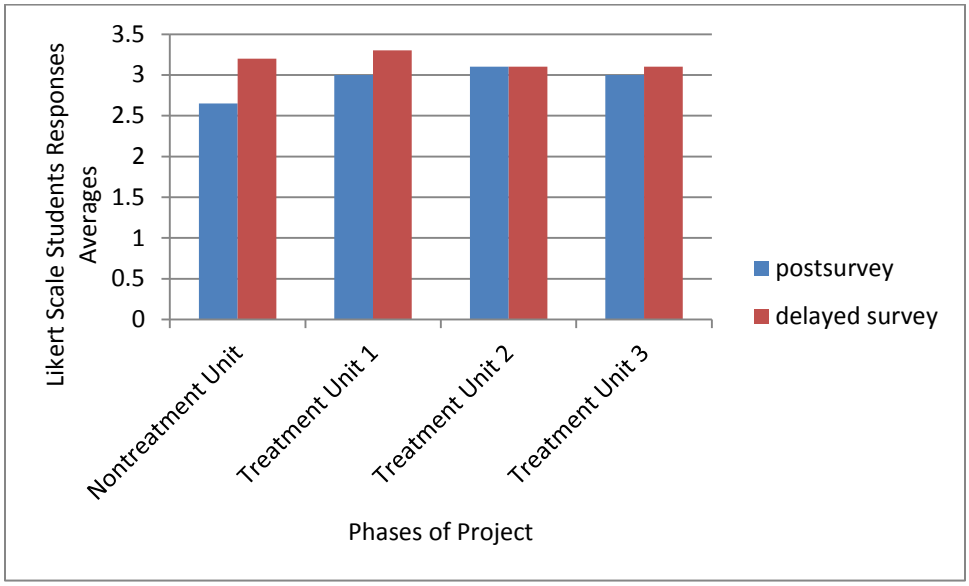

Figure 4. Student post-unit survey, and delayed survey for the nonintervention and intervention phases concerning their perception of their level of long-term memory, (*N*= 20). *Note.* Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree.

Students' scores during the postunit surveys for the nonintervention, intervention unit 1, and 3 showed gains in student knowledge. These data demonstrate student perceived long-term memory ability. According to the data the students' perception about their ability to recall information was greater for the nonintervention, though by only a small margin.

Part of my triangulation of data included delayed interviews compared to the postunit interviews. Data from the postunit and delayed unit interviews are demonstrated

in Table 8. These data indicated that the nonintervention unit had a positive effect on long-term memory for low-achieving learners. The intervention showed that throughout the units there were times when one of the low-achieving student's scores would either remain the same or drop and for one unit recall was shown for both students. However, the medium-achieving students showed recall after the nonintervention delayed unit interview as well for unit 2 and 3 of the intervention with one student of the two having dropped in recall ability on unit 1. High-achieving learners showed recall on the nonintervention delayed unit interviews and on unit 1 and 3 for the intervention with one of the two students on unit 2 showing recall while the other not.

Table 8
Student Postunit and Delayed Unit Interviews for Long-Term Memory (*N*=6) *Average Scores by Achievement Group, High-Achieving* (*n*=2), *Mid-Achieving* (*n*=2), *and Low-Achieving* (*n*=2) (*N*=6)

Units	Low	Low	Mid	Mid	High	High	Average	Normalized Gain
Heat-Post	0.1	0.1	0.5	0.5	1	1	0.53	
Heat-Delayed	1	2	1	1	1	1	1.2	0.007
Kinetic-Post	2	2	1	2	2	2	1.8	
Kinetic-Delayed	0.1	2	1	1	2	1.5	1.1	-0.07
Sound-Post	1	0.5	1	2	2	2	1.42	
Sound-Delayed	0.5	1	2	2	2	2	1.58	0.002
Electricity-Post	0.1	1	0.1	2	1	2	1.03	
Electricity-Delayed	1	1	2	2	1	2	1.5	0.005

Note. Scores out of 2.

Figure 5 shows the breakdown of students' scores by achievement group on the postunit and delayed unit interviews. The low-achieving students showed growth on the delayed interview after the nonintervention unit. For the intervention unit on sound one low-achieving student did not retain science concepts while one student gained. During the intervention unit on kinetic energy one of the low-achieving students was able to retain and recall science concepts on the delayed interview while one student was not. During the intervention on electricity one of the low-achieving students was able to recall science concepts while one increased. Medium –achievement learners were able to increase in scores on the delayed unit interview during the nonintervention.

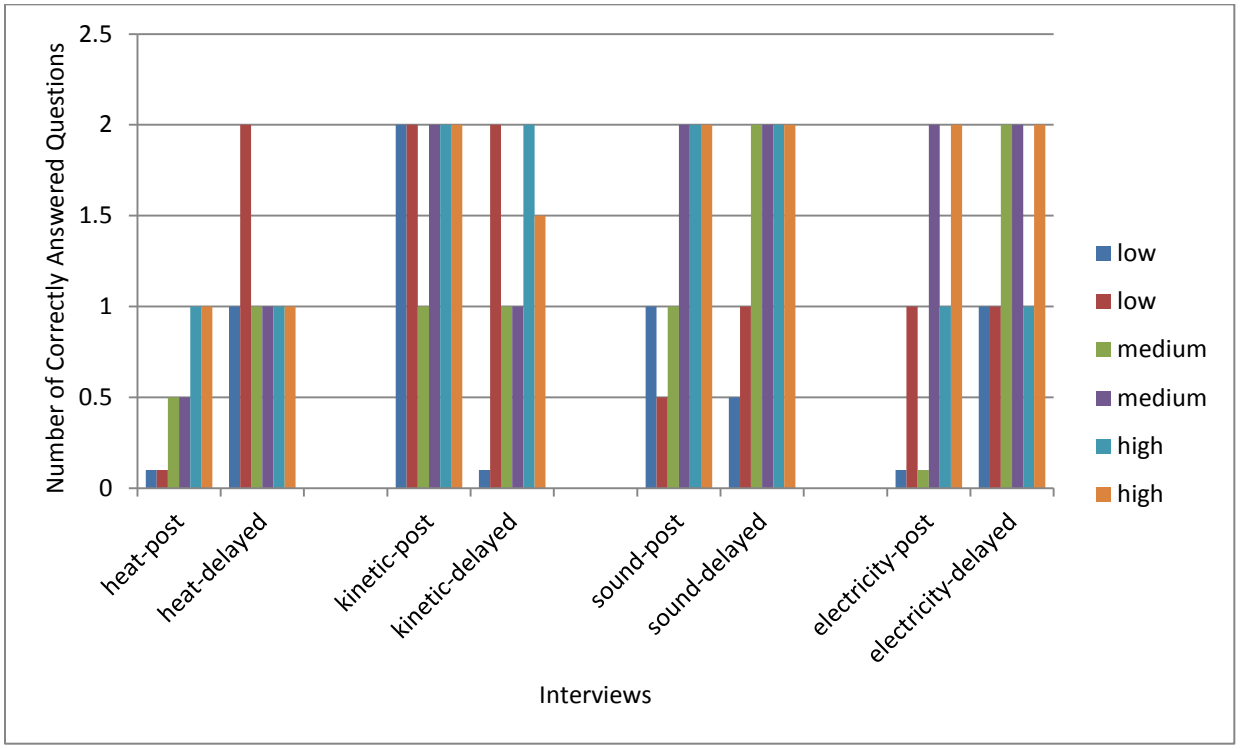

Figure 5, Student post-unit and delayed unit interview for the nonintervention and intervention units by achievement group, high-achieving students (n=2), Mid-achieving students (n=2), and low-achieving students (n=2) concerning their perception of their level of long-term memory, (N= 6).

During the intervention unit 1 on sound both students' scores increased on the delayed unit interview. For intervention unit 2 on kinetic energy one medium-achieving student's scores remained the same while the other students score fell. During intervention unit 3 one these students' scores increased while the others stayed the same. High-achieving students demonstrated recall ability, with their scores remaining the same during the nonintervention interviews. The same is true for unit 1, on sound, of the intervention where the scores for the high –achieving students did not change. For unit 2, on kinetic energy, one of the high-achieving students' scores dropped and for unit 3 of the intervention, on electricity, students' scores remained the same, showing recall ability.

In comparison to the postunit interview, the delayed interviews showed a consistency for medium -achieving students and high- achieving students, while the low - achieving students' scores diminished. The low- achieving students had more success during the nonintervention postunit interviews than they did on the intervention unit on sound, while the medium-achievement learners and high-achievement learners had success on both intervention and nonintervention units. As with the nonintervention unit, students were unable to answer some of their interview questions correctly only having success partially. Overall, both low-achieving students showed recall on the nonintervention and only one of the intervention units. The medium-achieving students showed recall during the nonintervention unit and only two of the three intervention units. The high-achieving learners also showed recall on the nonintervention unit and recall on only two of the three intervention units.

In regards to student motivation, Figure 6 shows students responses on surveys of what they felt about activities that supported their motivation to learn. These data indicated that most students preferred lab activities and experiments for both nonintervention and intervention units when surveyed about their motivation.

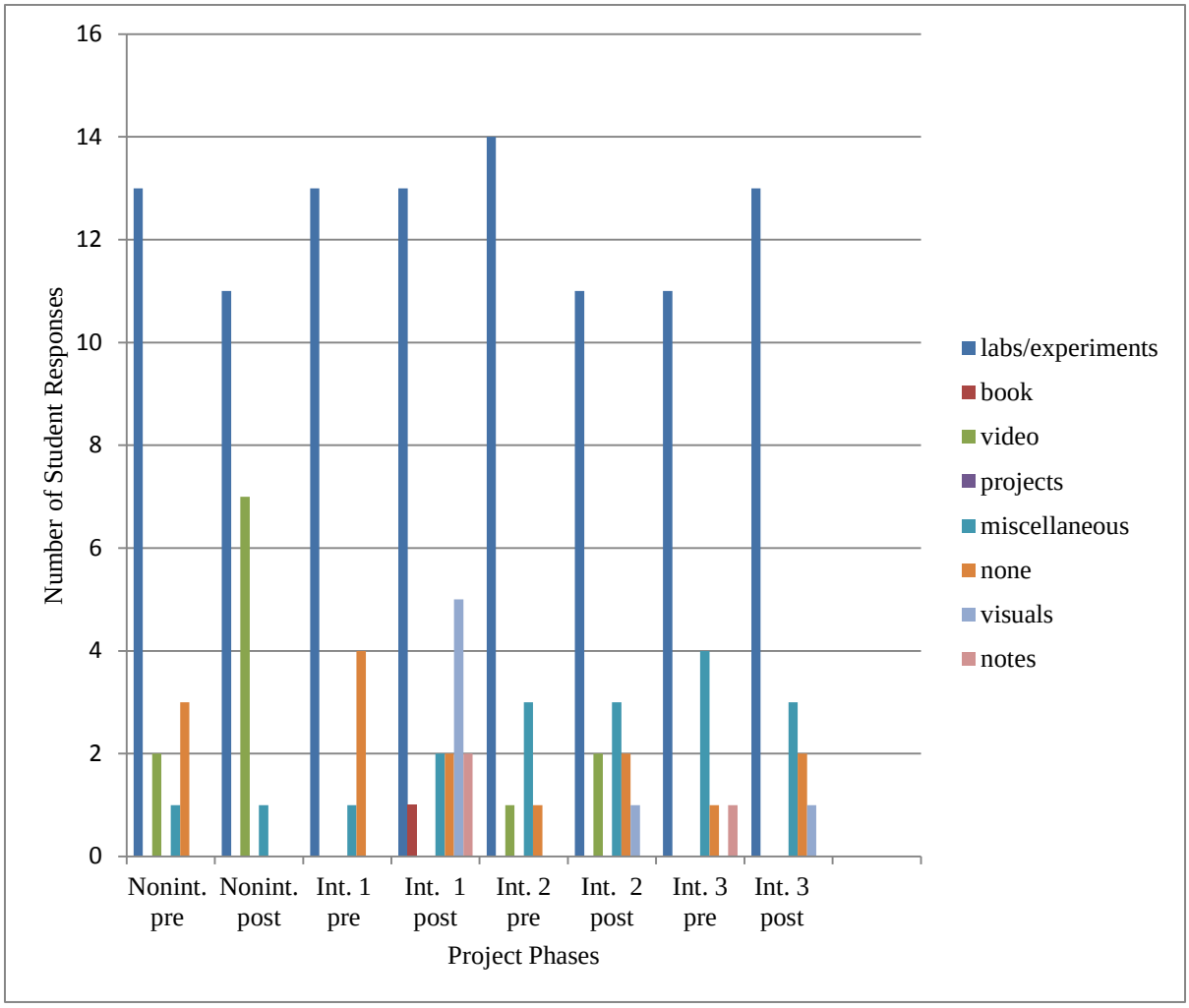

Figure 6. Student pre and post-unit intervention and nonintervention survey responses of activities students associate with motivating their learning (*N*= 20).

Videos and visuals were considered by some students as very important motivators also. Projects, note taking, use of the science textbook, observing visual presentations and demonstrations were all strategies that very few students selected as having a significant

impact on what students perceived as being conducive to their own learning. Overall, these data reveal that students prefer inquiry to the traditional methods. There were no labs or experiments used during the nonintervention, only demonstrations which students observed me perform. Experiments and planning were utilized during the intervention phase of the project only.

Table 9 shows students responses suggesting that students perceived that labs and learning how energy works made learning easier. All student achievement groups considered hands-on activities and lab experiences to be a positive influence and motivator to their learning. How energy works and moves showed to be a common theme found in student responses also.

Table 9
Trends of the Preunit Interviews and Postunit Interviews on Student Motivation (*N*=6)

Phase and Learning Level	Preunit Interview	Postunit Interview
Nonintervention low	Hands-on activities	More labs
Nonintervention medium	Labs and demonstrations	About how things work
Nonintervention high	Labs and activities	Seeing demonstrations
Intervention low	Labs and how energy works	Doing labs and learning how energy works
Intervention medium	Labs and how energy moves or works	How energy works together and doing labs
Intervention high	Labs how energy works and moves	Labs and activities

In Table 10 data were compiled from student observations during the lessons to measure student motivation. Results from student observations showed that student attitude, engagement, desire to learn and overall engagement during lessons were better during the inquiry phases.

Table 10
Average Scores of the Nonintervention and Intervention Observations about Student Motivation (*N*=20)

Observations	Nonintervention	Intervention
Positive Attitude	3	3.8
Students off task	2	1.2
Overall engaged	3.7	4.2
Desire to learn	3	3.7

Note. Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1.

Scores are higher for student motivation during the intervention unit compared to that of the nonintervention unit, however, not greatly. There were times students seemed to be disengaged and many more times when students were engaged during the intervention. For example, during the nonintervention unit there was one incident recorded when a medium –achieving student was off task. During the intervention unit there was one time when a high –achieving student, a medium –achieving student and a low –achieving student were all off task. Three low level learners were off task on three different occasions and one medium –achieving student on a separate occasion. However, most students were on task and engaged throughout the entire intervention.

Another aspect of my project was to measure the motivation and attitude of the teacher while using the 5E method. These data indicated a small decrease with the treatment units. I was able to use peer reviews to compare how my behavior and motivation seemed to a colleague as they viewed me during both nonintervention and intervention units. During the intervention unit a colleague responded saying that, “the students responded well to the combination of questions at the beginning of class and at

the follow up of the lab." She also stated that, "once the lab was completed I noticed the students took greater ownership of the topic and understanding increased in the process". A different peer reviewed me at a different occasion and made a comment about the intervention unit, "students seemed to enjoy all stations, telling others what they liked working on the most".

Figure 7 demonstrates peer review perceived responses during nonintervention and intervention units. The nonintervention data shows an increase over the intervention scores. The scores do not show a great difference between the nonintervention and the intervention strategies.

The variable that different content was being taught during the intervention and nonintervention units may have caused a change in teacher motivation. All data was collected during class at the same time throughout the project.

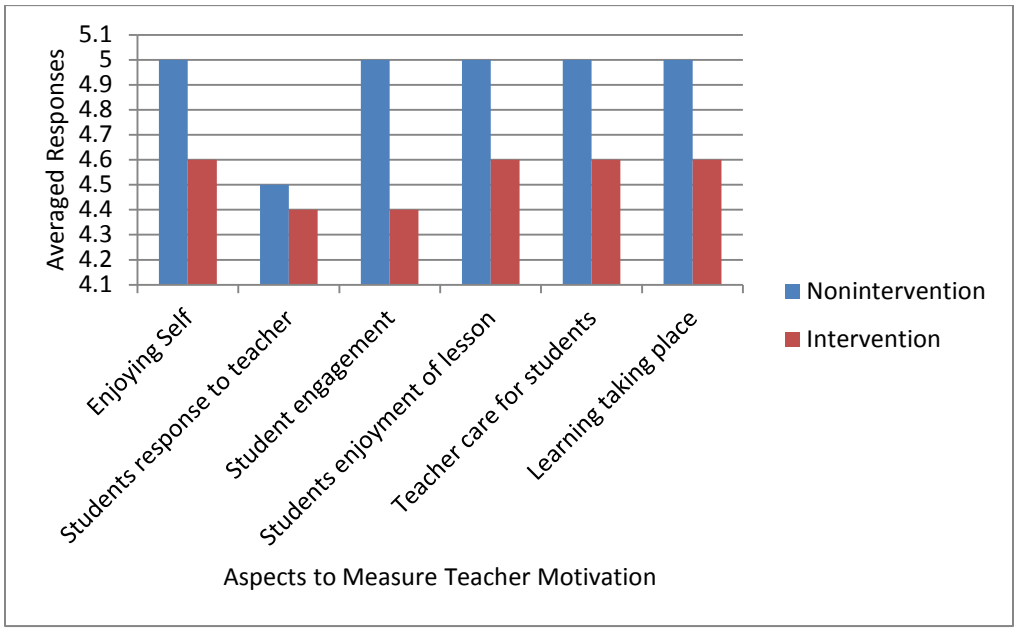

Figure 7. Teacher peer review responses during nonintervention and intervention phases , (*N*=20). *Note.* Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1.

An instrument I used to measure teacher motivation was journaling using reflection prompts. From these data I was able to compare intervention and nonintervention aspects of how I as the teacher felt the lesson had gone. Figure 8 demonstrates these data showing how I felt about the lesson I was teaching at the time. A comment that I made often during my reflections was that I really enjoyed having the students take part in the planning of their investigations during the intervention units. One particular aspect to look at is the way that I had felt that the intervention goals had been met. Here, I would consider an intervention goal met if the students had planned their investigation, started experimenting and had come up with a conclusion.

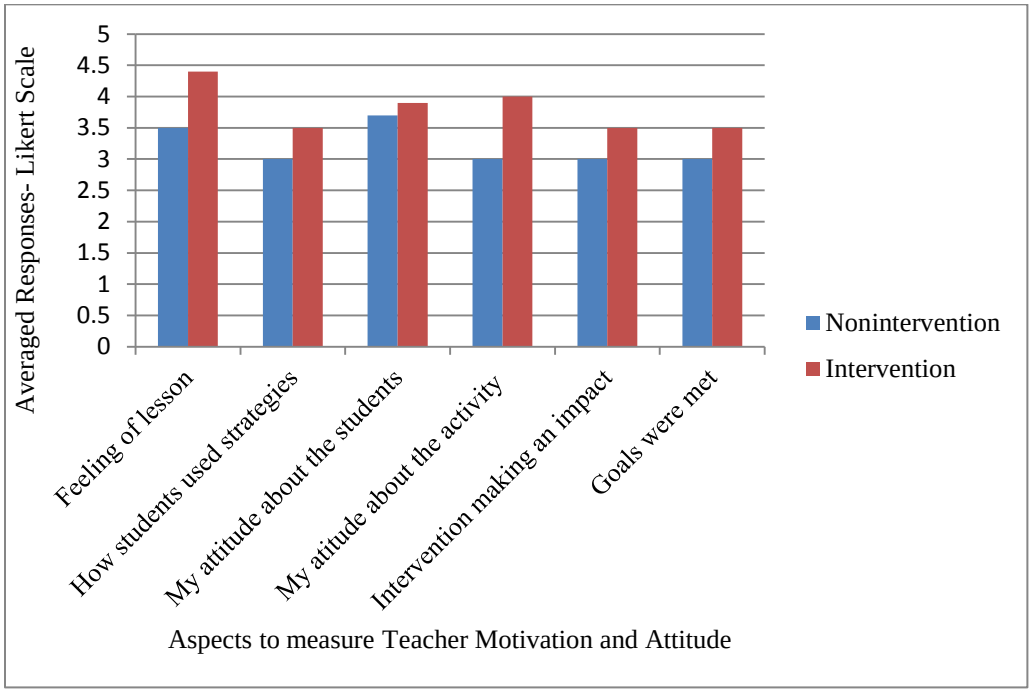

Figure 8. Teacher reflection prompts during nonintervention and intervention phases. *Note.* Very Good – 5, Good – 4, Neutral – 3, Not Good – 2, Not Very Good – 1.

At times students seemed to be a little confused about how to start the planning portion during the intervention, but after some questioning and guiding students were able to, for the most part plan out their procedure to test the question for the day.

Teacher surveys were another instrument I used to measure my attitude and motivation. Some responses that were made included that, “I enjoyed having the students plan their investigations” and that “students enjoyed the assignment”, but also statements that included “some students are disengaged” and “that is disappointing”.

Table 11 describes the data from the teacher surveys I took using a Likert scale. The data shows an increase in teacher motivation and attitude as well as expectations being met.

Table 11
Average Scores of the Nonintervention and Intervention Teacher Surveys about Motivation (*N*=20)

	Nonintervention	Intervention	Percent Change	Normalized Gain
Motivation	3.5	4.4	25.7	0.6
Positive Attitude	3	4.4	46.7	0.7
Expectations met	3.5	4.1	17.1	0.4

Note. Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1.

These data triangulated determines that the teacher attitude and motivation increased during the intervention units where the 5E learning method was used. Overall theses data for all aspects of the project shine a favorable light on the 5E model of instruction. Learning, recall, student motivation and teacher attitude and motivation all are demonstrated as having a positive effect on learning and at times a stronger impact than traditional methods of instruction.

INTERPRETATION AND CONCLUSION

The project focus question was to measure the effectiveness of the 5E model of instruction on student's understanding of concepts. The instruments used to measure this impact were pre and postunit assessments, pre and postunit surveys and pre and postunit interviews. The pre and postunit assessments indicated a positive result for using the 5E model of instruction with greater average scores and higher normalized gain. Student surveys indicated that students perceived the nonintervention strategies to help them have greater knowledge. There was a positive association from the intervention units but greater during the nonintervention.

Student interviews indicated that student understanding increased more greatly when the intervention strategies of the 5E model were employed. Though there are some mixed results from the assessments, surveys and interviews, overall the 5E method is associated as having a positive effect on student understanding.

In addition, data also was analyzed to determine the effects of the 5E model of instruction on long-term memory. The instruments used to measure this impact were post and delayed unit assessments, post and delayed unit surveys and post and delayed unit interviews. The delayed assessments had mixed results indicating that some student achievement groups did better during different phases of the project. The low-achieving students only demonstrated recall during the nonintervention phase, while the medium learners did not demonstrate recall on the nonintervention unit at all. However, on two of the intervention units, 2 and 3, the medium-achieving students demonstrated recall abilities. High-achieving learners demonstrated recall during all units except the intervention unit 1. Surveys indicated that student perceptions of their recall abilities

were positive for the intervention but showed the greatest increase after the nonintervention. Delayed interviews indicated a positive effect for the 5E model of inquiry for all intervention units except unit 2. The effect of the 5E model had positive results for long-term memory but the nonintervention did as well.

The project was also to focus on student attitude and motivation. The instruments used to measure this effect were pre and post unit surveys and interviews and observations made during class. Surveys indicated that the students preferred working in a lab setting using hands-on strategies compared to more tradition settings. Observations also indicated that students' attitude and motivation were heightened when using intervention strategies of the 5E model.

The project also focused on teacher attitude and motivation. The instruments used to measure this effect were peer review observations, weekly journaling, and pre and postunit surveys. Peer review observations indicated that my attitude and motivation during the intervention and nonintervention were positive for both, but greater for the nonintervention. Weekly journaling indicated a greater positive motivation and attitude for me during the intervention units. Teacher surveys also concluded that my attitude and motivation was greater during the intervention strategies.

Overall the 5E method of instruction showed to have a positive effect on student learning, student long-term memory, student motivation and attitude, as well as teacher attitude and motivation. As an educator I believe that the 5E method of instruction is valid and will be used in my science classes. It is important to create 5E lessons that are tailored to fit the needs of a class. Assessments must be valid and measure student growth and progress efficiently. Some student misconceptions still existed after the

nonintervention and intervention lessons had been taught so it was important for me to use class discussions to help clarify concerning issues for a particular concept.

Some limitations that I have found with this project come from the fact that when working with middle school students their teacher's research project seems not to have as much of a motivation to a students' best efforts as one might think. Meaning, with this project students' efforts were from a volunteered level. Grading was not allowed to be a motivator, so I had to simply rely on the students' determination of how they would perform. Some students may have been up to the challenge of giving and doing their best for the sake of research a little better than others. With that, middle school students have a diverse and varying amount of background knowledge. Some students come in much more equipped and able than others.

As educators we must find a way to level the learning field. When looking at the overall class scores I have to consider where some of these students started from and look for where growth occurred and try to continue to build from there.

Students may have had a difficulty being unfamiliar with the intervention. The 5E model has many parts that even a teacher must learn to use properly. Students must become familiar with the process as not to get lost in the exploration. That being stated, it could be a point of conflict when students are working together in groups exploring a concept where they might get carried away and think of the activity as play time. Without set guidelines for group work and initiated roles students can and do get off task easily.

One item worth mentioning that would be valid to change would be the amount of interview and assessment questions on the instruments used for this project. I think it

would be wise to have a broader spectrum of content questions available for students to answer in a subjective format. Often times on assessments we find out what students don't know instead of what they do. By allowing students more questions that they can answer, we, as well as the students, might see a lot more positive results and positive attitudes.

VALUE

Knowing that the students enjoy the lab activities and investigations and that there is growth in learning is a great motivator for me as a teacher. It is also important to see that the more traditional methods are still demonstrating growth also. The implications of this study for me and my students are that the 5E model of teaching is effective and allows for growth in science knowledge. The data from this study, however, demonstrates that the traditional method can yield positive results also. I think that in a science class, science needs to be done. In my opinion, exploring and investigating, collecting data and making conclusions about science content is the best way to learn. Some students take to this method better than others, and I think for some, this method may be very foreign to them and difficult. In the end though, the 5E method is more rigorous and helps my students be better thinkers as well as better students with better attitudes. The implications of this study for other classroom teachers are that there is a way to get students to do science and not just remember facts and figures. The important lesson to learn is that education should challenge students where they are to get them to the next attainable level in their learning. Teachers and parents can use these findings to help decide on how they are going to teach and instruct the content of their curriculum to the best outcome for their students.

I am excited to have been part of this research project. I learned much about my students as well as about myself. This project has helped me to be more organized in my thinking as well as in my teaching. Learning to plan assessments, surveys and interviews was a very important factor for me. These instruments helped me to see what my students knew and I was able to apply that which was learned from the data to help me gear lessons in a way that help students learn science more successfully. It is very important to me to take an assessment that a student has finished and use it to correct any misconceptions that the student might have or to adjust a lesson so as to better clarify and remediate a problem area. This I believe will be helpful to all my students.

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APPENDICES

APPENDIX A

SAMPLE LESSONS NONINTERVENTION

Nonintervention unit lesson 1

Warm up-

Students answer question--What is heat?- allow students to write a response into their composition books.

Demonstration

Show students an example of heat using a microwave and a toaster. Have students copy down their observations in their composition book.

Pose another question – how are these objects producing heat?

Activity

Give students a note taker on heat energy

Show PowerPoint presentation having students fill in note taker

APPENDIX B

PRE, POST, AND DELAYED ASSESSMENT HEAT

Pre- post-delayed

Properties of heat assessment- Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Describe the difference between heat and temperature.

Give and explain using a picture and a diagram the process of conduction.

What is the difference between convection and conduction?

Explain the differences between insulators and conductors.

Explain how radiation works.

APPENDIX C

PRE, POST, AND DELAYED SURVEY HEAT

Pre- post-delayed

Survey questions on heat –energy- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1

Mark which best fits your level.

1. What level of interest does learning about heat energy have for you?

   1 2 3 4 5

2. What level of knowledge do you feel you gained from learning about heat energy?

   1 2 3 4 5

3. What level of long-term recall do you think you might have in regards to heat energy?

   1 2 3 4 5

4. What kinds of activities help you to learn about heat the best?

5. What level of intensity would you say that annotating affected your learning of heat energy?

   1 2 3 4 5

APPENDIX D

TEACHER OBSERVATIONS: NONINTERVENTION/INTERVENTION

Teacher Observations – Nonintervention/Intervention

HIGH MED LOW STUDENTS

Date---
Phase of class beginning, middle, or end

Activity- lab/ classwork/note taking

What strategy was being used?

Student attitude toward lesson: 1 2 3 4 5

Observations/comments:

Students overall desire to learn: 1 2 3 4 5

Observations/comments

Students were overall engaged with
the lesson and material: 1 2 3 4 5

What type of student is disengaged? h-m-l

Observations/comments:

Students were off task and
misbehaving while working 1 2 3 4 5

Observations/comments:

The treatment helped students learn 1 2 3 4 5
Comments

What possible adjustments need to be made?

APPENDIX E

PRE, POST, AND DELAYED INTERVIEW HEAT

Pre- post-delayed

Interview questions-Energy (heat)- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Explain how heat moves.

Describe some properties of heat.

Explain how heat can transfer from material to another.

What did you like about learning concepts on heat?

What areas do you feel about heat energy are still a little "muddy"?

APPENDIX F

REFLECTION PROMPTS

Teacher Refection Prompts

Date-

Today's Activity--

How do you feel the lesson went today 1 2 3 4 5
Observations/comments:

How well do you think the students used strategies 1 2 3 4 5
Observations/comments:

My attitude about my students today 1 2 3 4 5
Observations/comments:

My attitude about the activity today 1 2 3 4 5
Observations/comments:

Is the intervention making an impact on 1 2 3 4 5
Students learning?

Has the intervention goals been met? How? 1 2 3 4 5

APPENDIX G

PEER REVIEW

Peer review

Date:

What was the class working on today?---

Teacher seemed to be enjoying himself 1 2 3 4 5

Comments on EACH
Students seemed to respond to instructor well 1 2 3 4 5

Students seemed to be engaged in the material 1 2 3 4 5

Students seemed as if they were enjoying the lesson 1 2 3 4 5

Instructor demonstrated care for students learning 1 2 3 4 5

It seemed as if “learning” was taking place 1 2 3 4 5

Additional remarks, observations, or comments:

APPENDIX H

TEACHER SURVEY

Teacher Survey

Date:

In regards to today's lesson-------

Motivation- was I motivated – 1 2 3 4 5

Additional remarks-

Attitude- how is my attitude- 1 2 3 4 5

Additional remarks-

Did the students meet your learning expectations-- 1 2 3 4 5

Additional remarks-

What you think of the students motivation and attitude-- 1 2 3 4 5

The treatment has a positive effect on student learning 1 2 3 4 5

Additional remarks-

APPENDIX I

PRE, POST, AND DELAYED ASSESSMENT SOUND

Pre- post-delayed

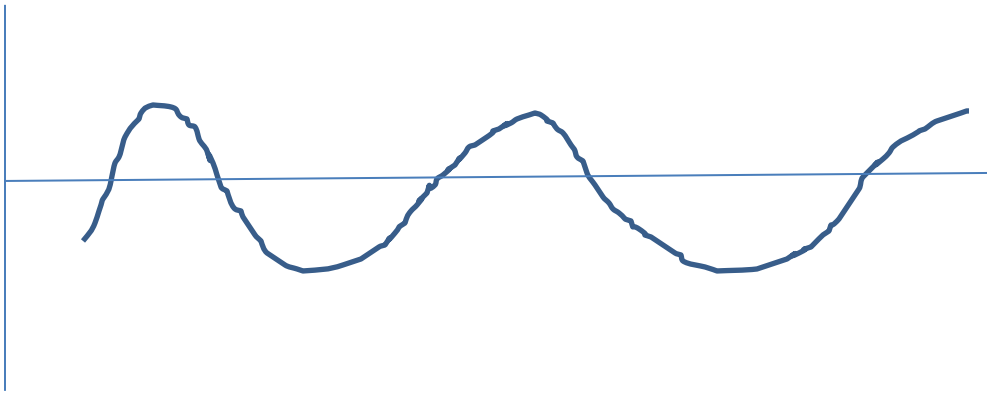
Properties of sound assessment- Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Describe and give an example of sound interference.

Make a concept map using the sound vocabulary words. (frequency, interference, wavelength, amplitude)

What is the relationship between amplitude, frequency and wavelength?

(Amplitude, frequency and wavelength) use these three words to describe the graph



APPENDIX J

PRE, POST, AND DELAYED ASSESSMENT KINETIC ENERGY/POTENTIAL

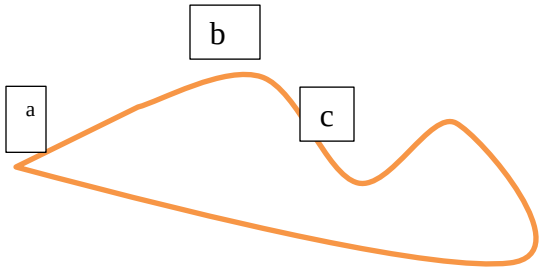
Pre- post-delayed

Properties of kinetic and potential energy assessment- Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Describe the difference between kinetic and potential energy.

Give and explain using a picture and a diagram the process of energy transfer.

Explain the potential and kinetic energy transfer that occurs on a roller coaster at different points.



APPENDIX K

PRE, POST, AND DELAYED ASSESSMENT ELECTRICITY

Pre- post-delayed

Properties of electricity assessment- Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

What is electricity?

What kind of things conduct electricity and why?

What is a circuit?

Explain how circuits used?

What is a battery and how do they work?

What kind of things use electricity?

APPENDIX L

SAMPLE LESSONS INTERVENTION

Intervention unit lesson 1- Light

Engagement

Why do you see yourself in a mirror?

Exploration- students are given mirrors, lasers and flashlights, water and straws and asked to plan an activity to test how a mirror allows for us to see our image. Students are asked to investigate the property of light that allows for these phenomena to occur.

Explanation- students share their findings and reflection is brought up

Extension-students then investigate the property of light as it goes through different mediums like air and water.

Evaluation- students are asked a question to compare the property they found in the first activity to that in the second

Compare refraction and reflection

I will facilitate the lesson by allowing the students to search out and investigate their question. If students need assistance or if the students are not finding the intended answers I will assist them with guiding questions.

Intervention unit lesson 2- kinetic energy

Engagement- have a ball resting on an edge of a table ask students to explain what is happening while the ball is at rest and then when I push it over the edge in regards to energy transfer.

Exploration-design an experiment that will determine which combination of plastic tubes(long, short) and metal rods(long, short) transfers the most and the least energy to a nail in a block of Styrofoam

Explanation- students prepare a data table to record their finding and share them with the class

Extension- how could we apply this concept to another situation?

Evaluation- students answer analysis questions

1.Which combination of tube height and
rod mass transferred the most and least
energy to the nail? Explain the evidence you gathered
to make this conclusion.

2.Where was the rod located when there was the most:
a. gravitational potential energy?
b. kinetic energy?
3.Do you think that all the energy from the rod transferred
to the nail? Describe any evidence that showed
it did or did not.
4.How do the following variables affect how
much energy is transferred to the nail?
a. Mass of the rod
b. Height of the rod
c. Shape of the rod

I will facilitate the lesson by allowing the students to search out and investigate their question. If students need assistance or if the students are not finding the intended answers I will assist them with guiding questions.

APPENDIX M

PRE, POST, AND DELAYED INTERVIEW SOUND

Pre- post-delayed

Interview questions-Energy (sound)- Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Explain how sound works.

Describe some properties of sound.

What did you like about learning concepts on sound?

What areas do you feel about sound energy are still a little "muddy"?

APPENDIX N

PRE, POST, AND DELAYED INTERVIEW KINETIC AND POTENTIAL ENERGY

Pre- post-delayed

Interview questions-Energy (KE and GPE)- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Explain how KE and GPE work together.

Describe some properties of KE and GPE .

Give and justify your opinion on how Kinetic energy and gravitational potential energy are related.

What did you like about learning concepts on KE and GPE ?

What areas do you feel about KE and GPE are still a little "muddy"?

APPENDIX O

PRE, POST, AND DELAYED SURVEY ELECTRICITY

Pre- post-delayed

Interview questions-electricity- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Explain how electricity works.

Describe some properties of electricity.

What did/would you like about learning concepts on electricity?

What areas do you feel about electricity are a little unclear?

What kind of things would you like to know about electricity?

APPENDIX P

PRE, POST, AND DELAYED SURVEY SOUND

Pre- post-delayed

Survey questions on Sound –energy- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1

Mark which best fits your level.

1. What level of interest does learning about sound energy have for you?

   1 2 3 4 5

2. What level of knowledge do you feel you gained from learning about sound energy?

   1 2 3 4 5

3. What level of long-term recall do you think you might have in regards to sound energy?

   1 2 3 4 5

4. What kinds of activities help you to learn about sound the best?

5. What level of intensity would you say that annotating affected your learning of light energy?

   1 2 3 4 5

APPENDIX Q

PRE, POST, AND DELAYED SURVEY KINETIC AND POTENTIAL ENERGY

Pre- post-delayed

Survey questions on kinetic and potential –energy- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1

Mark which best fits your level.

1. What level of interest does learning about KE and GPE have for you?

1 2 3 4 5

2. What level of knowledge do you feel you gained from learning about KE and GPE?

1 2 3 4 5

3. What level of long-term recall do you think you might have in regards to KE and GPE?

1 2 3 4 5

4. What kinds of activities help you to learn about KE and GPE the best?

5. What level of intensity would you say that annotating affected your learning of light energy?

1 2 3 4 5

APPENDIX R

PRE, POST, AND DELAYED SURVEY ELECTRICITY

Pre- post-delayed

Survey questions on Electricity- **Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.**

Strongly agree – 5, Agree – 4, Neutral – 3, Disagree – 2, Strongly Disagree – 1

Mark which best fits your level.

1. What level of interest does learning about electricity have for you?

   1 2 3 4 5

2. What level of knowledge do you feel you gained from learning about electricity?

   1 2 3 4 5

3. What level of long-term recall do you think you might have in regards to electricity?

   1 2 3 4 5

4. What kinds of activities help you to learn about electricity the best?

5. What level of intensity would you say that inquiry affected your learning of electricity?

   1 2 3 4 5

APPENDIX S

TIMELINE

Project Timeline

January 7- **Nontreatment- pre-assessment**. **Unit 1:** Energy-heat
Started nontreatment preunit concept interviews, assessment and survey.
January 8- Direct instruction introduce project and learning guide heat
January 9- lecture and note taker on heat
January 10- temperature and thermal energy1st observation by colleague
January 11 – observing temperature change
January 14- -Heat post assessment, survey and interviews
January 15- **Treatment unit 2** energy-sound, pre-unit concept interviews , assessment & survey
January 16- sound as energy investigation 1
January 17 – sound as energy investigation 2 -2nd observation by colleague
January 21- sound investigation 3
January 22- using notes and PowerPoint presentation to supplement student learning
January 23 post assessment, survey and interviews on energy-sound
January 24 **Treatment unit 3**- pre-unit concept interviews , assessment and survey energy – electricity
January 28 delayed post test surveys and interviews for heat energy unit 1 nontreatment
January29- electricity investigation 1-
January30 – electricity investigation 2-
January 31 - electricity investigation 3-3rd observation by colleague
February1- using notes and PowerPoint presentation to supplement student learning-
February4- electricity investigation 4
February 5-Post assessments interviews and surveys unit 3-electricity
February 6- – delayed post test surveys and interviews for sound energy unit 2 treatment
Treatment unit 4 energy- pre-unit concept interviews , assessment & survey
February 7- Energy investigation 1
February 8- energy investigation 2 -4th observation by colleague
February 11- energy investigation 3
February 12- energy investigation 4
February 13- energy investigation 5
February 14 –energy investigation 6
February 18- **post assessment interviews and surveys for unit 4 Energy**
February 19- delayed post test surveys and interviews for light energy unit 3 treatment
March 4- delayed post test Unit 4Energy