THE EFFECTS OF GUIDED INQUIRY ON STUDENTS' UNDERSTANDING OF PHYSICS CONCEPTS IN THE MIDDLE SCHOOL SCIENCE CLASSROOM

by

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A professional paper submitted in partial fulfillment
of the requirement for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

June 2013

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June 2013

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ABSTRACT

A large emphasis within the National Science Education Standards has been placed on using inquiry learning to deliver instruction. Many teachers either struggle with using inquiry learning or believe they are using inquiry learning due to lack of understanding. This paper set out to consider the effectiveness of guided inquiry in the middle school physics classroom. This project spanned a total of two months, where students were taught introductory physic concepts using one investigation that used traditional methods of instruction and three investigations using guided inquiry learning. Data collected identified the effects on understanding content, long-term memory, and student and teacher motivation using preunit, postunit, and delayed assessments, interviews, concept mapping, surveys, teacher journaling, and peer teacher observations. The study results were mixed. Understanding content and concept mapping had a positive impact on guided inquiry learning in general, while long-term memory showed mixed results. Data also indicated that guided inquiry increased student and teacher motivation.

INTRODUCTION AND BACKGROUND

To fully prepare students to be 21st century thinkers, a science teacher must be mindful of not only the Common Core State Standards, but also the Conceptual Framework for the New Science Education Standards. Students must not only learn fundamental science concepts, but also develop skills for problem solving and critical thinking using the process of inquiry. A common belief among educators is that inquiry-based instruction was a tool used to teach process skills and not content. Consequently, educators have relied upon cookbook labs, worksheets and other teacher-centered activities to teach basic content. Additionally, many teachers have had little to no training and have not been successful at teaching inquiry-based instruction and have abandoned the idea altogether. Reducing learning to memorizing a set of facts, strips students of the rich opportunity to actively solve problems independently. Guided inquiry prepares students for lifelong learning by using methods that promote a deeper understanding of content.

For the past ten years, I have taught eighth grade science in a small town of Montrose in southwestern Colorado. During this time the state has experienced budget cuts to education, which has forced the district to run on a limited budget. The demographics of this area consist of an unusually high poverty rate and a large population of English Language Learning students who are immersed into the regular classroom for most of the day. Along with budget constraints, there is the increased pressure for students to score at or above proficiency levels on state testing. Within our district, a large emphasis has been placed on improving math and reading scores at the elementary level. Consequently, many students are not receiving an adequate level of science instruction before they reach middle school. This has put increased pressure on middle school science teachers to fill the gaps left behind before the high stakes state standardized testing in the eighth grade.

The focus question of this study is: What are the effects of guided inquiry on students' understanding of physics concepts using guided inquiry strategies from Lillian McDermott's, 'Physics by Inquiry' (1996). My project subquestions were as follows: what are the effects of guided inquiry on students' long-term memory of physics concepts; what are the effects of guided inquiry on students' attitudes and motivation; and what are the effects of guided inquiry on my teaching and motivation toward teaching? These modules are laboratory based and provided a step-by step process that helps to guide students through the process of observing, developing concepts, constructing models, and interpreting information.

It is essential that students are taught the skills of problem solving and have the ability to think critically as outlined by the National Science Standards. Just as critical is the idea that teachers learn how to use a guided-inquiry process approach of thinking and learning, across all facets of the science classroom, to advance students' critical thinking skills.

To assist me with this project, I called upon various people with a variety of backgrounds in the educational field. First, my daughter Melissa, a Chemical Engineer for the past six years was a tremendous help in assimilating the data. To further assist, I had a very energetic and helpful educator, Joan Light, who is the librarian at the school where I am currently teaching. She has been a high school English teacher for fourteen years and a librarian for the last four years. My colleague Rob Miller, has taught eighth grade science for the last 18 years and has also taught in the same school as myself for the past ten years. My reader is Susan Kelly, who I met two summers ago teaching a Lake Ecology class at Montana State and is the Outreach and Education Specialist for Montana State University. Finally, my MSSE project advisor is Dr. Jewel Reuter.

CONCEPTUAL FRAMEWORK

The information gathered on the process of inquiry helps to define inquiry learning in the science classroom and the many facets of inquiry-based learning that have developed throughout the years. It further sheds some light on how educators can best use guided-inquiry activities effectively within their classrooms to support long-term retention of science concepts. Additionally, studies of attitudes and motivations of the inquiry process are analyzed from the viewpoint of the student and the teacher.

Inquiry-based learning obtained its roots during the 1960's as a result of a movement that perceived the old instructional methods as lacking in teaching analytical and problem solving skills. Learning theorists like Jerome Bruner, who pioneered inquiry-based learning argued that, "Practice in discovering for one's self teaches one to acquire information in a way that makes information more readily viable in problem solving" (Bruner, 1961, p.26).

Since Bruner's assertion, over the years the term *inquiry* has been somewhat misused and misunderstood. In 2000 the National Research Council sought to redefine the components of inquiry learning by stating "Inquiry requires identifying assumptions, use of critical and logical thinking, and consideration of alternative explanations" (National Research Council, 2000, p.23). Inquiry methods can vary to the degree at which students are self-directed learners, to the amount of teacher-direction or materials provided to the student by the teacher (Hansen, 2002). For the purpose of my capstone paper, I focused primarily on guided-inquiry methods whereby the teacher provides the materials and a problem to investigate, as well as providing students with additional instructional support when needed. Although this model of guided inquiry learning can be used for just about any science related subject, this study focused on the subject of physics in the middle school classroom.

Often times the concepts of physics are difficult for students to understand. Minority students often perform below other students in science classes, due to a lack of development of understanding of basic scientific concepts and reasoning. McDermott, Rosenquist and van Zee sought to identify a number of difficulties that impede progress for minority students (1980). They included lack of understanding of basic scientific concepts and difficulty with scientific reasoning. As these students progress into higher-grade levels, this problem becomes more pronounced. Having students work in cohort groups of varying academic abilities levels and solving problems together in an investigative manner was used in this investigation to help bridge this gap.

McDermott and colleagues found that many minority students in grades K-12 struggle with understanding new concepts when taught using primarily verbal instruction. Further studies on grades K-12 showed that direct experiences through labs and group work help students to examine their own thinking and build new knowledge. Students need hands-on practice and dialogue between each other to link important concepts (1980). McDermott and colleagues have also done extensive research on misconceptions in science. They found that by confronting misconceptions and exposing students to similar concepts creates confusion. This confusion becomes a primary talking point within groups as they work together to resolve their misconceptions. After carrying out a series of labs, students can eventually arrive at a correct conclusion (1980).

There are numerous reasons as to why inquiry or discovery learning may not go as planned. While completing group work, such as labs, a group may depend upon one or two students to do most of the work. Many students may try to cut corners by not reading all the instructions for an investigation and find they have to start over or are unable to finish the lab in the allotted class time. Students may fail to question their results and draw from prior knowledge to make important connections. Others cannot articulate important connections to the lesson and consequently fail to understand the validity of the lab itself. For the teacher, this can be exhausting, and for the student, the process of discovery learning and inquiry can be lost.

Having students start with a problem and working from start to finish through the investigative process does not always guarantee that students will retain the identified concept. How can guided-inquiry activities be implemented so that students are using the process of discovery learning as an effective teaching tool for long-term memory? McDermott (1996) states that effective learning must include, “mental engagement”. Through student observation, the building of concepts, interpretation, and construction of models, students are able to be mentally engaged and to develop fundamental concepts and basic reasoning skills. McDermott uses a process of discovery, where the teacher is the facilitator, as opposed to memorizing and questioning, over lecturing and cookbook labs. Teachers continue to play as active role to passively guide students through the process, by using questioning techniques and asking groups to share results throughout the process.

Many teachers choose not to use a student-driven approach in their classes because of lengthy class time involved in completing a lesson or concept. Some educators feel pressured to cover all the material before the end of the year state assessment, than spend additional time completing a student led investigations. Research from 138 studies analyzed from 1983 to 2002 on inquiry-based learning conducted by Minner, Levy, and Century found that students from grades K-12 perform better on state standardized tests when taught concepts using student-driven scientific investigations, compared to teacher led forms of instructional methods (2009). Therefore, the focus for teachers should be more about how instruction is delivered and not about the amount of material one can cover in a school year.

Given (2002) found through extensive research that the formation of long-term memory requires more than just participating, but actively processing as well. Given identifies five natural systems of the brain that can store information. The first natural system is the cognitive learning system that is involved in interpreting, storing, and retrieving information. The second is the emotional learning system, where personal meaning, and relevance are processed. Next, is the social learning system that governs interactions and communication. Fourth, is the physical learning system that gathers information through senses and disperses this information throughout one’s body. The final natural system is the reflective learning system that weighs the present, past, and future events in order to draw conclusions. The more natural systems that students use, as described above, the higher the likelihood that long-term memory will occur.

Sousa (2006) reports that research on retention shows that the greatest loss of newly acquired information or a skill occurs within the first 18 to 24 hours. A 24-hour period is a reasonable amount of time in determining whether long-term memory has taken place. This information lead to a study conducted by Teachers College and Columbia University (1994) that compared a constructivist approach to teaching versus direct instruction that involved sixth-graders from neighboring schools. The experimental group were students from one social studies class that were consistently taught using a constructivist approach, while the neighboring school used only direct instruction in their social studies classroom. Students were given information about a memory study and asked to find information to back-up the claims to prove the results. After a two-day period students were measured on pattern recognition, explanation and argumentation, and organization of data. The results showed that students taught using a constructivist approach scored slightly higher in recall, and 73% higher in pattern recognition. The organization of data was slightly higher for the control group. The study showed that when students are taught skills to be independent learners, they are more apt to store information learned in long-term memory.

Attitudes and motivation of students using guided inquiry provide insight into how students view the investigative process of reasoning and whether they are gaining a deeper conceptual understanding of the material. In a study conducted by Sandoval and Harven (2010), seventh-grade students from five diverse urban middle schools who were using guided inquiry in their biology classes for the first time, were asked how they perceived inquiry tasks. Overall, students did not find the inquiry process to be much different from what they were already doing, but did find the process useful.

Additionally, students found the writing and explanation component of the investigation less interesting and the informal task design and analysis of the investigation more interesting. The most dramatic results focused on how students from different socio-economic classes viewed the value of guided inquiry instruction. Students who were classified as coming from a low socioeconomic class rated the inquiry process as more interesting and useful when compared with students who rated high in socioeconomic class.

Jeanpierre completed a similar study, which focused on teacher attitude and motivation of guided-inquiry instruction, in 2006. It shed some light on what teachers report about their inquiry practices in the K-8 classroom. This five-year study looked at low socioeconomic schools that had 50% or more students on free and reduced lunch. Additionally, all teachers had completed a K-8 Master's in Mathematics and Science Program, which focused on reflective practices. The survey sought to gain insight into what teachers believed about their own inquiry practices and compared their responses to their actual practices and how they aligned with the National Science Education Standards. Most teachers rated themselves as having a student-centered classroom, but did not see themselves as a positive facilitator of inquiry learning. It was interesting to note that two-thirds of the teachers felt that they provided good opportunities for students to develop a hypothesis and interpret data, but only 41% of the teachers responded as *often* or *almost always* to allowing students to design their own experiments. Many teachers felt they had incorporated inquiry into their classroom, but in reality they may have been missing important components to the inquiry process.

In summary, guided inquiry is a process of discovery learning that is driven not by the memorization of concepts typically stored in short-term memory, but the asking of open-ended questions that opens dialogue between other students and the instructor. Students use prior knowledge as a building block for linking old ideas with new concepts. Through this open dialogue misconceptions are identified and encouraged, so that student understanding can be identified and corrected. It is essential that the instructor provide the ability for students to further question, investigate, and allow students time to build a new body of knowledge.

METHODOLOGY

Project Treatment

A physics unit was used for this investigation primarily because of the diversity of hands-on activities that could be used. To fully understand the impact of this investigation on student learning and teacher instruction, data were collected from both treatment and nontreatment units for the purpose of comparison. The nontreatment unit was lessons taught on Speed and Velocity using teacher-centered instruction that included a combination of teacher lecture, cookbook labs, videos, and reading that included questions to measure understanding of content. The treatment unit was taught Newton's Laws of Motion, Forces, and Acceleration using guided-inquiry modules adapted from Lillian McDermott's, 'Physics by Inquiry' (1996). All inquiry modules utilized cooperative learning groups that included individual KWL charts to start the lesson. Initially, this activity started group and class discussions about what students already knew and any misconceptions that needed to be addressed throughout the lesson.

Investigative labs gave students an opportunity to design a lab, based on the knowledge they had recently obtained about the subject matter. Videos were incorporated to provide students with a visual image and to give examples of real world applications about the subject matter. Reading activities were incorporated with the KWL charts in which students wrote down what they felt was the most important information within each subheading in the L section of their KWL charts. This information was then used to construct individual concept maps, then group's concept maps and finally a concept map for the class that were written on butcher paper and displayed in the classroom. Reading study guide activities and student roles within each group were developed from Hanson's POGIL design and were used to create concept maps that identified what students learned and misconceptions (2006).

At the beginning of the year, in preparation for the treatment unit, all students participated in various activities that fostered team building and cooperative learning. One such activity can be found in Appendix A. Students practiced how to solve real-world problems that were dependent upon the participation of all group members. Additionally, students completed learning style surveys that helped to divide them into heterogeneous groups. Students' academic abilities were also used to divide them, so that struggling learners would have support from other group members to complete all assigned tasks. Students were assigned specific rolls within each group for the week, which included, a leader, recorder, spokesperson, and a team analyzer. An explanation of these roles can be found in Appendix B. Groups had to then assign themselves a grade based upon their ability to complete tasks individually and for the group as a whole. They also had to explain why they deserved the grade they had chosen.

Both the treatment and the nontreatment units started each lesson by students' copying the learning goal and answering the warm-up question in their science notebooks. Next, the entire class reviewed the learning goal and answered the warm-up question with direction of the facilitator or teacher. Typically, these questions were important concepts that were taught the day before and provided an opportunity for students and the class to refresh what they had learned before. It also provided an opportunity for the class to discuss any misconceptions in an open-forum and correct the misconceptions with the teacher again acting only as a facilitator that guides students to the correct answer.

The nontreatment unit was Speed and Velocity and was taught using a variety of instructional methods that employed a teacher-centered approach. The classroom was designed so that students sat at individual desks designed in rows. Students were taught using many of the instructional methods laid out to Trefil's Science Integrated 2 textbook (2005). Students began each lesson by reviewing the key concepts and completing mini-explore lessons. Next, students read and answered questions from the text. Short videos were shown to reinforce key concepts that included questions. Students also worked in groups to complete labs in which students had to construct models and complete the predesigned lab. An example of one such lab investigation can be found in Appendix C. Groups of four to five students completed an investigation on how to measure speed using different types of balls and timed how long it took the balls to roll a designated distance. Speed was then calculated for the different types of balls. Additionally, students completed a formative assessment at the end of each class period that included three to four short answer questions.

There were three separate treatment units that were tested and covered topics in physics that included: Newton's Laws of Motion, Forces, and Acceleration. Each treatment unit had students work in groups and each group used the same criteria of instruction. All treatment units began with the inquisition phase, where groups of three to four students were asked to answer an open-ended question (or "what if questions?") that were designed to build upon prior knowledge about the particular subject matter within the physics unit. After groups were given time to reflect on the question, each group shared with the rest of the class what they knew. The teacher and the students worked closely to define important concepts as each group shared their information. Then students began each unit by working individually and in groups to complete a KWL chart. A detailed example of this activity can be found in Appendix D. The KWL chart was also used throughout the units to record key concepts that had been learned from each lesson and to write down any questions or misconceptions that needed to be addressed within groups or with the entire class. Trefil (2005) was also used as a reading resource for the treatment units. As described the Appendix D, students began the lesson by working individually, then sharing with their groups and finally with the entire class, to create a final product that represented what they had learned. During this activity the teacher or facilitator was there to guide students through the learning process and monitor each groups' progress, but not to teach or instruct. The facilitator was also responsible for redirecting the class as they transitioned from one component of the guided inquiry to the next. Misconceptions were also addressed and discussed as a class. The facilitator helped to direct students as how to how to find the correct information to answer each question. Labs were designed using the same guided-inquiry methods as described in Appendix E in which students worked in groups to calculate motion with a constant speed. Emphasis was put on group members to work in their assigned rolls. Groups were given cues from the lab to stop and wait for further instructions from the facilitator. This allowed time for the facilitator to check the progress of the group and check for misconceptions before students were allowed to continue to the next phase of the lesson. Because groups did not necessarily finish at the same time, the amount class down time was minimal. After students have completed the lab, they read about the subject being taught within their text and constructed important concepts as a group, that were later shared with the class. Additionally, students watched videos relating to the concept being taught. During the video each group compiled a list of the best questions and answers they had created, which were shared with other group members (Appendix F). Finally, one list of questions and answers were compiled and posted in class for all groups to share.

Data Collection Instruments

Centennial Middle School is one of two middle schools in Montrose, Colorado, located in the southwest corner of the state and is known for the abundance of open space and outdoor recreation. Many people who live in this community of approximately 25,000 people are either retired, or work in the service industry for the wealthy ski resort town of Telluride, Colorado, some 60 miles to the west. Because no major industries are located in this area, except for tourism, construction, and some agriculture, the area has been hit particularly hard by the recession. Approximately 53% of the students are on free and reduced lunch. Additionally, 40% of the students are considered English Language Learners. Gifted and talented students account for approximately 9% of students in the eighth grade. Another 8% of students have learning disabilities as described by their IEP's, and all have full inclusion in science classroom.

The state of Colorado has faced budgets cuts to education that have reduced the district's operating budgets by more than half over the past two years. This has reduced the number of teachers, taken away planning periods and increased class sizes. The average class size ranges from 19 to 25 students. My study included 108 eighth grade students broken up into five class periods. Most students were excited about learning and enjoyed science. This study included 37 low-achieving students, 45 mid-achieving students, and 26 high-achieving students. Although each class size was relatively large, there are no major behavior problems and students appeared to get along very well. This was a definite asset when students worked in assigned heterogeneous groups.

A triangulation matrix was used to show the three data collection methods that were employed in this project and are summarized in Table 1. This matrix helps to provide a more accurate understanding of the project's findings, by not relying on one source of data to draw conclusions. Data was collected from both the nontreatment and treatment units.

To fully comprehend the effects of student understanding of concepts and long-term memory of concepts with the use of guided-inquiry activities, students completed the pre and postunit assessment and delayed questions that were specific to each unit objective for the nontreatment (Appendix G) and the treatment units (Appendix H). Six students completed interview questions, both before and after each unit. Two students each from a low, middle, and high academic ability levels completed concept maps both before and after the treatment and nontreatment activities for the purpose of comparison

(Appendix I and Appendix J). The same students were interviewed at each phase. A rubric for the concept map can be found in Appendix K. Survey questions were also given to students both before and after each unit as an additional piece of data to measure understanding of the content. These questions can be found in Appendix L and Appendix M. To measure the effects of long-term memory, students were given the same questions that were given for the pre and post assessment for understanding content, as well as concept maps, but were delayed for a two-week time period.

Table 1
Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
Student understanding of concepts	Pre and postunit student assessments	Pre and postunit student interviews with concept maps	Pre and post treatment, student surveys on their percent of understanding
Effects of Long-Term Memory	Post and Delayed Unit Interview Questions w/ Concept Maps	Post and Delayed Unit Assessment	Post and Delayed Treatment Surveys
Student Attitude and Motivation	Pre and Post Treatment Surveys	Pre and Post Treatment Interviews	Teacher Observation with Field Notes
Teaching Attitude and Motivation	Pre and Post Treatment Teacher Journal with Prompts	Pre and Post Treatment Self-Evaluation Surveys	Nontreatment and Treatment Peer Observer

To understand students' attitudes and motivation toward understanding content, students completed surveys before and after each unit found in Appendix N and

Appendix O. The same students that were interviewed previously, were again asked questions concerning attitudes and motivation both before (Appendix P) and after the treatments (Appendix Q). A daily journal kept by the teacher also logged observations of attitudes and motivation of the students. This journal format can be found in Appendix T.

To measure teacher attitudes and motivation, an additional daily journal was kept by the teacher with prompts that included a Likert scale as a form of measurement along with additional questions that were used as a form of qualitative measurement (Appendix U). Self-evaluation surveys were also completed by the teacher (Appendix V), which also included a Likert scale for measurement. Peer observations were also completed for both the nontreatment and treatment units (Appendix W). An overall timeline of this project can be found in Appendix X.

DATA AND ANALYSIS

Data were collected from treatment and nontreatment units to compare results of low, medium, and high-achieving students for understanding of physic concepts.
Other methods were also used to allow for triangulation and will be discussed in detail.

Data used from the pre and postunit assessments were used to calculate percent change in the understanding of unit concepts for each academic ability level and a comparison was made between the nontreatment and treatment units.

When comparing the percent change for the nontreatment and treatment units, overall student achievement increased in the treatment units compared to the nontreatment unit. Table 2, shows the results for percent change and normalized gain on student scores from pre to postunit assessment for one nontreatment unit and three treatment units. The percent change was highest in the first treatment unit for all ability levels, but highest for mid-achieving students. Percent change continued to decease with each progressive treatment units, however, the pretest scores increased from one treatment unit to the next. Due to a steady increase in preassessment scores for treatment units, normalized gain was also calculated to compare the percent increase to total possible increase, based upon the preassessment score. A scoring method, introduced by Richard Hake in the American Journal of Physics (1998), concedes that students who are being taught using "traditional methods" typically score within .23 ± .04 range and students taught using methods of "interactive engagement" score within a range of .48 ± 1.04. All groups scored within the "interactive range", except for low-achieving students from the nontreatment unit. When comparing all student groups for a normalized gain, little change existed from the nontreatment to the treatment units, however, low-achieving and high-achieving students both scored higher when compared to the nontreatment unit.

Student average scores were higher for all treatments, when compared to the nontreatment unit. The percent increase for treatment unit 1 was the highest, followed by the treatment 2 and then the nontreatment. Treatment 3 had the lowest percent gain. Other data that measured student understanding and supported the pre and post unit assessments were student interviews with concept maps, which gave further insight into student understanding of concepts. Six students were chosen from random classes, with varying academic abilities. Students constructed concept maps with successive branches and cross-links, which provided a better picture of individual student thinking, as well as answering a set of oral questions. In the nontreatment unit, students only showed an 80% improvement in making connections between concepts, which were very linear, except for one low achieving and one high-achieving student. Conversely, during the treatment units, all student abilities to make connections using a concept map improved, compared to the nontreatment units, by an average of 157%.

Table 2
Average Scores and Percent Increase from Pre to Postunit assessment to All Units Split into Low-Achieving (n=37) Mid-Achieving (n=45) and High-Achieving (n=26) and All Students (N=108)

Group Name	Low	Medium	High	All
Nontreatment				
Pre	1.48	2.46	3.85	2.45
Post	8.15	11.80	13.60	10.98
Percent Change	450.68	379.67	253.25	348.2
Normalized Gain	0.05	0.69	0.87	.74
Treatment 1				
Pre	0.56	0.37	0.74	0.52
Post	9.86	11.70	14.60	11.77
Percent Change	1661.00	3062.00	1873.00	2163
Normalized Gain	0.64	0.77	0.97	0.75
Treatment 2				
Pre	1.32	2.40	3.59	2.32
Post	8.9	10.60	13.70	10.76
Percent Change	574.2	341.70	281.60	363.8
Normalized Gain	0.40	0.65	0.88	0.67
Treatment 3				
Pre	1.61	2.69	4.17	2.76
Post	8.56	11.37	14.37	11.13
Percent Change	431.7	332.70	244.60	316.85
Normalized Gain	0.52	0.70	0.94	0.69

Note. Assessment score based on 15 points.

Levels of hierarchy also improved from one treatment unit to the next for all ability levels. In the second treatment, most students could show a relationship between

Newton's 2nd Law, force, mass and acceleration and give examples of how calculations could be made, which showed a hierarchy of learning from the most general of concepts, to the most specific. Additionally, students showed in Newton's 1st Law (first treatment) a clear link between inertia and particular objects that were moving and at rest. One low-achieving student explained it as, "things like to keep doing what their already doing." This evidence showed an overall increase in all students' abilities to make connections between various components, which were not apparent when looking solely at percent change for the pre to postunit assessments.

The interview data showed a wide range of growth for the percent change of student understanding. One high-achieving student showed little growth for any of the treatment units. The highest increased in percent change occurred with one low and one mid-level achieving student. The same pattern existed for the mid-achieving students with some growth, while the other showed a 200 percent increase for all treatment units. One high-achieving student showed average growth in the treatment, while the other student showed the least amount for all ability levels. This accounted for high scores on all the preunit assessments for all treatments. Again, the first treatment unit percent change was higher overall for all students, except for one mid-achieving student who scored higher in the second treatment. Class observations showed that students who were more actively participating in their groups, by problem solving and asking questions, scored higher overall during the interview process. Figure 1 shows the tabulated results for percent change and interview questions for all treatment groups and ability levels.

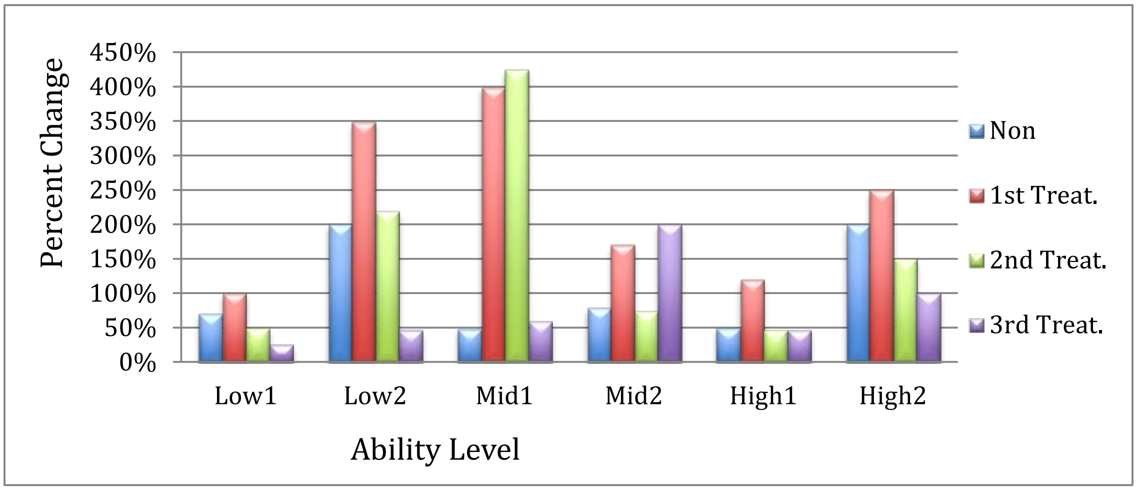

Figure 1. Percent increase on interview questions with concept maps from preinterview to postinterview by student for each unit.
Note. Low 1= low-achieving student number 1, Low 2= low-achieving student number 2, Mid 1= mid-achieving student number 1, Mid 2= mid-achieving student number 2, High 1= high-achieving student number 1, High 2= high=achieving student number 2 (*N*= 2 for each group)

When observing students working in groups during the treatment unit, a considerable amount of time was spent within groups discussing key concepts and working to come to a consensus about their meanings. Additionally, I observed students sharing misconceptions, such as ideas about the relationship between velocity and acceleration. Some students thought that acceleration only dealt with an object speeding up, and related this idea to the accelerator of a car. Explanations of various subject matters were shared within groups until all students had a clear understanding of the concepts, especially at the beginning of each treatment unit, when groups began working on their KWL charts. This was apparent during the interview portion of the assessment, in that students showed a deeper understanding of concepts. Most students were able to give answers during the treatment units that far exceeded the level of understanding seen in the nontreatment unit. A mid-achieving student was asked in the second treatment unit how increasing the centripetal force of an object would affect acceleration? This student related their answer to the force equals mass times acceleration equation and explained that, “If the force is increased, so is its acceleration, because of the formula we learned from Newton’s Second Law, which is force equals mass times acceleration.” When a low-level student was asked in the first treatment unit what happens to a moving object if all the forces are balanced, the student commented that, “since all the forces are balanced, that object will continue to move at the same speed and direction, like a ball floating in space.” Not only could the student explain the concept, but could also provide a real life example.

The level of oral answers given in the third treatment was not a detailed as those in the first and second treatment units and did affect the final scores in the interview process. The level of misconceptions observed in class was carried over into the postunit assessment. Students continued to misunderstand the idea of action-reaction forces. When students were asked how a jellyfish moves through the water, most all except the low-achieving students could explain the downward force applied by the jellyfish, and how the water applies an equal force in the opposite direction. Conversely, when students were asked to apply this concept to similar situations, such as what moves an inflated balloon when released in the air, many students could only think of extraneous variables, such as helium and wind as the cause for movement, instead of the action/reaction forces that were discussed in class. This was surprising, considering the lab that had been done in class was the Balloon Rocket Lab in which groups used balloons to show action/reaction forces. Only the high-level students interviewed could make the connection between the two ideas. Other misconceptions became apparent when students were asked the difference between balanced forces and action/reaction forces. One low-achieving student could not make the connection. The other low-achieving student stated that balanced forces are always at rest and action/reaction forces are always moving. One mid-achieving student and one-high achieving student saw a balanced forces as always acting on two objects, and action/reaction as always acting on one object, which is just the opposite of the what actually occurs. Only one high-achieving student could make the correct connection between the two concepts. This may have in part had to do with the ability for some groups to work together in a cohesive fashion.

Student concept surveys were also used to determine student understanding, with short open-ended questions that allowed students to share what they knew about a particular concept. Overall student scores increased in the nontreatment unit with a percent change of 114 percent, while all treatment groups averaged a 211 percent increase. Again, the first treatment unit showed the highest increase percent change. Table 3 below shows all the results for the percent change for student surveys for the pre and postunit assessment for one nontreatment and three treatment units, as well as percent change for academic ability levels.

The normalized gain showed positive results for the treatment units. All treatment units scored higher in normalized gain, with the exception of treatment 3.

Most responses students gave in the student survey did not include as much detail as the other assessments, but it did show that students had a basic understanding of the concepts. As an example, when students were asked in the first second treatment what they knew about force, mass and acceleration, many wrote the equation without any explanation. The majority of low-achieving students could explain inertia as something in motion or something at rest, but could did not always include both concepts. Normalized gain scores were higher for all levels of achievement in all three-treatment units, compared to that of the nontreatment unit.

Table 3

Scores and Percent Change from Student Concept Surveys for Pre to Post Unit Assessments by all Achievement Groups Low-Achieving (n=37) Mid-Achieving (n=45) and High-Achieving (n=26) and All Students (N=108)

Group Name	Low	Medium	High	All
Nontreatment				
Pre	0.64	0.83	1.39	0.9
Post	1.62	3.04	4.29	1.93
Percent Change	153.00	266.20	207.10	114.44
Normalized Gain	0.22	0.53	0.79	0.17
Treatment 1				
Pre	0.35	0.51	1.16	0.61
Post	2.87	3.86	4.60	3.70
Percent Change	720.00	656.80	296.50	506.56
Normalized Gain	0.38	1.00	0.88	0.48
Treatment 2				
Pre	1.10	2.09	3.47	2.08
Post	4.42	4.27	5.00	4.50
Percent Change	301.80	104.30	44.60	49.19
Normalized Gain	0.65	0.75	1.00	0.49
Treatment 3				
Pre	1.51	2.26	3.34	2.26
Post	3.24	4.25	4.92	4.07
Percent Change	114.5	88.00	47.20	80.09
Normalized Gain	0.49	0.72	0.95	0.23

Note. Maximum score based on 5 points.

In addition to determining if this method increased overall understanding of content, I was interested in knowing if guided inquiry methods of instruction promoted long-term memory. Two weeks after the postunit assessment, students were given a delayed assessment to test for long-term memory. After the postunit assessment was handed back to students, time was spent as a class reviewing concepts and addressing misconceptions, which did help to close the feedback loop. Table 4 shows a comparison of percent change from the postunit assessment to the delayed assessment for all academic ability levels.

Students showed improvement in treatment 2, except for high-achieving students. The highest percent change was recorded for low-achieving students in treatment 2 followed by mid-achieving students. The high-achieving students also showed gains in treatment 1, but did score higher in the nontreatment. For normalized gain, high-achieving students in treatment 1 showed the largest gain, while mid-achieving students in treatment 3 showed greatest decrease in scores. Overall, the treatment 2 showed the highest normalized gain.

These data suggests that an increase in students understanding resulted from to time spent in class addressing misconceptions and closing the feedback loop that were noted on the postunit assessment, using the same methods prescribed in the nontreatment and treatment units.

Table 4
Scores and Percent Change for Postunit Assessment to Delayed Assessment for All Units by Achievement Groups, Low-Achieving (n=37) Mid-Achieving (n=45) and High-Achieving (n=26) and All Students (N=108)

Group Name	Low	Medium	High	All
Nontreatment				
Post	8.15	11.8	13.6	10.98
Delayed	8.11	10.6	14.46	10.67
Percent Change	-0.49	-10.16	6.32	-2.87
Normalized Gain	-0.04	-0.32	.30	-0.07
Treatment unit 1				
Post	11.89	14.1	14.2	11.76
Delayed	10.94	12.3	15.0	12.48
Percent Change	-7.94	-12.7	5.63	-6.65
Normalized Gain	-0.28	-2.00	0.43	-0.82
Treatment unit 2				
Post	5.18	9.82	13.61	10.76
Delayed	5.89	10.53	13.46	9.64
Percent Change	13.70	7.23	-1.10	7.44
Normalized Gain	.01	.14	-0.1	0.03
Treatment unit 3				
Post	10.92	12.5	14.8	-0.06
Delayed	10.19	12.2	14.7	-0.02
Percent Change	-6.68	-2.4	-0.67	-3.44
Normalized Gain	-0.2	-3.75	-0.5	-1.75

Note. Maximum score based on 15 points

To further assess long-term memory, a postunit interview was given to the same six students from varying academic ability levels, 14 days after the first interview. During this interview students were asked to create a concept map using the same terms that were used in the pre and postunit interview, as well as answer the same set of interview questions.

Figure 2 shows the percent change of individual student's scores from the postunit interview to the delayed interview for both concept maps and interview questions.

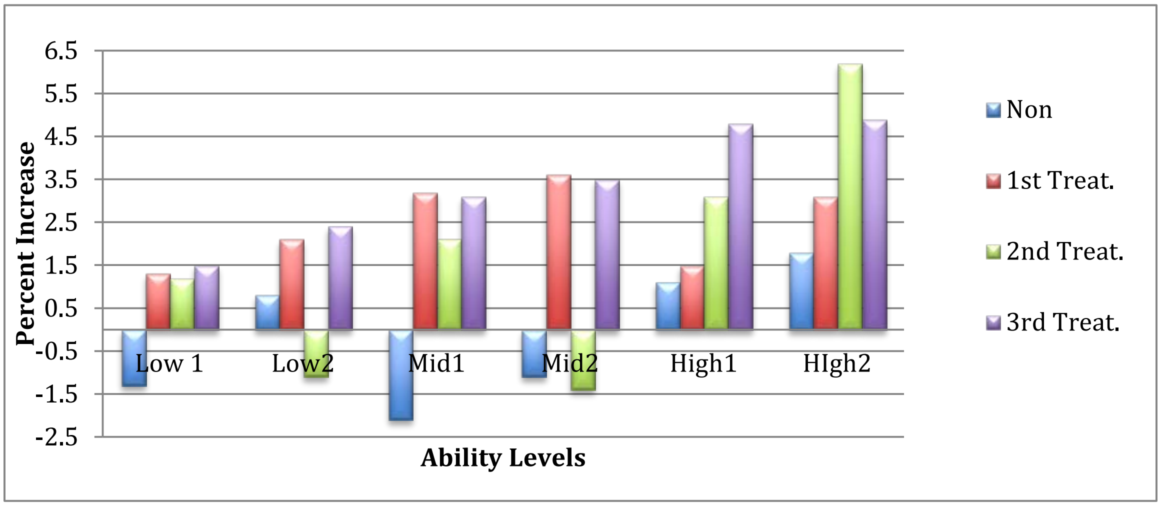

Figure 2. Percent increase from postunit interview and concept maps to delayed interview for one treatment and three treatment units. *Note.* Low1= Low-achieving student number 1, Low2= Low-achieving student number 2, Mid1= Mid-level achieving student number 1, Mid2= Mid-achieving student number 2 High1= High-achieving student number 1, High2= High achieving student number 2 *(N*= 2 for each group) *Note.* Non. Represents nontreatment, 1^{st} Treat. Represents the first treatment, 2^{nd} Treat. Represents the second treatment, and 3^{rd} Treat. Represents the 3^{rd} Treatment unit.

High-achieving students showed growth in both the nontreatment and treatment units, but the overall average increase was highest in the treatment units. All ability levels improved in the third treatment unit, which had previously showed the least amount of growth. Low and mid-achieving students struggled with the second treatment level, showing a 6.9% decrease, while high-level students showed an increase. Concept maps for all ability levels increased by 4.8% on average for the treatment units and 2.1% for the nontreatment. Progressively with each treatment unit, students improved on their ability to make connections and construct concept maps in part because groups had to construct their own maps within groups and share with the rest of the class. Having the concept maps displayed as posters in the classroom reminded students of the connections and were referred to frequently throughout the learning process.

Further analysis on percent change from the postunit assessment to the delayed assessments was completed using the same series of survey questions for both the nontreatment and treatment units. Fourteen days after the postunit assessment, students answered the same set of survey questions that pertained to understanding of content. Table 5 shows the percent change for both the nontreatment and treatment units. High-achieving students showed no loss of learning, but instead gain in the nontreatment and treatment 3. Low-achieving students in treatment 2 showed the least amount of knowledge lost when compared to the same nontreatment unit. The percent change for the nontreatment and treatment 2 showed the least amount of loss to student understanding. Treatment 1 showed the highest normalized gains with high-achieving students.

My observations indicated that for the first treatment level, many students were still struggling with how inertia affects moving objects. Several students reported that it could change the speed and/or velocity in some way. It was as if they were trying to incorporate concepts taught from the nontreatment unit on speed and velocity. In the second treatment unit, many students forgot how to rearrange the formula for force in order to find acceleration in a word problem, and ended up leaving the question blank. Students also continued to struggle with the correct units of measure for their calculations, especially when calculating momentum.

As part of this project, I was also interested in how methods used in guided-inquiry instruction affected attitudes and motivation of students. Six questions were asked of students pertaining to their attitudes and motivation and a Likert scale was used to measure how they felt about science, along with questions that allowed students to include comments that provided further evidence. Figure 3 below shows the tabulated results comparing student views before and after each treatment unit.

Table 5
Scores and Percent Change from Postunit assessment to Delayed Assessment Treatment Surveys for All Units by Achievement Groups Low-Achieving (n=37) Mid-Achieving (n=45) and High-Achieving (n=26) and All Students (N=108)

Group Name	Low	Medium	High	All
Nontreatment				
Post	1.62	3.04	4.27	2.84
Delayed	1.24	2.88	4.42	2.68
Percent Change	-23.00	-5.00	3.00	-13.00
Normalized Gain	-0.04	-0.28	0.02	-0.12
Treatment unit 1				
Post	2.87	3.86	4.60	3.70
Delayed	2.16	3.64	4.62	3.37
Percent Change	-24.0	-5.00	0	-10.3
Normalized Gain	-0.30	-0.41	0.25	-0.21
Treatment unit 2				
Post	3.78	4.27	4.85	4.24
Delayed	3.35	3.67	4.85	3.84
Percent Change	-11.0	-14.0	0	-9.60
Normalized Gain	-0.37	-0.8	0	-0.46
Treatment unit 3				
Post	3.24	4.27	4.92	4.06
Delayed	2.54	3.36	5.08	3.49
Percent Change	-21.0	-21.0	3.00	-15.2
Normalized Gain	-0.4	-1.2	0.5	-0.36

Note. Maximum score based on 5 points

The survey showed no change in student’s enjoyment for coming to science class or learning about the subject of physics. There was however a positive increase from the pre to the postunit assessment on students willingness to work in groups, to share and actively participate. Many students reported on the postunit assessment that working in groups helped them to know and learn more than working independently.

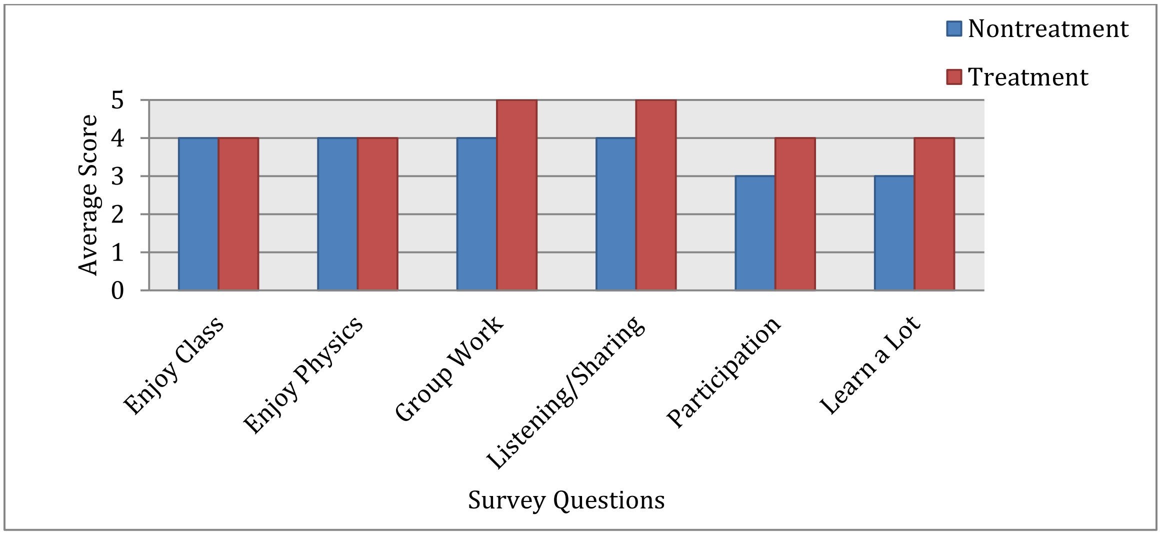

Figure 3. Comparison of student attitudes and motivation for pre and postunit assessments of student surveys of treatment units (*N*=108).
Note. Likert scale 5= strongly agree to 1= strongly disagree

Before the treatment units, few students commented on whether they liked to work in groups. Although scores in this area ranked at a four on the Likert scale for the pre, many more positive comments were posted on the postunit assessment. When one student was asked how working in groups affects their performance, the student replied, “Because if you do something wrong or don’t understand, the group helps me understand better.” Another student reported that they typically don’t like science, but that working in groups helped them to pay attention. Several students also commented on enjoying the labs in which they had to design their own investigations. One student wrote, “It was challenging, but fun.”

Another source of data that supported attitudes and motivation of students was that of the treatment interviews with the same six students as before. Their responses were broken up into common reoccurring themes from key words that were present throughout student's answers. A data were tabulated in Table 6.

Table 6

Student Interview Responses pertaining to Learning Styles, Attitude, and Motivation from preinterview to postinterview (N=6)

Targeted Question	High-Achieving Student Responses (%)	Mid-Achieving Student Responses (%)	Low-Achieving Student Responses (%)
Like Best - Preunit			
Lab	100	100	100
Group Work	0	0	0
Individual Work	0	0	0
Like Best - Post			
Lab	50	100	50
Group Work	50	0	50
Individual Work	0	0	0
Lab Attitude - Pre			
Like	100	100	100
Neutral	0	0	0
Dislike	0	0	0
Lab Attitude - Post			
Like	100	100	100
Neutral	0	0	0
Dislike	0	0	0
Group Work - Pre			
Like	50	50	50
Neutral	50	50	0
Dislike	0	0	50
Group Work - Post			
Like	100	100	100
Neutral	0	0	0
Dislike	0	0	0
Motivation - Pre			
Good Grades	50	50	0
Intrinsic	50	50	50
My Teacher	0	0	0
Motivation - Post			
Good Grades	100	50	0
Intrinsic	0	50	50
My Teacher	0	0	50

In the preunit assessment, all students reported that lab work was their preferred methods of learning. In the postunit assessment, one-high and one low-achieving student preferred group work over lab work, although both areas were still considered important in learning for both students. Student attitudes did not change from the pre to the postunit assessment, but one low-achieving student reported not liking group work because, "His group was always telling him what to do." It was also interesting to note that both low-achieving students were not motivated by grades, but by intrinsic items, such as money or gifts and by their teacher. It was not surprising that all high-achieving students were motivated by good grades.

Teacher observations were also used to measure student attitudes and motivation for both nontreatment and treatment units. Students were documented doing various tasks and recorded according to their ability levels. Figure 4 below shows the results for the nontreatment observations only.

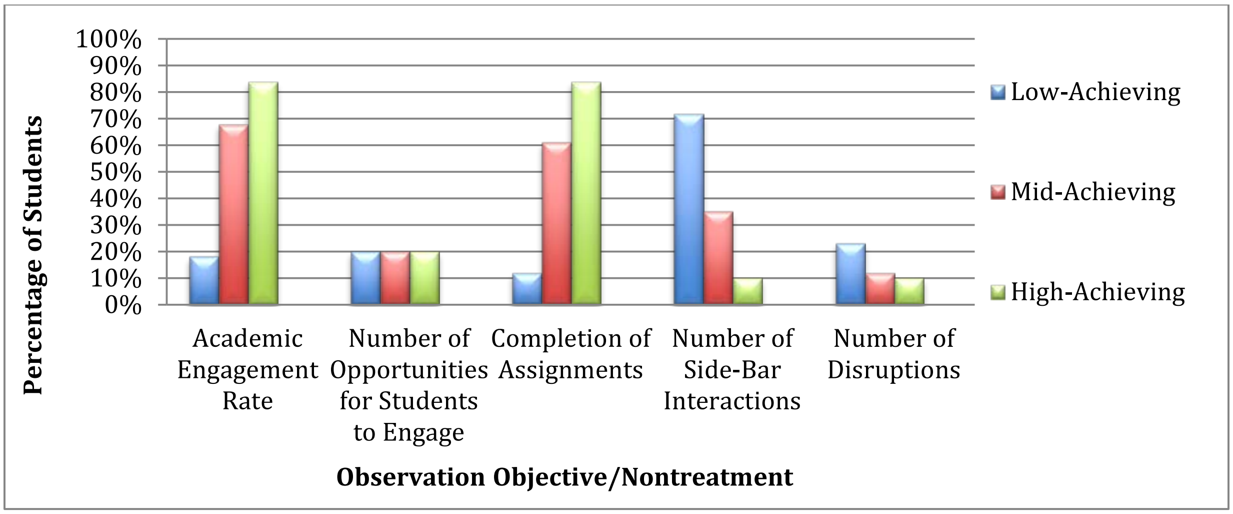

Figure 4. Teacher observation for percentage of students from various academic ability levels for the nontreatment. Low-achieving Students (*N*=37), Mid-Achieving Students (*N*=45), and High-Achieving Students (*n*=26), Total Students (*N*=108).

Students in the nontreatment unit had very little opportunity to work as a group and spent most of their time doing independent work. Low-level students struggled to stay on task and only had a 14% engagement rate. This pattern followed low-achieving students in their ability to complete assignments at only 19%. The number of off-task sidebar conversations and disruptions were also considerably high for low-achieving students.

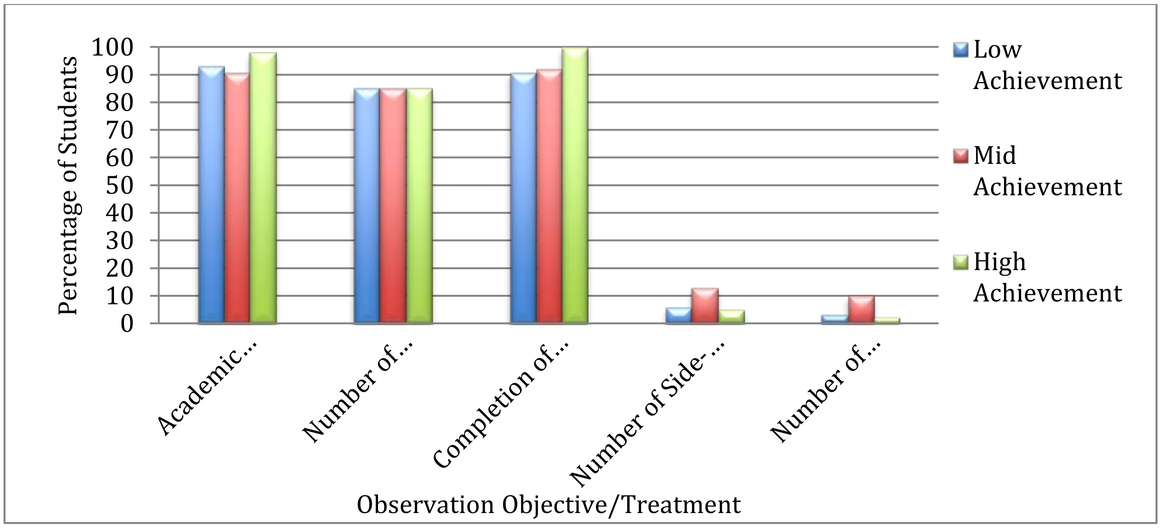

Figure 5. Average for teacher observations of treatment units with students divided into different academic ability levels *(N*=108).

All students showed high levels of academic engagement and numerous opportunities to engage between 90 to 95% for all the treatment units. Students spent the majority of time in class engaged in some type of group activity. Completion of assignments increased dramatically, especially for low-achievement students from 12% in the nontreatment unit to 91% on the treatment units. The number of distractions in class was dramatically reduced as well.

It was observed that at the beginning of the first treatment, student did not appear to be too excited about starting this unit. However, as the days progressed and classes continued with the treatment units, students became more excited about participating in class. It was noted numerous times in my field notes that some high-level students wanted to take over all responsibilities and do everything, even though all group members had very specific assigned tasks. I also observed that groups worked more effectively when I was roaming throughout the room. Once I stopped, some group members would venture off task. The KWL activities, at the beginning of each unit, sparked great conversation, which started with student's preconceived ideas about each concept. Groups worked cooperatively to correct misconceptions. A large piece of butcher paper was used to post questions that groups could not answer and were addressed throughout the unit. This provided an opportunity to dispel misconceptions when they arose, without rescuing students with the answer, as well as starting the process of discovery and investigation.

The final project question I wanted to address in this project was to compare my attitudes and motivation from the preunit to the postunit treatment. A teacher journal with same three questions were filled out at the end of each day and measured using a Likert Scale. Other questions provided qualitative data that gave further insight into my attitude and motivations for those days' lessons before and after each treatment unit.

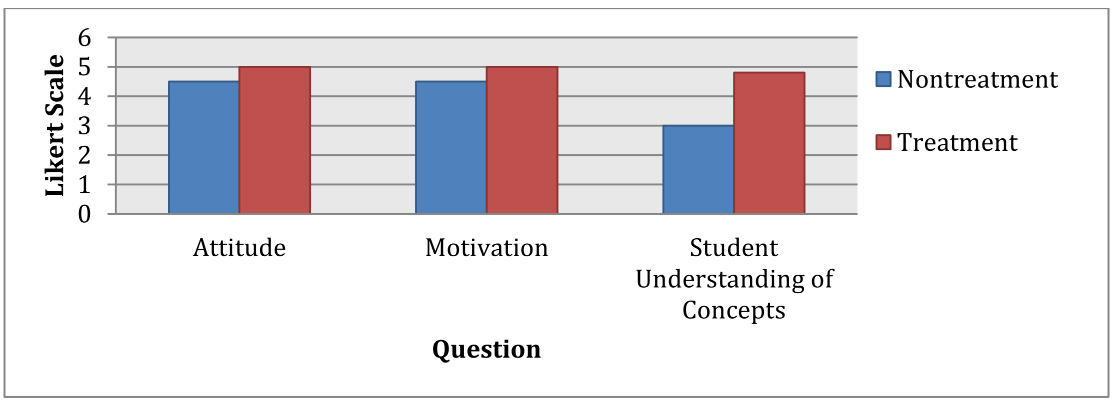

Figure 6. Comparison of nontreatment and treatment units on teacher attitudes motivation and perceived student understanding of concepts using a Likert Scale.
Note. Likert Scale 5= strongly agree to 1= strongly disagree

The journal showed a positive change in my attitude, as I was very excited about starting the treatment units. My students felt the excitement and were enthusiastic about being a part of my research. I have always had a strong motivation to teach and use the most effective strategies that will help my students with the learning process. Several times I found myself wanting to rescue students as they struggled with concept, but held back and watched, as the answers would evolve within their groups. Motivation increased because of this desire and continued strong until the third treatment unit when some students began to complain about groups and completion of responsibilities within their groups. I also became frustrated in the third treatment unit when I could see that my lab investigation was not going as planned and I was running into time constraints with the completion of this unit because of spring break. It was apparent to me that student understanding was improving because of the level of students participation and the number of students who remained on task throughout the class period.

Along with my teacher journal, I also completed a self-evaluation survey during the nontreatment and treatment units that provided additional information about my attitudes and motivation. Figure 7 below shows a comparison of journal prompts from the nontreatment to the treatment units.

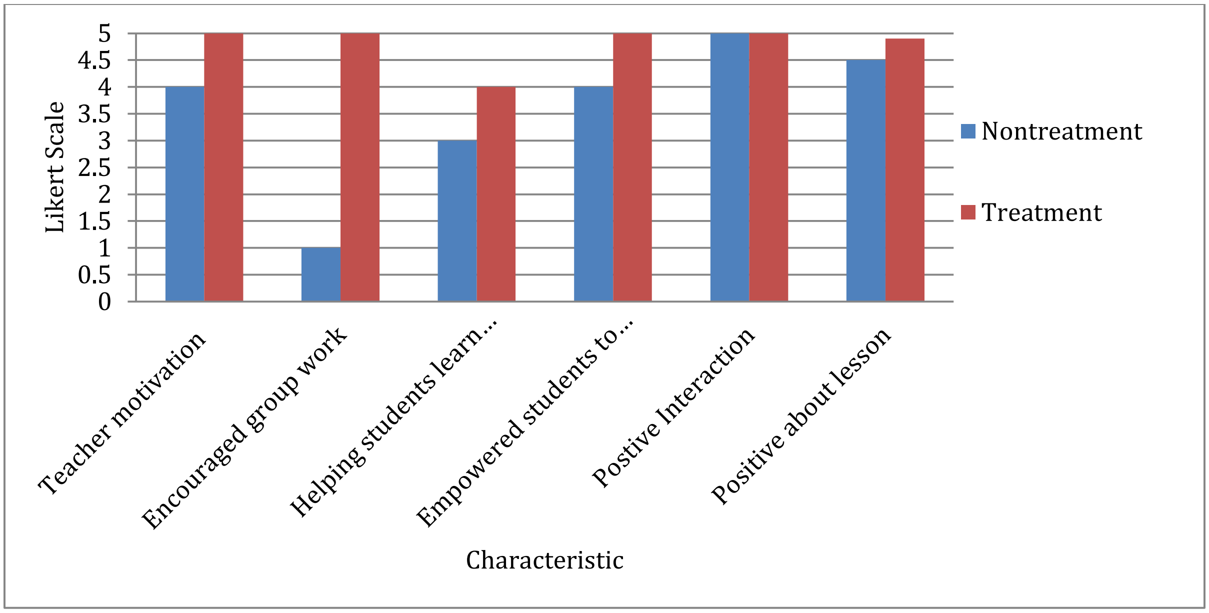

Figure 7. Comparison of treatment and nontreatment unit on teacher attitudes and motivation of lesson in a survey, as well as perceived effects on students using a Likert Scale.
Note. Likert Scale 5= strongly agree to 1=strongly disagree.

The journal showed a positive change in my attitude for guided inquiry methods of instruction and the impact it can have on student learning. The methods of instruction from the nontreatment to the treatment units were in such opposition to each other and show a sharp contrast in encouraging group work and helping students to become independent thinkers. Working in a cohort empowered students to learn and gave them to tools to work in a group effectively. It provided me the opportunity to become the facilitator of instruction and not the person that provides all the answers for the students to memorize. One of the biggest attributes I found with guided inquiry was the ability to get students talking, to think critically and helping them find a solution to a problem. While students may not have fully understood the concepts, they could talk about it and justify their answers.

I was also interested in having a peer observer give me feedback on classroom instruction for both the nontreatment and treatment units. Observations were made during lab activities and investigations. A Likert Scale was used to measure motivation, level of student's engagement and attitude towards students and teaching. Additional questions were also included to provide qualitative data. Figure 8, shows the tabulated results.

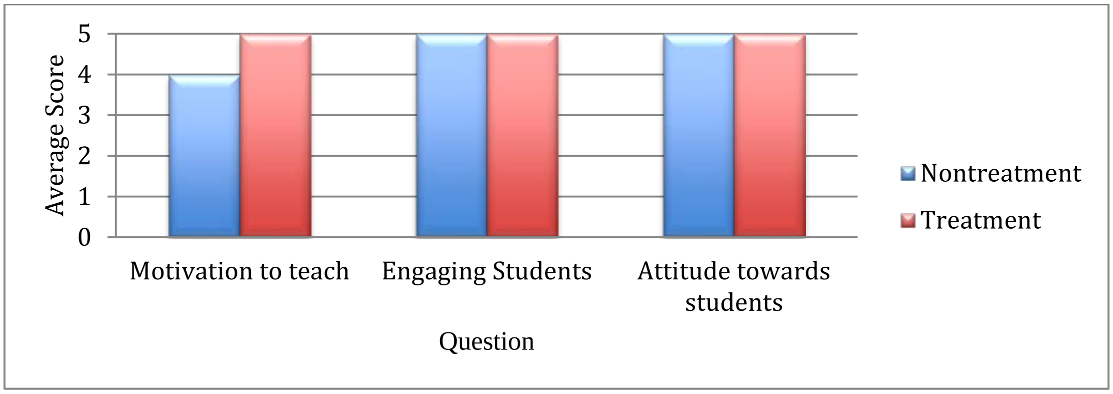

Figure 8. Peer teacher observation of nontreatment and treatment units on teacher motivation, engagement of students and positive attitude towards students.
Note. Likert Scale 5=strongly agree to 1=strongly disagree

The results of the peer observation showed a strong motivation for teaching in both the nontreatment and treatment units. It also showed the ability for me to try to actively engage students in the classroom. It was commented that I am always roaming about the room helping students to stay on task. No change was recorded for my attitude toward students. He commented that, "She has a lot of patient with students and takes time to help students find answers." Although my colleague never picked up on my frustration during the third treatment unit, he did note that taking students to another room they are unfamiliar with, could create some distractions for students and noted that I remained calm during the situation and tried to get students back on task. In the end students felt positive about what they had accomplished because of high-test scores and completion of assigned work, which continued to make my motivation for teaching very positive.

INTERPRETATION AND CONCLUSION

Data were analyzed to answer my focus question on the effects of guided inquiry on students' understanding of basic physic concepts. In addition, data were also analyzed to understand the effect of long-term memory, students' attitude and motivation, as well as my own attitude and motivation toward teaching. Evaluation of the data collected from a nontreatment and three treatment units suggest guided-inquiry methods were most effective in understanding of basic physics concepts, however the greatest reduction on scores was the result of units that included more of a math component, that for some students, was slightly above their cognitive ability level.

When looking at percent change of students' understanding using guided inquiry, the results were mixed, but when looking solely at normalized gain, almost all treatments units scored higher. Normalized gain helped to show that more academic growth had occurred than originally thought, when looking solely at percent change from the preunit to postunit assessments. An improvement was also noted in concept mapping throughout the treatment units, which primarily had to do with students getting better at using this tool, and being forced to think about the connections from one concept to another. My students, along with myself, could see the value of mapping out these connections and explaining their relationships as a group and as a class. Many students reported that not enough time was spent on the Newton's Third Law, due to spring break, which did affect the final scores in the third treatment unit.

Results also showed that the loss of long-term memory was slightly less in the treatment units, with some gains reported for high-achieving students. Taking the time to review incorrect answers on the postunit assessments and addressing misconceptions to close the feedback loop was a major factor in the delayed assessment scores. Low-achieving students reported the greatest loss in long-term memory overall, which primarily had to do with the math component required by several of the concepts taught. Concept mapping and survey question scores scored higher because the math component was not included in these questions or had less of an emphasis. Using formulas and having to rearrange their order to find a missing variable proved to be above many low-achieving students ability level. Additionally, these students struggled with using the correct units of measure.

Interviews and surveys of student attitudes and motivation showed little change, however students did report preferring guided-inquiry instructional methods that included group work, labs, and interaction with other students, when compared to individual or direct classroom instruction. Students reporting that they felt that they participated more in the learning process, which consequently helped them to learn more about physics concepts. Much improvement also was observed in students' ability to stay on task and complete assignments, with very little disruptions in all the treatment units. Students were more engaged during the time they were in class and many commented on how quickly the class time passed. The largest frustration for students was reported in the middle of the third treatment unit when students began complaining about members of their groups and the amount of work they may or may not have been putting forth toward their group. Some high-achieving students felt that they were doing most of the work, while some low-achieving students were not doing their part, for the good of the group. I did observe some students who started the process very positive and willing to do their part, only to later become lazy and depend more on other group members to complete their assigned roles. Some high-achieving students reported that they preferred working independently and no longer wanted to be part of a group. Moving group members didn't appear to change the problem, but only transfer the problem to another group.

My attitude about teaching did improve slightly, along with my motivation to teach. Because I could see positive results in my class using these guided-inquiry methods, I was excited to watch the evolution of learning that my students were experiencing and the learning tools students had acquired, such as KLW's, concept mapping, and the ability to work cooperatively to solve problems and help each other to dispel deep seeded misconceptions. I could see how this learning opportunity had empowered my students to be independent learners and thinkers, which is often times difficult at the middle school level. My peer-teaching observer, who was impressed with student's ability to work as a group, also recognized this.

Overall, I felt this research project helped me to see the value is using guided inquiry to teach physic concepts. It has also given me the tools to design and plan other units in science using the same techniques and instructional methods. Planning and preparation appear to be a major factor in the success in using guided inquiry in my teaching. Some of the changes that I have identified in using guided inquiry methods would be to practice with my students the use of concept maps and cooperative learning techniques at the beginning of the school year. I also plan to add a week to this unit, to allow more time to teach Newton's Third Law, so that I am not forced to end the unit because of spring break. Additionally, I plan to change the Balloon Rocket lab used in this unit to a class demo and find another lab that would be applicable.

VALUE

The implications of this study have helped me to see that students have a deeper conceptual knowledge of content when taught using guided-inquiry learning. It has given my students tools in which to communicate with others and solve problems using an investigative process. This journey has helped me to become a better teacher, by teaching me how to use research-based tools to improve the instruction in my classroom and the importance of taking time to reflect on my personal values as they relate to myself and to my students. As a result, I have begun to see the value of guided-inquiry learning and its impact on helping students to become independent learners.

This form of teaching provided a framework for my students in which they could work together to solve problems and internalize information. It has opened up the door for open dialogue between each other and helped to give them the tools to work cooperatively. With practice and guidance my students progressively improved at communicating and sharing thoughts and ideas with others. I'm hoping these tools will prove to be valuable to their learning experience as they continue to the high school level and beyond.

Completing a study with 108 students with a large number of low-achieving students was not an easy process, but I could see the value in having a large student base within my study, not only for myself, but for other researchers and teachers as well. Teaching a large number of students in a high needs school is not an easy process and can be exhausting. Exploring guided inquiry learning has helped to revitalize me as a teacher and has opened dialogue between other teachers in my building and my administrators.

As I look ahead for the next school year, I plan to attend a training using guided inquiry learning called Process Oriented Guided-Inquiry Learning (POGIL). Although this method has not be specifically designed for middle school, I'm hoping to adapt what I learn from the POGIL guided-inquiry training, so that it will be more age appropriate to meet the needs of a middle level classroom. In essence, I plan to incorporate what I have learned from this action research project with other effective research-based tools.

I believe the methods that I have used in this research can be adapted to be used in other science related courses that I teach. My written reflections from classroom observations have helped me to think about aspects of teaching that I would otherwise not have seen to be important, such as the constant feedback from students and testing for long-term memory. Watching the impact that this method had on low-achieving students made me realize the importance of open dialogue can have from one student to another.

My capstone project has made me reevaluate my current methods of instruction and move away from the more traditional methods of teaching. It has shown me how using guided inquiry can be an effective learning and teaching tool for myself and for my students. It has given me the tools to effectively research methods of instruction to use in my classroom and provided a variety of measurement devices that can be used to determine whether instructional methods are effective. This project has helped to refocus my attention back on the student, and to be less complacent about my teaching strategies. I intend to continue to explore guided inquiry learning to better meet the learning needs of my students.

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APPENDICES

APPENDIX A

TEAM BUILDING ACTIVITY

Appendix A
Team Building Activity

Shipwreck Challenge
Instructions:

Your group is a crew of fisherman whose boat is sinking off the shore of an uninhabited island. No one knows of your whereabouts. You have to swim to the island and carry only *one item* each. Your challenge is to decide as a group which items you think will be necessary for survival before getting rescued. You have sealable plastic bags in which to place your items in to avoid getting wet.

Each group has 10 minutes to decide what they will bring.

The items you have to choose from are:

- Map of where you are
- Book about edible plants for the region
- Large plastic sheet
- Flashlight
- Pocket Knife
- Small mirror
- Waterproof metal container holding three pounds of ice
- Book of matches
- Pack of signal flares
- Comb

The four items we have chosen are:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Each group will take turns having a spokesperson justify what they chose to bring and why.

Discuss as a group how working together increased the chances for everyone's survival.

What can we learn about this activity when doing group work within the classroom?

APPENDIX B

GROUP ROLES AND ASSIGNMENTS

Appendix B

Group Roles and Assignments

Member Assignments for the Weeks of_______________
Team Members *(write name by role)*

Leader: ____ *In charge of the final project and reports, keeps the team on task, delegates team responsibilities, makes sure all assignments have been turned in to the teacher*

Recorder: ____ *Takes notes during labs and projects, compiles and organizes data for the group to share, checks that all group members have necessary information*

Spokesperson: ____ *Presents findings to the group, summarizes group projects, and assists students with information when a group member is absent*

Team Analyzer: ______________________________________ *Keeps track of questions, collects materials for the group, verifies data collection and findings, and verifies lab station is clean.*

All group members turned in all assignments for the week.   Yes   No

All team members worked to make sure all tasks were completed for the week. Yes   No

If not, please explain.

We give our group the following grade for this week.   A   B   C   D   F

Explain why your group deserved this grade.

APPENDIX C

SPEED LAB: NONTREATMENT

Appendix C
Speed Lab: Nontreatment

How Can You Measure Speed

Objective: Understand how to calculate an objects speed and the relationship between speed and distance.
Time: approximately 45 minutes
Materials: Each team of four students needs: 2 timers, 1 soft-sided meter tape, 1 roll masking tape, and 1 marker, different types of balls
Procedure:

1. Each group will need to build their track by spreading out the meter tape in a straight line on the floor, until it reaches the 10-meter mark on the tape.
2. Using three pieces of masking tape, attach the meter tape to the floor at a distance of (0 m, 5 m and, 10 m). Use a marker to write out each distance on the masking tape.
3. Complete the data table below by rolling different types of balls down the track with as close to a similar force as possible. Your group will need to have people with timers or stopwatches at the 5-meter and the 10-meter points to record the time each ball reaches that point.
4. Complete the chart below.

TYPE OF BALL	DISTANCE	TIME	SPEED
Tennis Ball	5 meters		
	10 meters		
Ping-Pong ball	5 meters		
	10 meters		
Marble	5 meters		
	10 meters		
Basketball	5 meters		
	10 meters		

1. Which ball resulted in the fastest speed? Which ball has the slowest speed?

2. What would be the speed of the tennis ball if it could roll 50-meters at a constant speed, based on the speed of the 10-meter trial? Make sure to include the units of measure.

3. How long would it take for the Ping–Pong ball to roll 30-meters at a constant speed, based on the speed of the 5-meter trial? Show your work

5. Explain why the balls do not travel at a constant speed?

6. Which ball had the fastest speed? How did size affect the speed of the ball?

7. Using the 5-meter time from the tennis ball, create a new data table that shows a constant speed up to a distance of 50-meters (use increments of 5-meters). Graph the new results.

APPENDIX D

USING KWL CHART IN READING ABOUT FORCES: TREATMENT

Appendix D
Using KWL Chart in Reading about Forces: Treatment

Objective: Students will understand how forces change the motion of objects in predictable ways.

Time: Approximately 45 minutes

Setting: In this cooperative activity, students work in groups of 4 to 5 students.

Goal: Students will read for understanding and work in groups to complete a concept map that details important information from the text.
(This activity can be adapted to be used for any grade level and subject)

Materials: A textbook from the appropriate grade level that includes a section on forces.

In this guided inquiry activity, students will be using a combination of the following: working individually, in groups, and sharing results with the entire class. The teacher or facilitator will be responsible for keeping groups on task, directing students as to when they should work individually, in groups, and as a class. It is important that the facilitator roams around the room not instructing, but guiding each group to the task at hand and redirecting should students or groups need help.

Directions:

Students begin by constructing a KWL chart by folding a blank piece of paper into three equal sections. At the top of each section, students will write a K in the far left section, a W in the middle, and an L in the far right section. Students may also want to write the meaning of each letter if they have never used this process. Constructing a KWL chart: K stands for what students already know. W stands for what questions students may have throughout the lesson, and L represents what students have learned.

1. To start the lesson, students are asked by the facilitator to work individually and write all they know about forces under the section of their paper marked K.

2. Next, students are directed to take turns sharing in their groups what they know about forces. Students draw a line under what they know about forces in the K section. This will represent the information they know and understand. As students are sharing what they know about forces, each group determines if this information is accurate. If everyone agrees that the information is accurate, they can then add it to the K side of their paper, under the line they have drawn.

3. After all groups have had an opportunity to share what they know, groups then share their information with the rest of the class. Again, the class must agree that

this information is correct, before they write it on the K side of their paper. The facilitator should let students know whether the information is correct.

4. Next, students are directed to read silently in their textbook about forces. As questions arise, students are to record their questions under the W section of their KWL chart. Using a blank sheet of paper, students construct a concept map to record important information from the text. The concept map can be partially completed for students who struggle with this concept. It is important that the facilitator walks around the room and checks the progress of each student's concept map.

5. After everyone in the group has had an opportunity to read and complete their concept maps, students work in groups to create one large concept map unto a large piece of butcher paper that will be shared with the rest of the class. Groups will also address any questions that they may have had during the reading. Any question that they group cannot answer will be added to a poster board found in the front of the class. These questions will be covered as a class, after each group's concept maps have been shared. The class will work together to find the answers to these questions through sharing of their thoughts and ideas. The facilitator may also add questions to the poster board to help with any misconceptions that need to be discussed as a class.

6. From this concept map, one final concept map will be created for the class that includes all the important information. Each group will decide what should be added to the final concept map that will be displayed on butcher paper in the front of the class and left until the end of the unit.

7. Finally, questions are addressed from the list on the board and each group must decide how they will find the information to answer each question. This information can then be used for a future lesson.

APPENDIX E

MOTION WITH A CONSTANT SPEED LAB: TREATMENT

Appendix E
Motion with Constant Speed Lab: Treatment

This investigation will examine how objects move in a straight line without speeding up or slowing down. We will refer to this kind of motion as *uniform motion* or *motion with a constant speed*. As we continue with our investigations, you will understand how the motion of an object can be described by its position, direction of motion, and speed.

Materials Needed: Obtain several balls and tracks from your facilitator

Activity:

A. Using the materials provided, work with your group and try to produce the most uniform motion.

1. Describe what you did to make the motion as uniform as possible. You may include illustrations with your explanation.

2. How can you check to make sure the motion was uniform? Explain why your method is a good test to determine uniform motion.

3. Give quantitative evidence that the motion is uniform.

WAIT FOR THE FACILITATOR TO CHECK YOUR ANSWERS. BE PREPARED TO SHARE YOUR RESULTS WITH THE REST OF THE CLASS.

B. Write an operational definition of uniform motion. You may need to refer to reference books found in the classroom or the Internet.

4. Your definition should include a test that can be used to show *uniform motion* that includes some type of measurement. Include in your explanation, a written procedure that explains how uniform measurement is measured.

DISCUSS YOUR RESULTS WITH THE FACILITATOR.

APPENDIX F

VIDEO GROUP QUESTIONS ACTIVITY: TREATMENT

Appendix F
Video Group Questions Activity: Treatment

Objective: Using a visual learning tool, such as video, students will work in groups to create questions about important concepts learned that will be shared with the rest of the class.

Setting: Students should work in groups of four to five students.

Videos can provide a great picture in our mind of a concept we are learning.

1.Your task is to watch the following video and write down any important information that is relevant to what you are currently learning.

2. After previewing the video, formulate three or four questions from your notes and prepare to share these questions and answers with the group.

3. Once everyone in your group has completed their questions, in your group take turns sharing your questions and answers with the rest of the group. Discuss amongst the group whether these are valid questions/answers that represent most important concepts. Use this time to correct any misconceptions within your group or with your teacher before proceeding.

4. Choose four questions from your group that you would like to share with the class. Once questions have been chosen, write down all questions on a piece of butcher paper. Take turns sharing questions with each group. Quiz other groups to find out if they know the answers and discuss with the class in detail.

5. Post your group’s questions in the classroom.

APPENDIX G

PRE AND POSTUNIT ASSESSMENT AND DELAYED QUESTIONS: NONTREATMENT

Appendix G

Pre and Postunit assessment and Delayed Questions: Nontreatment

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing. Please complete the following questions.

Understanding of Content-

Unit One- Speed and Velocity-

1. Explain how speed is related to distance and time.

2. How would decreasing the time it takes you to run a certain distance affect your speed? Explain your answer.

3. Suppose you are roller-skating with a friend. How would your friend describe your relative motion as he passes by? Explain your answer.

APPENDIX H

PRE POSTUNIT ASSESSMENT AND DELAYED ASSESSMENT QUESTIONS: TREATMENT

Appendix H

Pre and Postunit Assessment and Delayed Assessment Questions: Treatment

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Understanding of Content-

Unit Two- Newton's 1st Law of Motion-

1. Explain the difference between balanced and unbalance forces.

2. A ball is at rest on the floor of a car moving at a constant velocity. What will happen to the ball if the car swerves suddenly to the left?

3. What can the changes in an object's position tell you about the forces acting on that object? Describe an example from everyday life that shows how forces affect the position of an object.

Pre and Postunit Assessment and Delayed Assessment Questions

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Understanding of Content-

Unit Three- Newton's 2nd Law of Motion

1. If the forces acting upon an object are increased, what happens to the object's acceleration? Explain your answer.

2. What forces keep an object moving in a circle? In what direction does this force act? Explain your answer.

3. Jeff pushes a 3 kg box with a force of 9 N. The force of friction on the box in 3 N in the opposite direction. What is the acceleration of the box? Hint: Combine forces to find the net force.

Pre and Postunit Assessment and Delayed Assessment Questions

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Understanding of Content-

Unit Four- Newton's 3rd Law

1. Identify the action/reaction force pair involved when you catch a ball.

2. A man pushed on a wall with a force of 50 N. What is the size and direction of the force that the wall exerts on the man?

3. Suppose you are holding a basketball while standing on a skateboard. You and the skateboard have a mass of 50 kg. You throw the basketball with a force of 10 N. What is your acceleration before and after you throw the ball? Explain your answer.

APPENDIX I

INTERVIEW QUESTIONS WITH CONCEPT MAPPING: NONTREATMENT

Appendix I
Interview Questions with Concept Maps: Nontreatment

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Understanding Content
Interview Questions for Unit 1- Speed and Velocity

1. How are speed and position related?

2. What is velocity? Give an example of velocity. Explain your answer.

3. Use a Venn diagram to compare and contrast speed and velocity.

Concept Mapping- Unit 1- Speed and Velocity

Write each term below on a post-it note that has been provided for you. Using the word ‘speed’ at the top, arrange the remaining words to show a connection and use connecting words between the words. You may use other words with your remaining post-it notes if you choose. Once you have each term in the proper location, please write linking words in between each term to describe the relationship.

Speed distance time vector reference point

APPENDIX J

INTERVIEW QUESTIONS WITH CONCEPT MAPPING: TREATMENT

Appendix J
Interview Questions with Concept Mapping: Treatment

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Interview Question for Unit 2- Newton's 1st Law

1. What is a contact force? Give an example.

2. What happens to a moving object if all the forces on it are balanced? Explain this concept.

3. If a car makes a sudden stop, what happens to a passenger riding in the back seat who is not wearing a seat belt?

Concept Mapping- Unit 2- Newton's 1st Law

Write each term below on a post-it note that has been provided for you. Using the word 'Force' at the top, arrange the remaining words to show a connection and use connecting words between the words. You may use other words with your remaining post-it notes if you choose. Once you have each term in the proper location, please write linking words in between each term to describe the relationship.

Newton's 1st Law   Force   net force   inertia   gravity   friction

Understanding Content

Interview Questions for Unit 3- Newton's 2nd Law

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

1. What three concepts are involved in Newton's second law?

2. If the same force is applied to two object of different mass, which object will have the greater acceleration?

3. How does increasing the centripetal force on an object affect its acceleration?

Concept Mapping- Unit 3- Newton's 2nd Law

Write each term below on a post-it note that has been provided for you. Using the word 'Acceleration' at the top, arrange the remaining words to show a connection and use connecting words between the words. You may use other words with your remaining post-it notes if you choose. Once you have each term in the proper location, please write linking words in between each term to describe the relationship.

Centripetal force   Newton's 2nd Law   Acceleration   motion

Understanding Content

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Interview Questions for Unit 4- Newton's 3rd Law

1. What moves an inflated balloon when released into the air?

2. When you bang your toe into the side of a table, the same amount of force that you exerted on the table is exerted back on your toe. Identify the action/reaction force.

3. Explain the difference between balanced forces and action/reaction forces.

Concept Mapping- Unit 4- Newton's 3rd Law

Write each term below on a post-it note that has been provided for you. Using the word 'Motion' at the top, arrange the remaining words to show a connection and use connecting words between the words. You may use other words with your remaining post-it notes if you choose. Once you have each term in the proper location, please write linking words in between each term to describe the relationship.

Newton's 3rd Law   action/reaction   Newton   motion

APPENDIX K

CONCEPT MAP RUBRIC

Appendix K
Concept Map Rubric

Map Component	Possible points	Awarded points	Special things noticed about map
Proposition			
Clear and meaningful to the central topic	2 each		
Beyond given set of terms	3 each		
Not properly linked	1 each		
Vague	1 each		
Branch			
Top	1		
Successive branches	3 each		
Levels of hierarchy (general to specific)	5 each level		
Cross Links	10 each		
Examples	1 each		
Total			
Overall reaction to map and special things noticed.			

Reference
Novak, J.D. & Gowin, D.B (1984). *Learning how to learn.* New York, NY: Cambridge University Press

APPENDIX L

PRE AND POSTTREATMENT SURVEY QUESTIONS FOR UNDERSTANDING CONTENT: NONTREATMENT

Appendix L
Pre and Post Treatment Survey Questions: Nontreatment

Student Surveys- Please answer the following questions in as much detail as possible. You may want to provide examples as well.
All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Unit One - Speed and Velocity

1. What have you learned as a result of all the activities we completed in class about speed and velocity? Please explain.

2. Give an example of how you could apply what you learned to everyday life? Please explain.

3. How does one measure speed?

4. Speed is considered a rate. Give two examples of everyday measures that are rate. Please explain.

5. Is there anything else you would like to say about speed and velocity? Please explain.

APPENDIX M

PRE AND POSTTREATMENT SURVEY QUESTIONS FOR UNDERSTANDING CONTENT: TREATMENT

Appendix M

Pre and Posttreatment Survey Questions for Understanding Content: Treatment

Student Surveys- Please answer the following questions in as much detail as possible. You may want to provide examples as well.

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Unit Two- Newton's 1st Law

1. What have you learned as a result of learning about Newton's First Law? Please explain.

2. Give an example of how you could apply what you have learned to everyday life?

3. How does inertia affect moving objects? Please explain.

4. If you are holding a book so that it does not move, what can be said about the force of gravity on the book?

5. Is there anything else you would like to say about Newton's First Law? Please explain.

Pre and Posttreatment Survey Questions

Student Survey- Please answer the following questions in as much detail as possible. You may want to provide examples as well.
All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.
Unit Three- Newton's 2nd Law

1. What have you learned as a result of learning about Newton's 2nd Law? Please explain.

2. Give an example of how you could apply what you have learned to everyday life?

3. How does one measure force? Please explain.

4. An apple and a bowling ball are pushed with the same force. Which one will accelerate more? Please Explain.

5. Is there anything else you would like to tell me about Newton's 2nd Law? Please explain.

Pre and Posttreatment Survey Questions

Student Surveys- Please answer the following questions in as much detail as possible. You may want to provide examples as well.
All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing.

Unit Four- Newton's 3rd Law

1. What have you learned as a result of learning about Newton's third Law? Please explain.

2. Give an example of how you could apply this principle to everyday life?

3. Explain an action reaction force? Please explain.

4. If the reaction force is 5 N, what is the action force? Please Explain.

5. Is there anything else you would like to tell me about Newton's 3rd Law? Please explain.

APPENDIX N

ATTTUDES AND MOTIVATION SURVEY: PRETREATMENT

Appendix N
Attitudes and Motivation Surveys: Pretreatment

Please answer the following survey questions. Try to be as honest as possible, as I will use this information to plan for future science lessons. You do not have to put your name on this survey. This is not a test and will not affect your grade. **All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing**

Circle one of the following: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. In general, I like coming to science class everyday. 1 2 3 4 5

2. Explain what you like or dislike.

3. I think I will enjoy learning about Physics. 1 2 3 4 5

4. Explain what you like or dislike about the subject.

5. Working in groups helps me to understand the material. 1 2 3 4 5

6. Explain how working in groups affects your performance.

7. Listening to group members share their thoughts and ideas helped me to learn the material. 1 2 3 4 5

8.Discuss how members of the group affected your performance in the classroom.

9. Participating in various activities in physics increased my motivation to learn. 1 2 3 4 5

10. What class activity was most helpful to your learning?

11. I learned more from this physics class than most science classes. 1 2 3 4 5

12. Explain your thoughts.

APPENDIX O

ATTITUDES AND MOTIVATION: POSTTREATMENT

Appendix O
Attitudes and Motivation Survey: Post treatment

Please answer the following survey questions. Try to be as honest as possible, as I will use this information to plan for future science lessons. You do not have to put your name on this survey. This is not a test and will not affect your grade. **All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing**

Circle one of the following: 1 (strongly disagree), 2 (disagree), 3 (indifferent), 4 (agree), and 5 (strongly agree).

1. In general, I like coming to science class everyday. 1 2 3 4 5

2. Explain what you like or dislike.

3. I enjoy learning about Physics. 1 2 3 4 5

4. Explain what you like or dislike.

5. Working in groups helps me to understand the material. 1 2 3 4 5

6. Explain how working in groups affects your performance.

7. Listening to group members share their thoughts and ideas helped me to learn the material. 1 2 3 4 5

8. Discuss how members of the group affected your performance in the classroom.

9. Participating in various activities in physics increased my motivation to learn. 1 2 3 4 5

10. What class activity was most helpful to your learning?

    Example: Independent reading, Cookbook labs, KWL charts, Group inquiry labs, Concept Mapping, Groups Reading.

11. I learned more from this physics class than most science classes. 1 2 3 4 5
12. Explain your thoughts.

13. Please feel free to write any additional comments here. Are there any other questions that you think I should have asked? If so, state them here.

APPENDIX P

STUDENT ATTITUDES AND MOTIVATION INTERVIEWS: PRETREATMENT

Appendix P

Student Attitudes and Motivation Interviews: Pretreatment

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing

1. What do you like best about science? Please explain.

2. What do you think of labs? Please explain.

3. How do you feel about working with students in a group? Please explain.

4. What is your favorite part about science class this year? Please explain.

5. What is your least favorite part about science class this year? Please explain.

6. What motivates you the most in science class? Please explain.

7. Do you have suggestions on what could be done to improve science class?

APPENDIX Q

ATTITUDES AND MOTIVATION INTERVIEWS: POSTTREATMENT

Appendix Q

Attitudes and Motivation Interviews: Posttreatment

All participation in this research is voluntary. If you choose to participate or not to participate, in no way will your decision affect your grade or your class standing

1. What did you like best about each unit? Please explain.

2. What did like best about the labs? Please explain.

3. How did you feel about working with students in a group setting? Please explain.

4. Which parts of this unit were most confusing to you? Please explain.

5. Do you have additional questions? Please explain.

6. Do you have suggestions on what could be done to improve this unit? Please explain.

APPENDIX R

TEACHER OBSERVATION AND FIELD NOTES: NONTREATMENT AND TREATMENT

Appendix R
Teacher Observation with Field Notes Checklist

Approximate Academic Achievement Ranking	High	Middle	Low
Academic Engagement Rate In general, groups appear to be on task.			
Number of Opportunities for Groups to Engage Groups discussing lesson when appropriate.			
Completion of Assignments Students in groups completing all tasks and assignments			
Number of Side-Bar Interactions Any activities or conversation that is off task.			
Number of Disruptions Any statement or action by one or more students that interferes with an ongoing activity			

Daily Teacher Observation Journal

Date______________ Class Period ________________ Phase of class- beginning, middle, end

Unit Being Taught ______________________ Specific Lesson ________

Record additional observations below:

____

____

____

____

____

____

____

____

APPENDIX S

TEACHER JOURNAL WITH PROMPTS

Appendix S

Teacher Journal with Prompts

Today Activity: **Date:**

1. My attitude toward today's activity and students. 1 2 3 4 5

How did my attitude affect my students' learning?

What shaped my attitude today?

2. I was motivated to teach today? 1 2 3 4 5

How did my motivation affect my students' learning?

3. My students have a better understanding of the concepts today after my lesson? 1 2 3 4 5

What improvements could I make to this lesson?

What is my plan tomorrow?

APPENDIX T

SELF-EVALUATION SURVEYS

Appendix T
Self-Evaluation Surveys: Pre and Posttreatment

Lesson: Date:

My motivation regarding today's activities	1 2 3 4 5

Comments:

Today's activities were successful in encouraged group work	1 2 3 4 5

Comments:

Today's activities helped students to learn independently	1 2 3 4 5

Comments:

Today's activities kept students on task	1 2 3 4 5

Comments:

Student/teacher interaction was positive	1 2 3 4 5

Comments:

I feel positive about today's lesson	1 2 3 4 5

Comment

APPENDIX U

PEER OBSERVER: NONTREATMENT AND TREATMENT

Appendix U
Peer Observer: Nontreatment and Treatment

Lesson: Date:
Class Period:

1. The teacher shows motivation for teaching. 1 2 3 4 5

Explain:

2. The teacher helps to actively engage students in the lesson. 1 2 3 4 5

Explain:

3. The teacher has a positive attitude towards students and teaching. 1 2 3 4 5

How does this affect students?

4. How does the attitude of teachers affect the attitudes of students?

5. How does the motivation of the teacher affect the motivation of the students?

6. Please suggest any improvements toward the teacher's attitude and motivation.

APPENDIX V

PROJECT TIMELINE

Appendix V
Project Timeline

Start Project Implementation: January 8, 2013

January 8 – Take Pre- Speed and Velocity- nontreatment
Take Pretreatment Attitudes and Motivation Survey- Nontreatment
Take Pretreatment Student Survey on Percent Understanding- Nontreatment
January 9 - Finish Assessment
Watch Eureka Video on Speed and Velocity and Answer questions
January 10 – Complete, 'How Can You Measure Speed' Lab- Nontreatment
January 11 – Complete Questions and Graph from Speed Lab

January 14- Read from McDougall Little textbook on Speed and Velocity and Answer questions from reading
January 15- Complete word problems relating to Speed and Velocity.
January 16 – Watch video on Acceleration and answer questions
Introduce the Acceleration Equation
January 17 – Complete lab on Calculating Speed Acceleration
January 18 – Read and answer questions pg. 25D-31D and answer questions
Complete Acceleration Calculations Handout

January 21- No School -Martin Luther King Day
January 22 – Finish Acceleration Handout- Work on Pretest questions
January 23 – Grade Pretest and review unit for the test
January 24 – Take Postunit assessment- Speed and Velocity- Nontreatment
Take Postunit assessment Student Survey- Nontreatment
Take Postunit assessment Attitudes and Motivation- Nontreatment
January 25 – Take Pre-Newton's First Law- Treatment
Take Pre- Attitudes and Motivation- Treatment
Take Pre- Student Surveys- Treatment
Fill out student roles within groups -handout

January 28 – Do KWL Chart Activity- Newton's First Law
Begin building Concept Maps
January 29- Continue KWL Activity
Build a class Concept Map
January 30- Complete Inertia Investigation- Design Own Lab
January 31 – Finish Inertia Investigation
February 1 – Watch Video on Newton's First Law- Complete Video Activity
Review for Assessment

February 4 – Take Postunit assessment- Newton's First Law- Treatment
Complete Group Role Sheets and turn-in
Complete Postunit assessment- Student Surveys- Treatment

Complete Postunit assessment- Attitudes and Motivation
February 5 – Start Unit 2- Newton's 2nd Law
Complete Pre- Newton's 2nd Law- Treatment
Complete Student Survey- Pre
Fill-Out Group Roles Sheets
Begin Pendulum Lab
February 6 – Finish Pendulum Lab –Graph Results
Complete Force and Acceleration Calculations
February 7 – Develop Concept maps individually and with Groups
February 8 – Take Delayed-Post Assessment on Unit One- Speed and Velocity- Long-Term Memory
Watch Video- Misunderstandings of Why Objects Fall at the Same Rate- Develop Questions within each Group- Relate back to Pendulum Lab

February 11- Take Postunit assessment on Newton's Second Law- Treatment
Complete Posttreatment- Newton's Second Law-Student Survey
Take Posttreatment Attitudes and Motivation
Take Delayed Assessment on Newton's First Law
Turn-in Group Roles Sheets
February 12 –Take Pre Newton's 3rd Law- Treatment
Take Pre on Student Surveys- Treatment
Fill-out new Group Roles Sheet
Complete KWL Chart Activity
February 13 – Balloon Rocket Lab- Action/Reaction
February 14 – Finish Write-up for lab and Graphs
February 15 – No School

February 18 – No School
February 19 – Calculating Momentum- Group/Class Handout
February 20 – Read and Complete Reading Study Guides
February 21 – Review for Assessment- Do You Know the Answer To…activity
February 22 – Postunit assessment- Newton's Third Law
Postunit assessment- Attitudes and Motivation Survey
Postunit assessment- Student Survey
Delayed Assessment- Newton's 2nd Law

February 25 – Pre- Laws of Conservation of Mass and Potential and Kinetic Energy
Take Pre- Student Survey
February 26 – Compose KWL Charts/ Read and groups share real world examples
February 27 – Watch video on Law of Conservation of Mass
February 28 – Complete Lab
March 1 – Take Delayed Assessment on Newton's Third Law