

THE EFFECTS OF DIFFERENTIATED INSTRUCTION ON UNDERSTANDING
MIDDLE SCHOOL SCIENCE CONCEPTS

by

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ABSTRACT

Through daily observation, I realize that my traditional classroom environment does not sufficiently meet the learning needs of the wide variety of students in my classes. For example, as students work through daily laboratory experiments and class work, I consistently sense boredom in my high-achieving students alongside of confusion in my low-achieving students. The goal of this project was to better meet my students' diverse learning needs.

This project took place in two sixth-grade general science classes at a large international school in Hong Kong, China. It focused on how implementing differentiated instruction, which is instruction designed with student differences in mind, such as students' background knowledge, instructional level, interests, and learning styles, affected students' understanding of introductory chemistry concepts. Lessons implementing four differentiation methods of scaffolding, alternative learning products, tiered homework assignments, and graphic organizers were compared to traditional lessons where all students completed the same assignments and demonstrated their learning in the same format.

Data revealing students' understanding of concepts were collected through pre and postunit assessments, writings, and interviews, which included concept mapping and conceptual questions. Data regarding effects on my own attitude, planning time, and motivation were also collected through writings, surveys, and a time log.

The project's results indicated that differentiated instruction did not have a positive effect on my students' overall understanding of concepts or cognitive level of understanding. Neither did the differentiated instruction have a positive effect on the understanding of my high, middle, or low-achieving students. My attitude, planning, and motivation yielded both positive and negative results.

INTRODUCTION AND BACKGROUND

As I reflect about my teaching, I realize that I strive to have a learning environment that allows each student to reach his or her full potential. Daily observation of my students reveals that this is not consistently happening in my traditional classroom setting. Since there is no ability grouping within the grade level I teach, my class consists of students classified as *gifted* as well as those considered to have *learning needs*. How can a classroom where all students work on the same assignments and take the same assessments meet the needs of such a wide spectrum of students? I consistently sense confusion and stress in my low-achieving students and annoyance and boredom in my high-achieving students. Classroom lab activities are one of several situations where this problem is evident.

As the students work through classroom lab activities, the gap between high-achieving and low-achieving students becomes very apparent. Students are instructed to complete an experiment and then answer reflection questions. The lab groups containing high-achieving students usually finish quickly, since these students are very efficient in their work. These students take charge throughout the experiment and then answer the questions on their own. Although a brief discussion within the lab group takes place, others don't fully understand the explanation or reasoning of the high-achieving students. Low-achieving students, feeling intimidated, let the high-achieving students do the majority of the work.

From my reflection, I recognized that teaching to the middle was meeting the needs of a very limited population. For this reason, I chose differentiation as my capstone project topic. My desire was to better meet the diverse needs of my students through using differentiated instruction. Carol Ann Tomlinson, an expert in

differentiated instruction, explains that differentiation is “an approach to teaching that advocates active planning for student differences in classrooms” (Tomlinson, 2003, p.1).

I teach sixth-grade math and science at Hong Kong International School, a private international school of about 2500 students located in Hong Kong, China. My two classes are each comprised of about 20 sixth-grade students from middle to high-income homes and of a variety of nationalities and cultures. In addition to a variety of average students with no specially designated needs, these heterogeneously grouped classes also consist of students with identified learning needs, that are second language learners, and that have been tagged as gifted. The curriculum with which my study took place was a nine-week introductory chemistry unit.

The project focus question is, what are the effects of using differentiated instruction on students’ understanding of sixth-grade introductory chemistry concepts? The project subquestions are as follows: what are the effects of using differentiated instruction on high, middle, and low-achieving students’ understanding of concepts; what are the effects of using differentiated instruction on students’ various cognitive levels of understanding science concepts; and what are the effects of implementing differentiated instruction on my preparation time, teaching methods, thoughts about my role in student learning, attitude and motivation to teaching? This topic is significant to me because I believe that differentiating my instruction will increase the learning of my low-achieving and high-achieving students. This topic is significant to my students because, at this time, our sixth-grade science curriculum does not contain any strategies built in to account for student learning differences.

My hope is to put forward successful, usable differentiated activities to my four sixth-grade science colleagues.

The members of my support team helped me in the planning, analyzing, and writing of my capstone project and paper. This group consisted of three colleagues from Hong Kong International School: a fellow math/science teacher, learning specialist, and language arts teacher. Other members of my support team included Jewel Reuter, my MSSE capstone advisor, and Lisa Brown, of Montana State Extended University, my MSU project reader.

CONCEPTUAL FRAMEWORK

In this conceptual framework, the reader should find prior research and information that promotes the need for differentiated instruction in the classroom. The reader should see theory behind why implementing differentiated activities can help students' understanding of concepts as well as help them to understand concepts more deeply. The reader should also see how implementing differentiated activities has affected other teachers' motivation and preparation. Finally, this section ends with a look at methods suggested by experts for implementing various differentiated instruction strategies.

The terms *zone of proximal development* and *moderate challenge* are two learning theories that support the need to differentiate instruction for low, middle, and high-achieving students. A child's *zone of proximal development* refers to a level of appropriate difficulty in tasks within which the child cannot succeed on their own, but can be successful, avoid frustration, and grow in understanding due to scaffolding and teacher support. Similarly, the term *moderate challenge* says that students should not work on tasks or with concepts where they are bored due to succeeding too easily.

Appropriate tasks should ensure students' thinking is appropriately challenged (Tomlinson, Brighton, Hertberg, Callahan, Moon, & Brimijoin, 2003). Put together as an upper and lower limit, these ideas indicate that there exists a window or range of content and task difficulty that challenges a learner because it is just above where he or she can work independently, but, because they are supported by the teacher to ensure success, below his or her frustration threshold. This window of challenge is optimal for learners because, if encouraged to work within this range, they are able to stretch themselves academically while still being successful in their learning tasks. The negative effects of students not working in this optimal zone, suggests Tomlinson (1999), are that students who succeed in classroom tasks too easily become unmotivated to learn, and students who fail consistently become discouraged and shut down.

These ideas of *moderate challenge* and *zone of proximal development* cause a dilemma for teachers because one academic task is often simultaneously too easy for one student and too difficult for another. In order to keep each child *moderately challenged*, teachers must adapt tasks and instruction according to the level of each student in the classroom.

To be able to adapt learning tasks to such a wide variety of student levels, teachers must have an understanding of what makes a learning task more or less challenging. Bloom's taxonomy is one tool that can be used to help accomplish this goal. According to an article by Krathwohl (2002), Benjamin Bloom created six categories useful for classifying learning tasks and objectives: knowledge, comprehension, application, analysis, synthesis, and evaluation. These levels, known as Bloom's taxonomy, were recently revised to become more modern and applicable to the twenty-first century classroom (Krathwohl, 2002). The six revised levels are:

remembering, understanding, applying, analyzing, evaluating, and creating. The first and most concrete cognitive level is remembering. After remembering, categories gradually increase in cognitive difficulty and abstraction, ending with the highest level: creating. Mastery of a previous lower level is required before moving to the next more complex level (Krathwohl, 2002). For example, a student who has not understood the concept of classification could not be expected to apply this concept to a given set of objects.

These levels can be used to create tasks for students at a level where they are *moderately challenged*. In addition to providing appropriate academic challenge, applying Bloom's taxonomy can help assess students' cognitive level of understanding. By seeing at which level within the taxonomy students can independently work, teachers can assess their depth of understanding.

In researching differentiated instruction, several studies have been done that indicate success in increasing the achievement and deepening the levels of understanding of low, middle, and high-achieving students. One study implemented differentiation in 13 middle school science classes and found that students scored higher on unit tests in comparison with students from nontreatment classes. From follow up surveys, six out of seven of the participating classroom teachers agreed that differentiated instruction increased their students' academic performance (Mastropieria & Scruggs, 2006).

A second study, applied in an inclusive fifth-grade science class, also promoted differentiated curriculum. In this case, low and middle-achieving students responded better to questions from the application level of Bloom's taxonomy than a class of control students. This study, however, did not find any difference in students'

response to identification questions, or questions at the knowledge level of Bloom's taxonomy (Simpkins, Mastropieri, & Scruggs, 2008).

Qualitative results from a third study of a differentiated sixth-grade poetry unit determined that differentiated classroom activities had a "positive impact on children's learning" (Avci, Yuksel, Soyer, & Balikcioglu, 2009, p.1069). Lastly, implementing differentiated instruction with teaching that also focuses on cultural diversity, Santamaria (2009) found that student achievement improved steadily based on pre-and postassessment data taken over a five-year period.

Although studies have shown differentiated instruction to be beneficial to students, teachers do not always adapt their instructional activities and presentation to provide *moderate challenge* at individual students' cognitive levels since it requires additional planning time and philosophical understanding. According to Grimes and Stevens (2009), an elementary classroom teacher who conducted differentiation action research with 20 fourth-grade math students said, "Differentiation is a lot of work! Taking the time to constantly assess, reassess, and adapt lesson plans to meet every students' needs can be time consuming" (p.680).

In addition to the amount of work, a concern repeatedly raised by researchers and experts in differentiated instruction is that teachers often lack proper training in the philosophy and strategies of differentiation. Therefore, many teachers, despite sometimes having good intentions, do not implement differentiation properly due to misunderstanding or lack of initiative (Hong, Greene, & Higgins, 2006; Hertberg-Davis, 2009; Sisk, 2009; Tomlinson et al., 2003; Brighton & Hertberg, 2004).

Another challenge of differentiating instruction is that it requires a deep understanding of the many aspects of the subject being taught. This deep

understanding is difficult for teachers who teach multiple subjects and are stronger in knowledge of pedagogy than content (Hertberg-Davis, 2009).

Although differentiated instruction can initially be time consuming and difficult to apply, teachers have found it a rewarding practice. Grimes and Stevens (2009) states:

Differentiated instruction not only improved test scores for all my students, but it also increased students' desire to do math, their desire to improve in math, and their confidence in their math abilities. Because students benefited from the differentiated model, I continue to use differentiated instruction in my mathematics classroom. (p.680)

From the previously mentioned study of implementing differentiation in fifth grade science classes, teachers and students both reported a high degree of satisfaction after using differentiated curriculum (Simpkins, Mastropieri, & Scruggs, 2009). However, a challenge mentioned by middle school science teachers was, since differentiated activities often take longer than whole-class instruction, it is hard to find time to implement the strategies and cover the necessary amount of material required by high-stakes testing (Mastropieri & Scruggs, 2006; Hertberg-Davis, 2009).

If differentiated activities are time consuming and challenging to implement, what strategies do experts suggest for an efficient and effective implementation? To begin with, teachers must know which facts, concepts, principles, attitudes, and skills they want their students to learn. It is only after this foundation is established that teachers can go about varying the instruction to meet student needs. This ensures that each task is aligned with the desired learning objectives and differs only in cognitive difficulty (Tomlinson, 1999).

After teachers have established their learning objectives, next they can decide when and what to modify based on observations regarding students' readiness, interest, and learning profile. Students' readiness looks at students' prior learning and skills about a particular idea or concept. Students' interest takes into account their likes, dislikes, and passions when designing activities and examples to use in instruction. Students' learning profile considers in which environment a student learns best. For example, would students understand directions most clearly when given through auditory or visual means, or prefer to work on an assignment cooperatively or individually (Tomlinson, 1999).

Finally, after considering the needs of their students, teachers are ready to adapt their instruction. According to Tomlinson (2000), three aspects of teachers' instruction can be modified: content, process, and products. Modifying content means adjusting what teachers want their students to learn. Modifying process refers to varying the activities or work students do to learn the content. Modifying products means providing different opportunities for students to demonstrate their learning (Tomlinson, 2000).

Many methods exist that provide opportunities for teachers to adjust for student readiness, interest, and learning profile. A study of five middle school teachers of various subjects, categorized as *master teachers* at using differentiation in their daily practice, found four commonalities: providing personal scaffolding for students, having flexible means to reach their desired end, knowing multiple ways to teach material, and providing a caring classroom (Carolan & Guinn, 2007). The use of classroom stations, cooperative grouping, student agendas, orbital studies, student choice menus, and tiered assignments are some practical strategies capable of transforming a traditional classroom and curriculum into one designed to meet the

needs of a variety of learners (Tomlinson, 1999). Preassessing student knowledge and experience is vital in recognizing students' readiness and interest with upcoming content. Also, implementing effective classroom management strategies is of great importance as many different tasks and activities are taking place in the classroom simultaneously (Tomlinson 1999).

In conclusion, due to the range of students' prior knowledge and instructional levels coupled with the necessity for appropriate learning tasks and new information, it is important that teachers design their instruction to address this variety. Bloom's taxonomy is one opportunity to differentiate the level of content presented to and expected of students. Although differentiation is a challenging method, it is rewarding and necessary for quality instruction. Finally, after preplanning regarding learning objectives and student profiles, various strategies can be applied in a typical classroom setting to allow for instruction to be differentiated. Many of these procedures and strategies were applied and analyzed in my personal capstone project on the implementation of differentiated instruction within a sixth-grade introductory chemistry unit.

METHODOLOGY

Project Treatment

To determine the effectiveness of my differentiated classroom instruction, I compared data collected without this intervention (a nontreatment unit) to data collected with this intervention (treatment units). The research methodology for this project received an exemption by Montana State University's Institutional Review Board, and compliance for working with human subjects was maintained. The form used to gain consent from the principal of Hong Kong International School and

student guardians can be found in Appendix A. My capstone project took place through approximately six weeks of instruction plus two initial weeks of preunit data collection. These six weeks of instruction were broken down into three, two-week long, units. My first unit about density was taught, documented, and assessed without intervention. During units 2 and 3 about buoyancy and boiling point, I implemented differentiated instruction and collected data to allow for comparison.

The students were introduced to new vocabulary and concepts in my untreated unit on density through lab experiments, textbook readings, video clips, and discussion. One lab experiment in the untreated density unit titled *Wat-ar Densities?* can be found in Appendix B. For this experiment, students were randomly grouped into teams of three to four with each group given the same instructions both prior to and during the experiment. All students were also given the same worksheet to complete during the lab.

The topic of my nontreatment unit was density, and the topics of treatment unit 1 and 2 were buoyancy and boiling point respectively. Before instruction in each unit began, I gave students a pretest assessing their readiness with these topics. These pretests can be found in Appendix C. I also used standardized test scores from a reading test called the DRA to collect data about students' reading levels. Lastly, I gave students a learning profile survey to collect information regarding their strengths and the ways in which they learn best. From this survey, I placed students into a learning style group according to the category in which they had the highest total score. This student learning profile survey can be found in Appendix D.

In Treatment Unit 1, students predicted when substances would sink or float by looking at density, as well as the relationship between mass and volume. In Treatment Unit 2, students studied how time, volume, and temperature affect the

changes of state through which a substance will go. As with the nontreatment unit, students were introduced to new vocabulary through lab experiments, textbook readings, video clips, and discussion. During these treatment units, I implemented intervention through the use of graphic organizers, scaffolded laboratory experiments, learning style assignments, and tiered homework.

As one part of my intervention, I purposefully grouped students by reading ability when reading from the textbook. After reading the assigned textbook pages, all students wrote responses to questions regarding new vocabulary, new concepts, and a summarization of the reading's main idea. They also verbally explained diagrams found in the reading. Before reading, low readers were given a graphic organizer that helped these students find and organize their responses to these questions. The graphic organizers for the textbook readings on States of Matter and Changes of State can be found in Appendix E. Follow up for all students was a classroom discussion in which all groups were called upon equally to share their answers.

Each treated unit also contained four laboratory experiments. As a second part of my intervention, during one lab in each treated unit, I purposefully grouped students based on readiness. After assigning groups, I scaffolded the lab for certain groups by breaking it down into more detailed steps, which gave more instruction to students with lower readiness and less instruction to students with higher readiness. An example of one laboratory experiment in my Buoyancy Unit in which I used scaffolded instruction was entitled *Flinker*. In this lab, students made a given object neutrally buoyant. I used the pretest, prior science assessments, and daily classroom observations to group students into categories of low, middle, and high-achieving based on their readiness for this task. This scaffolded laboratory assignment can be

found in Appendix F. A laboratory experiment in my second treatment unit on boiling point in which I also used scaffolded instructions for students grouped into the categories of low, middle, and high-achieving was called *Time to Boil*. For this assignment, students predicted the effect water's volume has on its boiling point. Students completed an experiment, recorded data in a table, and discussed their conclusions from the experiment. This scaffolded assignment can be found in Appendix G. I assessed student understanding of both scaffolded experiments by checking their completed assignment using a rubric.

As a third modification to my instruction, during a different, unscaffolded lab in each unit, students had the opportunity to demonstrate understanding based on their learning profile. First, students were randomly assigned to lab groups. Following the experiment, to demonstrate their understanding of laboratory procedure and learning objectives, students created one of the following products as part of a group assignment: song, speech, poster of real-life application, logical analysis and graph, cartoon strip, or three minute skit. Students were assigned to a particular task due to their learning profile strength determined from the learning profile survey completed during the first week of the project's implementation. To assess this assignment, I created one rubric that was used for all products. The rubric from these learning profile demonstrations can be seen in Appendix H. This rubric, which required students' products to answer specific questions about new concepts, was given to students at the beginning of the assignment. After that, students were placed into a group according to their product and given a specific amount of class time to complete this assignment. In addition to their final product, each group was also responsible for submitting a completed form explaining each person's role or job within their group assignment. Lastly, each group was responsible for sharing their

final product the following class period, where it was assessed using the given rubric.

As my final intervention strategy, I assigned homework questions using a differentiation strategy called *menu*. Each day's homework topic contained three levels of questions, with three questions per level. Students were instructed to choose four questions to complete. Questions from *level one* were created using the first two levels of Bloom's taxonomy: remember and understand. Questions from *level two* were created using the second two levels of Bloom's taxonomy: apply and analyze. Questions from *level three* were created using the highest two levels of Bloom's taxonomy: evaluate and create. A sample *menu* homework assignment from Treatment Unit 1 can be found in Appendix I. Answers to these assignments were shared within students' class groups, discussed as a class, and submitted to me as homework.

Using graphic organizers and scaffolded laboratory experiments aided student understanding by giving students more individualized learning experiences. The amount of time and assistance provided was more flexible based on students' needs. Also, allowing students to work on activities within their learning style aided understanding since students transferred new information into a form that was meaningful to them and with which they think most easily.

Giving students tiered assignments and scaffolded instruction had an influence on students' cognitive level by allowing students to grapple with ideas that were not too easy or too difficult, but at their instructional level. High-achieving students were encouraged to make sense of higher-level ideas. Low-achieving students were provided with additional time and support to process and make sense of foundational concepts as well as the additional guidance needed to understand higher-level idea

assignments.

Data Collection Instruments

At Hong Kong International School, I teach two sections of sixth-grade math and science to a total of 42 students. Of the 110 minute block I am allotted for each section, 55 minutes is spent in science instruction and 55 minutes in math instruction. The students move to a different teacher for Language Arts and Social Studies, as well as separate teachers for their elective classes. All 42 of my math and science students received the differentiated activities intervention during science instruction. Each of these two classes contained several students classified with learning needs and several students that were indicated as high-achieving. English was not the first language of about 35% of these students, but most had been in an English medium environment like Hong Kong International School since primary school and had a strong command of the English language. No students in my classes were formally supported as second language learners. Each class contained a balance of boys and girls of a variety of nationalities and cultures.

I collected data from three sources for each project question to allow for triangulation. Therefore, no one data collection method was fully responsible for my conclusions. Table 1 is the data triangulation matrix for this capstone project.

Table 1
Triangulation Matrix of Data Sources by Project Question

Project Questions	Data Source		
What are the effects of using differentiated instruction on students' understanding of sixth grade introductory chemistry concepts?	Preunit and postunit test	Preunit and postunit student journals	Preunit and postunit student interviews
What are the effects of differentiated instruction on students' various cognitive levels of understanding science concepts?	Daily student journals with prompts (through treated and nontreated units)	Preunit and postunit test (for treated and nontreated units)	Preunit and postunit student interviews (for treated and nontreated units)
What are the effects of using differentiated instruction on high, middle, and low-achieving students' understanding of concepts?	Daily student journals with prompts (through treated and nontreated units)	Preunit and postunit test (for treated and nontreated units)	Preunit and postunit student interviews (for treated and nontreated units)
What are the effects of implementing differentiated instruction on my preparation time and teaching methods	Teacher reflection journal with prompts (through nontreated and treated units)	Teacher planning time-log (through nontreated and treated units)	Daily teacher attitude survey
What are the effects of implementing differentiated instruction on my thoughts about my role in student learning, attitude, and motivation to teaching?	Teacher reflection journal with prompts (through nontreated and treated units)	Teacher planning time log (through nontreated and treated units)	Daily teacher attitude survey

All 42 students participated in the pre and posttests. Only one class of 22 students participated in the journals. Lastly, I chose seven students, four girls and three boys, to participate in interviews. The composition of these students was as

follows: three low-achieving, two high-achieving, and two middle-achieving students. I chose this because it seemed like a reasonable representation of my class, would be a manageable amount of data to analyze, and was a large enough number to account for outliers. The factors for being classified as low, middle, or high-achieving were science test scores from previous units and pretests from the capstone project.

My project question investigating students' understanding of concepts was assessed through student journals, preunit and postunit tests, and student interviews. Once a week, students were prompted to explain the day's learning objective and then wrote for three to five minutes at the end of a lesson in a journal. Since all students at my school have laptops in class each day, the journal entries were typed and submitted in a Googledoc. Student journal prompts can be seen in Appendix J. After reading the students' journal entries, I used a rubric to sort the entries into three categories: basic, on-level, and advanced. Next, I compared the quantitative data of the class as a whole by counting the number of students whose responses fit into each category based on students' ability to understand and apply the new information. Lastly, I compared qualitative data by typing up statements that were representative of each basic, on level, or advanced category. Looking at these responses helped me know students' readiness for upcoming lessons as well as their current level understanding. From my second data source, I compared students' average preunit and postunit test scores. I used this information to see the amount of progress within each unit as well as the amount of gain in across the three units. My third data source, interviews, allowed me to probe deeper for student understanding about each unit than could be done on the test. I asked students to answer concept questions and to create a concept map with the unit's key terms and vocabulary. Afterwards, I compared students' responses from their preunit interview to their postunit interview and

recorded the amount of increase in their understanding. I also looked at students' postunit interview responses and compared them between the three units. Interviews were given during students' lunch or break period and aurally recorded using Garageband, which is a computer application that allows for easy audio recording, and paper and pencil notes taken by myself. The interviews took place before the start of each nontreatment and treatment unit and after the assessment of each treatment and nontreatment unit. Student preunit and postunit interview questions can be seen in Appendix K.

Students' level of understanding was assessed through preunit and postunit tests, student journals, and student interviews. Tests were designed with questions that allowed students to work at the different levels of Bloom's taxonomy: knowledge, comprehension, application, analysis, synthesis, and evaluation. I looked at how students were able to answer questions at these various levels on the postunit test and compared this to their results from the preunit test. I also compared the levels they achieved on the three postunit assessments to see the impact of my differentiated activities. Student interview questions allowed me to compare students' level of understanding by asking questions at the different levels of Bloom's taxonomy.

High, middle, and low-achieving students' understanding of science concepts was determined by analyzing the data from pre and posttests, interviews, and journal entries. For each data source, I first categorized the results by student achievement level before looking at the qualitative and quantitative data.

I assessed my motivation, attitude, role and methods in student learning through a self-created survey where I rated my view about the management, engagement, and instruction of each unit daily during project implementation. This survey can be seen in Appendix L. My teacher journal with prompts was completed

daily and also gave me feedback on these areas. These prompts can be seen in Appendix M. My teacher time-log, seen in Appendix N, gave me information about my preparation time, which was also documented through the attitude survey and reflection.

The timeline for my capstone project was about eight weeks. I began collecting preassessment data and parental and student consent on December 1, 2010, prior to my study. From January 17-28, 2011 was my nontreatment unit. My treatment units began February 7, 2011 and continued through March 11, 2011. The detailed timeline of this project is attached in Appendix O.

DATA AND ANALYSIS

With the data I collected from my various data sources, I attempted to answer my project's questions. First, I attempted to see if the differentiated activities implemented had any effect on students' understanding of sixth grade introductory chemistry concepts. Figure 1 illustrates the average class scores calculated from the pretests and posttests of my nontreatment and treatment units.

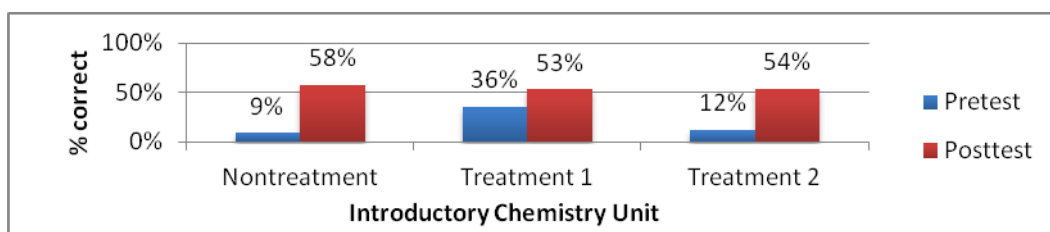


Figure 1. Average Pretest and Posttest Scores During Project Phases, ($N=42$).

These data show that students made the most amount of gain during the nontreatment unit. Students' average posttest scores were fairly consistent and varied by only four points between the three units. Students' pretest scores showed a greater difference between units with a variance of 27 points from the nontreatment pretest to the

treatment pretest. Despite the increase in the amount of prior knowledge students possessed as they progressed through the three units, there was not a parallel increase in their postunit test scores. In contrast, postunit scores were slightly lower than the postunit test from the nontreatment unit.

The second set of data was collected from the student interviews conducted. I used a rubric to sort students' oral responses into those that demonstrated no understanding, partial understanding, or full understanding. A sample of students' responses from each of these categories can be seen in Table 2.

Table 2
Sample Responses from Treatment Unit 2 Categorized by Level of Understanding

Level of Understanding	Sample Student Responses to "Define boiling point."
No Understanding	When you boil water and when its overflowing and the water's making a sizzling sound that means you should turn it off because its going to explode of something.
Partial Understanding	When there's boiling temperature comes. We time ourselves, we put ice cubes in the science lab in the heater and we saw when the boiling point. We had a timer with us and we saw when it starts to boil, there were bubbles, and it starts to change state.
Full Understanding	Boiling point is a temperature where a liquid starts to turn into a gas.

Students whose oral responses showed no scientific understanding of the topics learned were categorized as demonstrating no understanding. Students whose oral responses answered the question fully were categorized as having full understanding. Students' answers that showed some understanding of the topics but either also included some incorrect information or did not respond with enough information to demonstrate a full understanding were categorized as having a partial understanding.

To quantitatively analyze my students' interview responses, I then assigned each category of response with a numerical value. Student responses that showed no

understanding were assigned zero points, responses that demonstrated partial understanding were assigned one point, and responses that demonstrated full understanding were assigned two points. Next, looking at students' answers to the three conceptual questions from my interviews, I used these values to determine a separate preunit and postunit value for each student from each unit. A student with 100% correct would have answered with full understanding on all three questions. A student with 0% correct would have answered all three questions with no understanding. The percentage from these values can be seen in Figure 2.

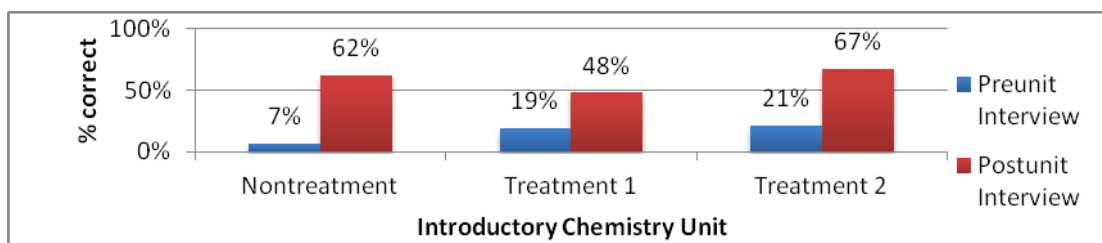


Figure 2. Average Percentage of Correct Answers from Preunit and Postunit Interviews During Project Phases, ($N=7$).

Like the pre and posttests, these data also show that there was an increase in the amount of prior knowledge students possessed as they progressed through the three units. Strangely, despite this increase in prior knowledge, the posttest results from treatment unit 1 were much lower than those of both the nontreatment unit and treatment unit 2. Again, when comparing the gain made on the posttest compared to the pretest, the most was made during the nontreatment unit.

My last source of data used in assessing students' understanding of introductory science concepts was a weekly journal entry from each student. I first analyzed my students' responses qualitatively by using a rubric to sort them into three categories: below level, on level, and above level. A sample student response from each category can be seen in Table 3.

Table 3
Sample Journal Responses Categorized as Below, On, or Above Expected Level

Level of Understanding	Sample Student Responses to the prompt: “What was the major topic of today’s lesson and what did you learn about that topic?”
Below Level	Density, I learned different ways to find the density of things.
On Level	I learned that mass is different from weight. Mass is a measurement of what an object contains. Weight is the effect gravity has on an object.
Above Level	I learned that the bigger mass and the same volume and the bigger volume and the same mass both effect the density and that Archimedes found out the to figure out the way about the density of irregular object. And also the difference between weight and mass. Mass weighs how much matter in an object and weight is mass + gravity.

Students were classified on level if they were able to accurately remember and understand information that they had learned from class. Students were classified below level if their answer showed misunderstandings or did not include enough information to demonstrate an understanding of the new information. Students were classified as above level if, in their answer, they demonstrated accurate understanding by recalling but also applying the information learned.

Next, I quantitatively analyzed my journal responses by averaging the number of student responses that had been classified as above level, at level, or below level in each of the treatment units. The results from this analysis can be seen in Figure 3.

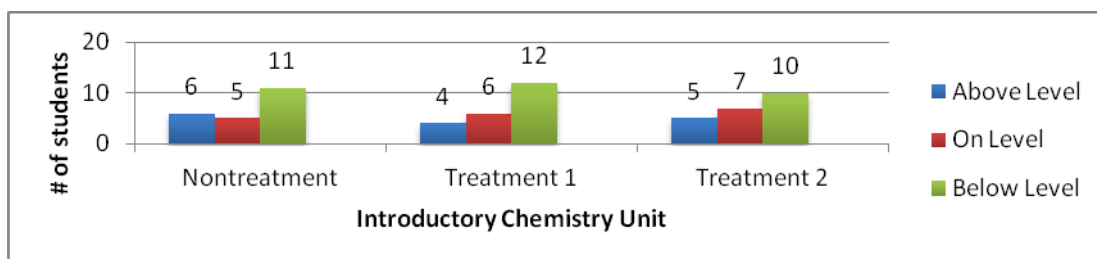


Figure 3. Average Number of Student Journal Entries Categorized by Understanding During Project Phases, (N=22).

Results between the three units did not show much variance. The number of on level students rose slightly from the nontreatment unit through the second treatment unit. The number of students above level fell slightly from the nontreatment unit to the treatment units. From this analysis of the three units, it appears that students were slightly more successful in understanding the second treatment unit about boiling point as the fewest number of students were below average and the most on level. Overall, the journal entries data indicate that no apparent positive or negative difference resulted from the differentiated instruction during the treatment units.

My first subquestion addressed students' understanding and focused on the cognitive level to which students understood new concepts. The first collection of data analyzed in attempt to answer this question came from students' responses on the pre and posttests. The pre and posttest questions were written at three different levels based on Bloom's Taxonomy: remember and understand, apply and analyze, and evaluate and synthesize. Sample questions categorized into each of these levels can be seen in Table 4.

Table 4
Sample Pre and Posttest Questions from Treatment Unit 1 Categorized by Cognitive Level

Cognitive Level	Sample Pre and Posttest Questions from Treatment Unit 1
Remember and Understand	An object that sinks in water must have a density that is... A. Less than 1 g/mL B. Equal to 1 g/mL C. Greater than 1 g/mL
Apply and Analyze	An object with a mass of 45g and a volume of 35mL was dropped in water. Predict whether the object will sink or float and explain your reasoning.
Evaluate and Synthesize	Is it possible for a substance with a density of 3g/mL to float? Explain your reasoning. Design an experiment that could prove your answer.

After noting which questions on the pre and posttests fell into which cognitive level, I then tabulated the number of students who correctly answered the posttest questions in each of these three levels. These results can be seen in Figure 4.

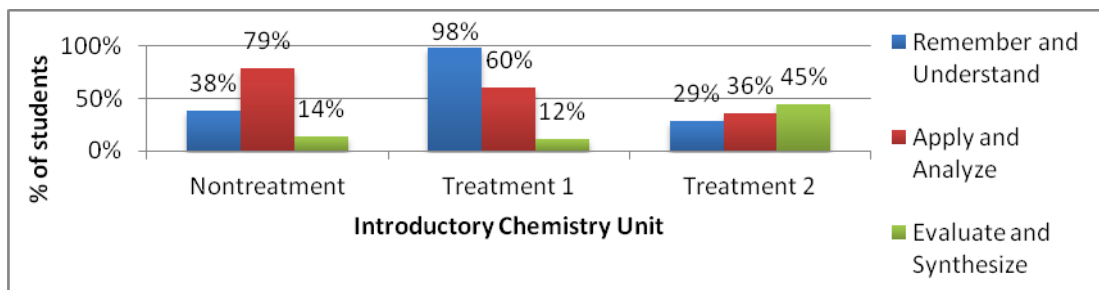


Figure 4. Percentage of Correct Posttest Questions Categorized by Cognitive Level During Project Phases, ($N=42$).

According to this analysis, in each of the three units students were more successful with a different level of cognitive question. In the nontreatment unit, students were most capable of applying what they've learned. This makes sense as the lessons focused on applying the density formula to various objects and situations. In the first treatment unit, students were most capable of remembering new information. In the second treatment unit, students' strongest area was evaluating and synthesizing. The second treatment unit shows a decrease in the categories of remembering and applying new learning, but also shows an increase in evaluating new information compared with the previous two units.

Students preunit and postunit test results categorized by cognitive level were used to calculate the percent change. These results can be seen in Table 5.

Table 5
Percent Change from Preunit to Postunit Test Categorized by Cognitive Level

Cognitive Question Level	Nontreatment Unit			Treatment Unit 1			Treatment Unit 2		
	Pre	Post	% Change	Pre	Post	% Change	Pre	Post	% Change
Remember and Understand	10	38	280%	83	98	18%	19	29	53%
Apply and Analyze	2	79	3850%	29	60	106%	very low but greater than zero	36	3600%
Evaluate and Synthesize	5	14	180%	7	12	71%	10	45	350%

From this data analysis, it is apparent that, across the nontreatment and treatment units, the middle cognitive level of application and analysis had a greater amount of gain than the lowest or highest cognitive levels. Students made the most gain in the highest cognitive level of evaluating and synthesizing during treatment unit 2.

The second source of data analyzed for students' cognitive understanding came from my student interviews. As with the pre and posttests, questions from my interviews were leveled according to the three cognitive categories described above: remember and understand, apply and analyze, evaluate and synthesize. Within each cognitive level, I then sorted each response as having no understanding, partial understanding, or full understanding. To produce quantitative data, I gave each type of response a numerical value. No understanding was assigned zero points, partial understanding one point, and full understanding was assigned two points. From these values, I calculated the average percentage of correct responses to the three levels of questions given by my students. These results can be seen in the Figure 5.

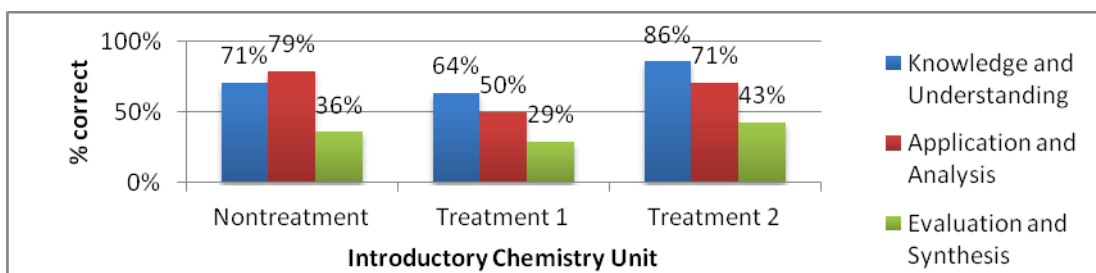


Figure 5. Percentage of Correct Postunit Interview Responses Categorized by Cognitive Level During Project Phases, (N=7).

From this presentation, it appears that students' ability to evaluate and synthesize the new concepts was slightly more prevalent in treatment unit 2 than in the first two units; however, this cognitive level score lowest when comparing all three levels. All three types of cognitive thinking were lowest in treatment unit 1. The most basic cognitive level of knowledge and understanding was strongest in treatment unit 2. In the nontreatment unit, students were most successful with application questions.

I also analyzed student interview data to find the percent change for each cognitive question type across the treatment and nontreatment units. This analysis can be seen in Table 6.

Table 6
Percent Change from Preunit to Postunit Interviews Categorized by Cognitive Level

	Nontreatment Unit			Treatment Unit 1			Treatment Unit 2		
	Pre	Post	% Change	Pre	Post	% Change	Pre	Post	% Change
Remember and Understand	very low but greater than 0	10	1000%	2	9	350%	4	12	200%
Apply and Analyze	1	11	1000%	3	7	133%	4	10	150%
Evaluate and Synthesize	2	5	150%	3	4	33%	1	6	500%

According to this analysis, the greatest gain in the first two cognitive levels was made during the nontreatment unit. However, the most gain in the highest cognitive level of evaluating and synthesizing information was made during the second treatment unit.

The next data analyzed for students' cognitive understanding came from students' journals. I found it difficult to sort students' entire journal entries into a single cognitive level. In a journal response of five sentences, students might accurately explain information they had learned for four sentences but also explain ideas in one sentence incorrectly. While I did not feel that the one incorrect sentence discounted the other accurate sentences, I also did not want to disregard areas where students had misunderstandings. For this reason, I qualitatively analyzed the entries by sorting students' ideas within their writing into four categories. The first category contained statements that were incorrect in understanding. The second category contained statements that lacked the information needed to truly assess understanding. The third category's entries correctly expressed new information by remembering and understanding it. The fourth category's entries demonstrated application and/or synthesis of new information by showing more than basic recall of information. If one student's response contained sentences about three different topics, but each topic was understood at a different cognitive level, that student was recorded three separate times. Sample responses categorized in this way can be seen in Table 7, with italicized writing representing the ideas at the indicated level.

Table 7
Sample Journal Responses Categorized by Cognitive Level

Cognitive Level	Sample Student Responses: “What was the major topic of this lesson and what did you learn about that topic?”
Misunderstanding	The major topic for today is the density and the volume. I learned that density can be in different equations such as extending the mass and keeping the volume the same or increasing volume. <i>I learned that as you pass by objects, you want to fit something in a perfect volume, you have to make the volume the same and change mass that will be much easier for yourself to figure out.</i>
Lacks sufficient Information	The major topic for today is the density and the volume. <i>I learned that density can be in different equations such as extending the mass and keeping the volume the same or increasing volume. I learned that as you pass by objects, you want to fit something in a perfect volume, you have to make the volume the same and change mass that will be much easier for yourself to figure out.</i>
Remember and/or Understand	<i>I learned that mass is different from weight. Mass is a measurement of what an object contains. Weight is the effect gravity has on an object.</i>
Application and/or synthesis	The major topic of today’s lesson was density. <i>What I learned about this topic was that there are some things that are dense and not dense for example the dense for and island is when there is a lot of people but if it is not dense for this island then there would not be that many people on that island.</i>

After categorizing student responses, I tabulated the average number of student responses of each type. This analysis can be seen in Figure 6.

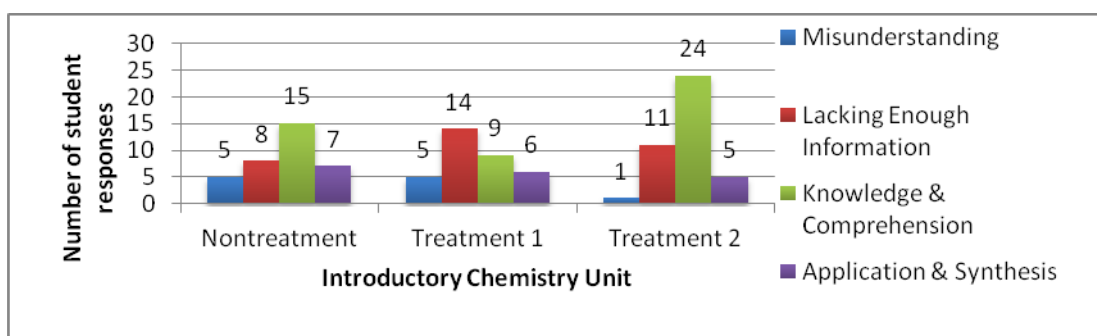


Figure 6. Number of Students' Written Journal Responses Categorized by Cognitive Level During Project Phases, (N=22).

From this analysis, it appears that the amount of misunderstanding dropped slightly from the nontreatment unit to the treatment units. The number of students who

demonstrated a level of application and/or synthesis in their journal entries also dropped slightly from the nontreatment unit to the treatment units. Students were able to accurately recall and explain the most new information from the lessons in the second treatment unit.

My final subquestion regarding students' understanding addressed the influence my differentiated activities had on my high, middle, and low-achieving students. For the pre and posttests, I first sorted the data by whether the student was typically a high, middle, or low-achieving student. Next, in each achievement category, I found the three units' average pretest and posttest score as a percentage out of 100. Lastly, I subtracted these scores to determine how much average gain the three levels of students made. These results can be seen in Figure 7.

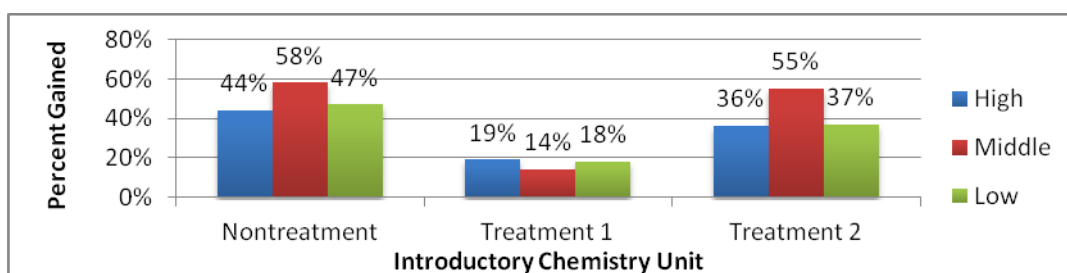


Figure 7. Amount of Gain in Percentage from Pretest to Posttest Categorized by Achievement Level During Project Phases, ($N=42$).

Overall, the thing that stands out from this analysis is the small amount of gain made by all three levels of students during treatment unit 1. Also, it can be seen that the greatest gain made by each achievement level was during the nontreatment unit. Finally, middle-achieving students made the most amount of gain overall.

Next, I analyzed these pre and posttest data for the percent change of each achievement level. These results can be seen in Table 8.

Table 8
Percent Change from Preunit to Postunit Test Categorized by Student Achievement Level

	Nontreatment Unit			Treatment Unit 1			Treatment Unit 2		
	Pre	Post	% Change	Pre	Post	% Change	Pre	Post	% Change
High-Achieving	23	66	187%	43	61	42%	26	63	142%
Middle-Achieving	6	64	967%	42	56	33%	10	65	550%
Low-Achieving	2	49	2350%	24	42	75%	6	43	617%

When analyzed in this way, low-achieving students had the greatest amount of gain in each treatment and nontreatment unit due to their initial limited amount of prior knowledge demonstrated on the pretest. Once again, all three levels of students made the most gain during the nontreatment unit.

Without taking prior knowledge into account, viewing only the average posttest scores, the results of high, middle, and low-achieving students across the nontreatment and treatment units are more similar. This analysis has been included in Figure 8.

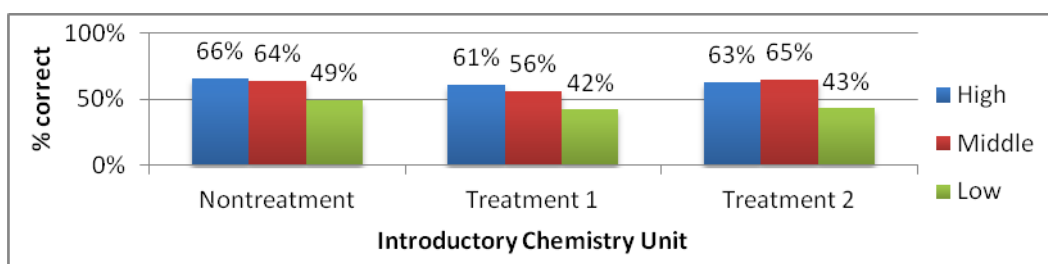


Figure 8. Average Posttest Scores Categorized by Achievement Level During Project Phases, ($N=42$).

From this analysis, results of high, middle, and low-achieving students during treatment units one and two were slightly lower than the nontreatment unit. The maximum difference between the nontreatment and treatment units was six points, with the minimum difference being only one point.

Next, I looked at the amount of gain by my high, middle, and low-achieving students as shown from their interviews. From my previous analysis of students' overall understanding, I had assigned each student's preunit and postunit interview a score representing their percentage correct. I now subtracted these values for each student, sorted them by achievement level, and averaged the values in each level to see the average amount of gain made by my high, middle, and low-achieving students. These results can be seen in Figure 9.

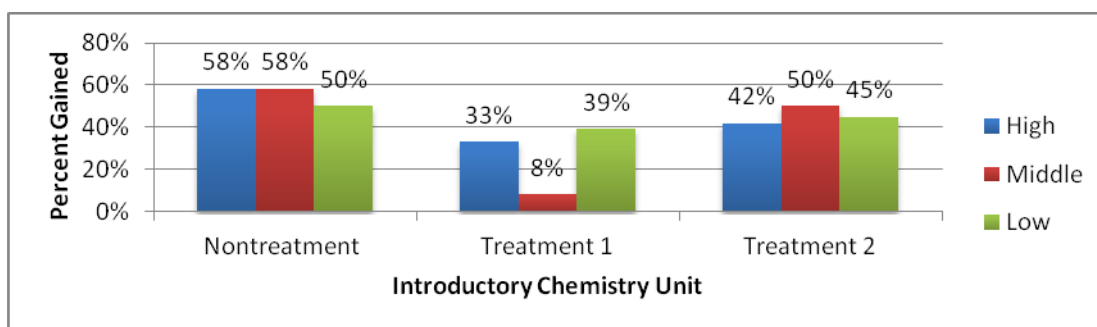


Figure 9. Percent Gained from Preunit to Postunit Interviews Categorized by Achievement Level During Project Phases, ($N=7$).

Like the pre and posttest analysis, interviews also show treatment unit 1 having the least amount of gain and nontreatment unit the most. Treatment unit 1 showed a very low gain for my middle achieving students. This was due to a particular student whose answers to questions during the preinterview showed a greater understanding than when she answered during the postunit interview. It seemed that the activities from treatment unit 1 caused her to become confused and develop some misunderstandings. Results from this student averaged with the other interviewed middle-achieving student resulted in an average gain in understanding of only eight points from the treatment unit 1 preinterview to the postinterview.

Next, I analyzed these pre and postunit interview data for the percent change of each achievement level. These results can be seen in Table 9.

Table 9
Percent Change from Preunit to Posunit Interviews Categorized by Student Achievement Level

	Nontreatment Unit			Treatment Unit 1			Treatment Unit 2		
	Pre	Post	% Change	Pre	Post	% Change	Pre	Post	% Change
High-Achieving	25	83	232%	42	75	79%	50	92	84%
Middle-Achieving	very low but greater than zero	58	580%	25	33	32%	8	58	625%
Low-Achieving	very low but greater than zero	50	500%	0	39	390%	11	56	409%

This analysis shows that high-achieving students made the least amount of gain across the nontreatment and treatment units. Middle-achieving students demonstrated a greater amount of gain than low or high-achieving students during both the nontreatment unit and treatment unit 2. During treatment unit 2, these middle-achieving students made the greatest overall gain. In contrast, both low and high-achieving students showed the greatest gain during the nontreatment unit.

Lastly, I used students' journal entries to determine how students of various achievement levels performed throughout the units. After qualitatively categorizing responses as above level, on level, or below level, sorted students by achievement level and determined the average number of students in each achievement level whose answers were below expectation. This analysis can be seen in Figure 10.

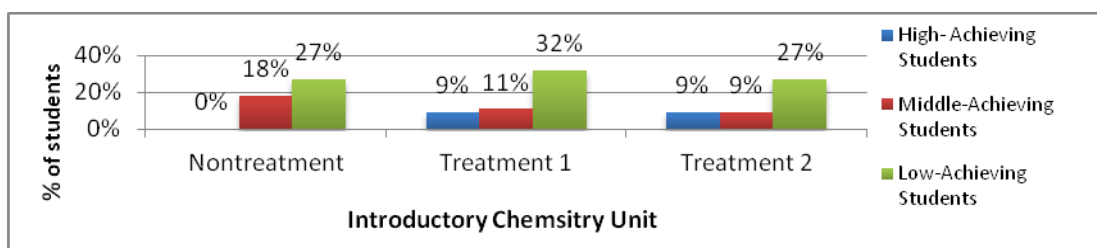


Figure 10. Percentage of Students' Journal Responses Written Below Expected Level Categorized by Typical Student-Achievement Level During Project Phases, ($N=22$).

High-achieving students had more below level responses in both treatment units when compared to the nontreatment. Middle-achieving students had fewer below level responses in the treatment units when compared to the nontreatment. Low-achieving students stayed fairly consistent. Overall, this analysis of journal responses shows middle-achieving students benefiting from the activities more than high or low-achieving students.

My next subquestion focused on how implementing differentiated instruction affected my preparation and teaching methods. From my daily teacher survey, I averaged together my daily Likert responses to the four questions regarding these aspects. The results can be seen in Figure 11.

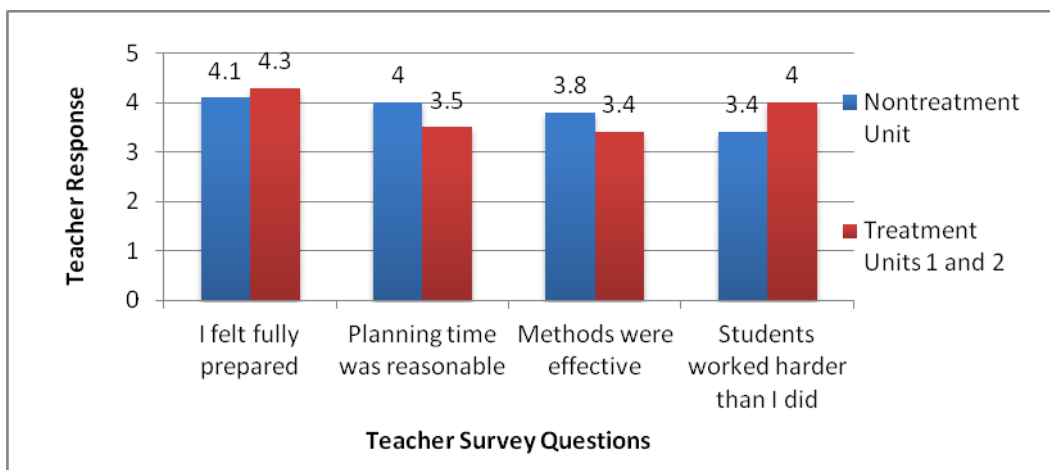


Figure 11. Average Teacher Survey Responses Regarding Preparation Time and Teaching Methods During Project Phases, ($N=23$).

Note. 5=Strongly agree, 1=Strongly disagree.

Planning for the differentiated activities took more time than activities that did not differentiate according to students' needs or interests. However, the amount of time was still fairly reasonable. Despite many activities being new, I felt just as prepared before teaching differentiated lessons. This is probably due to the extra planning time spent. I felt that the differentiated methods were not always as effective as the nondifferentiated methods. This feeling is also supported by the data analysis of my

project questions. When differentiated methods were used, the students were forced to work harder than when differentiated methods were not used.

In addition to my average preparation time, it is helpful to see the unaveraged data regarding the reasonableness of my preparation time collected throughout the project. Figure 12 shows the daily results of my survey as the project progressed.

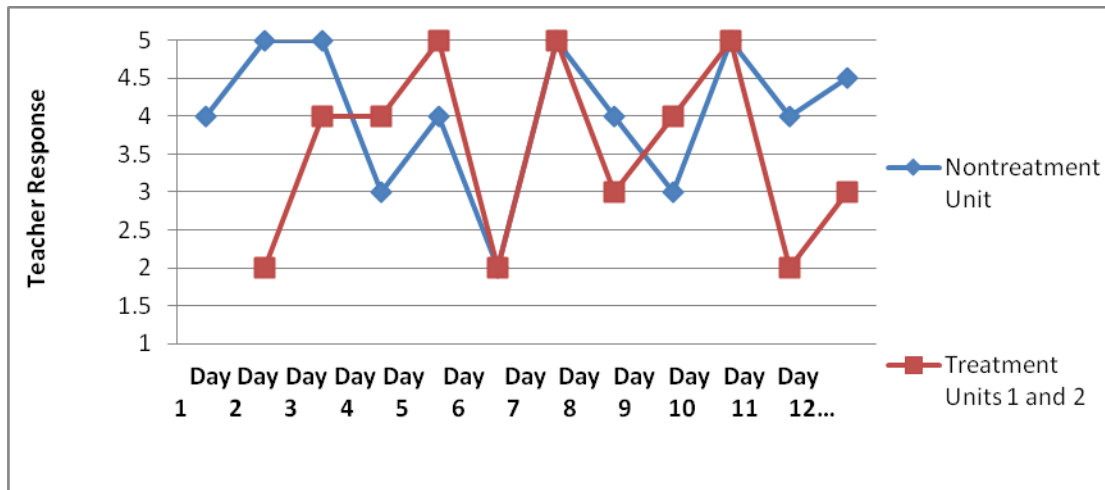


Figure 12. Reasonableness of Preparation Time for Differentiated and Non-Differentiated Activities During Project Phases, ($N=23$).

Note. 5=Strongly agree, 1=Strongly disagree.

The daily results show that differentiated lessons did not always need to take a long time to plan. On the first day of differentiated instruction I indicated that the amount of time was slightly unreasonable, but four days into the differentiated activities I indicated that it was a very reasonable amount of time. In contrast, on the second day of undifferentiated activities, I said the time needed was very reasonable, but six days later I indicated that it took a lot of time to plan even without differentiated activities. Some statements I made in my journal regarding my preparation time can be seen in Table 10.

Table 10
Teacher Journal Responses Regarding Preparation Time Needed

	Nondifferentiated instruction	Differentiated instruction
Positive	It took me 20-30 minutes to create a lab data collection Googledoc and email it to all the students.	Preparing was not too bad. I used the same rubric as from Some Like it Salty Activity. I also used the same team groupings.
Negative	I made a Jeopardy game, and it took me about 1.5 hours to do.	Creating the scaffolded instructions for the three levels of students in the lab took a very long time. It took quite a while to analyze students' learning profiles and place them into appropriate groups.

The daily survey indicated that I felt that the differentiated activities were a bit less effective than traditional methods. Table 11 indicates some statements I made in my daily journal that share some of my positive and negative thoughts regarding the activities.

Table 11
Teacher Journal Responses Regarding Differentiated Teaching Methods

Positive Responses	Negative Responses
Students could work through the activities using as much time as they needed. Students were motivated because they also had some choice in what order they did the activities and who they would work with.	I'm not sure that the scaffolding method I used to differentiate the lab was that effective because it was a lot of reading. It seemed like not many students followed the written instructions on the lab sheet. Since all had different tasks it was difficult to get them all started. There was not enough opportunity for me to clarify with individual students that they understood what they were doing. Students really needed to be independent, and many were not able to be.

My final subquestion focused on how implementing differentiated instruction affected my thoughts about my role in student learning, attitude, and motivation to teaching. Figure 13 displays the average results from my daily survey in response to these topics.

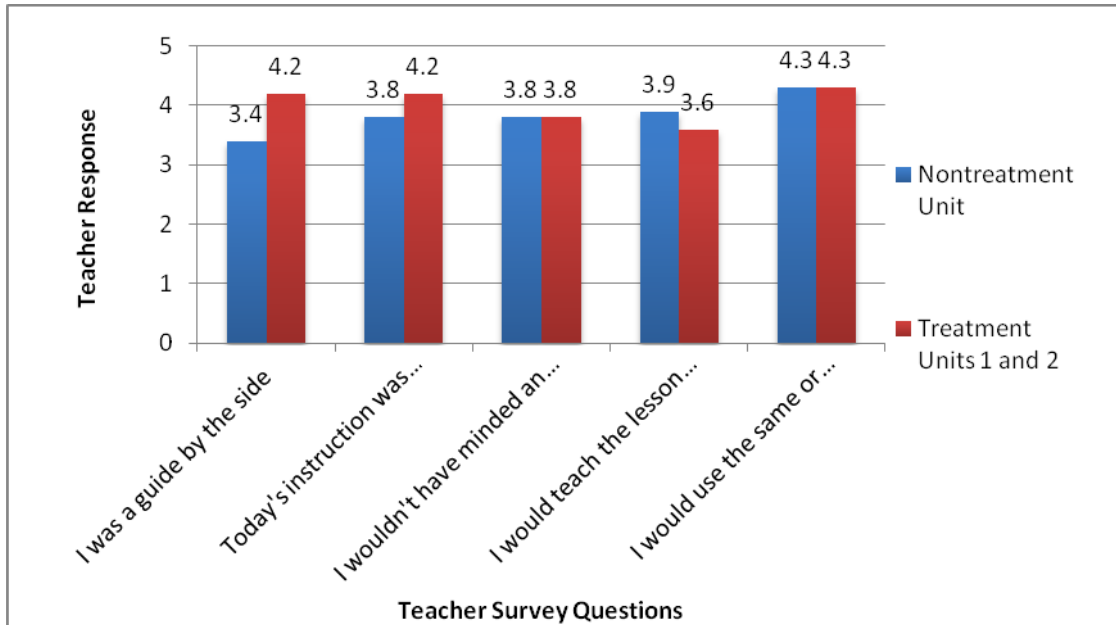


Figure 13. Average Teacher Survey Responses Regarding Attitude, Motivation, and Role in Teaching During Project Phases, ($N=23$).

Note. 5=Strongly agree, 1=Strongly disagree.

According to my survey, my role during differentiated instruction was more of a guide than when I did not use differentiated activities. I also enjoyed the differentiated activities more. I indicated that after using differentiated activities I would make more changes to the same lesson before reteaching it. The last question indicates that I was just as likely to want to use differentiated activities in the future as I was to use nondifferentiated ones.

It is useful to look at the unaveraged data to the question regarding motivation to use similar activities in the future. This can be seen in Figure 14.

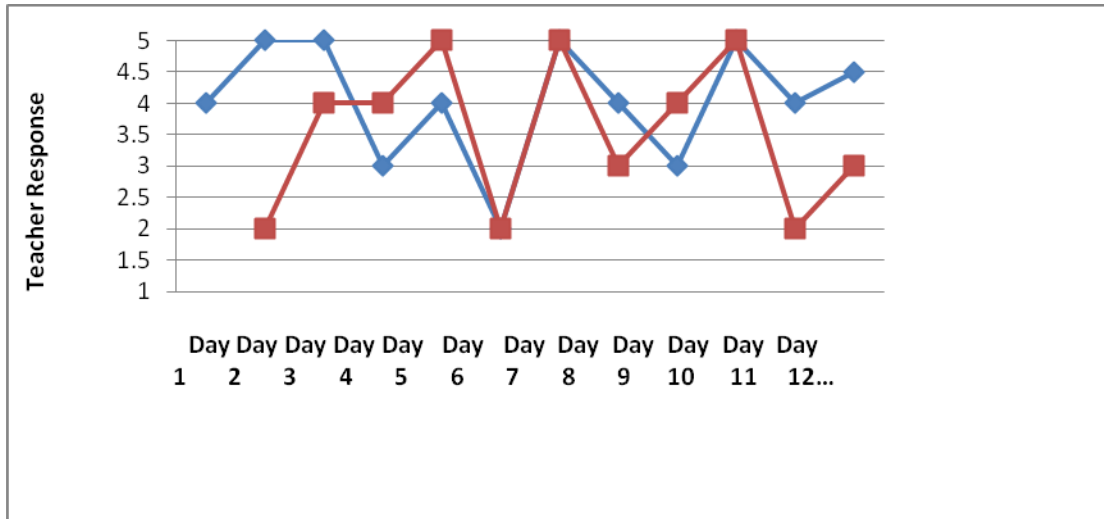


Figure 14. Comparison of Responses Regarding Motivation to Use Similar Classroom Activities in the Future During Project Phases, ($N=23$).

Note. 5=Strongly agree, 1=Strongly disagree.

Although the average indicates that I am just as likely to use similar differentiated activities in the future as to use nondifferentiated activities, looking at my daily responses shows that my feelings regarding this were not as drastic as when I did not use differentiated activities. On day two during the nontreatment unit, I indicated that I would definitely use the nondifferentiated activities from that day again. However, on day three I indicated that I would not be very likely to use those nondifferentiated activities again. In contrast, after the first day of using differentiated activities during the treatment units when I was fairly neutral, the days following I bounced back and forth between being pretty likely to use the activity again and definitely using it again.

My daily journal entries often indicated how much I enjoyed seeing students work through differentiated activities due to the opportunity to see students' creativity, strengths, motivation, and chance to work at their own level. Some of my positive comments can be seen in Table 12.

Table 12
Positive Teacher Journal Responses

Subquestion	Positive Responses
Attitude	I really enjoy seeing students be creative during their alternative product presentations. Particularly Thomas and Keegan's presentation; it was so accurate and so unexpected. They had fun and were fun to watch. I liked seeing students working at a level that they were capable of. I liked students being ability grouped and able to support each other without being bored or overwhelmed.
Role	I did not use any direct instruction other than to explain the expectations for the task. I went around and offered suggestions as I heard groups discussing their ideas. I made sure groups stayed on task. I ensured all group members were participating equally.
Motivation	I enjoyed seeing the students excited about the experiment and seeing students working with students of their same ability level. This meant that students were able to participate more equally; it wasn't the student who <i>gets it</i> doing all the work. The presentations were a fun way to see students' understanding. It is pretty clear which students have a good understanding. Some students say things that indicate misconceptions.

There is variety in my positive comments. I indicate that I am enjoying the activities and the students are enjoying the activities. One of my initial concerns for my classroom was that some students take over while others do all the work. I indicate that through differentiating the activities I see students participating more equally. Additionally, I indicate that it is clear which students have a good understanding of the concepts from their presentations and class work.

While there were many positive comments, there were also negative comments in my journal. Some of these responses are in Table 13.

Table 13
Negative Teacher Journal Responses

Negative Comments

When supervising students creating the presentations, I don't feel like I'm helping enough. Some groups finished before others. Some students went off task. The room was noisy and chaotic.

Students came away from the activity with misconceptions. I wonder if what students are learning or solidifying is in balance with the amount of time the task takes. It consistently takes longer than I would like it to for some groups to finish.

I was stressed in this lab. Students seemed to be having fun, but some were also off task or not doing things the way I intended.

At the end, many students did not fully understand and apply the idea of calculating the density in order to make the density of the film canister 1g/mL. I gave them too much independence.

These negative comments address the management of the differentiated activities and students' lack of understanding at the end of the activity.

INTERPRETATION AND CONCLUSION

When comparing my results from the nontreatment and treatment units, I did not find differentiated activities to have a positive effect on students' understanding of science concepts. The number of correct responses from the nontreatment unit's posttests and postunit interviews was fairly consistent with the number of correct responses from the results of the treatment units. This was true despite the fact that students' prior knowledge about the topic studied when starting the treatment units was greater than when starting the nontreatment unit. Therefore, the greatest gain in understanding on the unit tests occurred during the nontreatment unit. Interview results were consistent with the results from the unit tests, with a greater amount of prior knowledge demonstrated during the pretreatment unit interviews and a

consequent lesser amount of overall gain. Student journal entries did not favor the nontreatment unit's nondifferentiated activities or treatment units' differentiated instruction. Comparing the nontreatment unit to treatment unit 1, five percent of the class dropped from being onlevel to below level. Comparing nontreatment unit to treatment unit 2, 5% of the class increased from being below level to on or above level.

No consistent evidence demonstrated that the differentiated activities students participated in had a positive effect on their cognitive level of understanding concepts. Several results pointed to the benefit of nondifferentiated activities. For example, the unit tests demonstrated that, when comparing the three cognitive levels of remembering, applying, and evaluating, the most gain was made in the application and analysis questions. The gain in this level was made during both nontreatment and treatment units alike, but was greatest during the nontreatment unit according to posttests, postunit interviews, and journal entries. Additionally, all three data sources showed that the least amount of gain in any of the cognitive levels was made during treatment unit 1, as students were first getting accustomed to the differentiated instruction. In contrast, results that pointed to the benefit of differentiated activities included the unit tests and interviews, which both indicated that students' level of evaluating and synthesizing information gained the most during treatment unit 2. However, this was contradicted by students' journal entries, where the fewest number of responses including evidence of evaluating and synthesizing new information occurred during treatment unit 2. Students' basic knowing and understanding new information was, according to interviews and journal entries, strongest in treatment unit 2. According to posttests, this cognitive level was also strongest in treatment unit 1, but contrastingly low in treatment unit 2.

The hope that the needs of my high and low-achieving students would be better met through differentiated instruction was not supported by my data. Of the three achievement levels, high-achieving students made the least amount of gain. Of the gain made by high and low-achieving students, the tests, interviews, and journals indicated that this was highest during the nontreatment unit. However, data from interviews and journal entries did indicate that middle-achieving students were overall most successful in their learning during the second treatment unit. Overall, the data does not support differentiated instruction as benefiting my students' understanding of introductory chemistry science concepts.

The results regarding my personal thoughts about teaching using differentiated activities contained positive aspects not seen in the data collected from students. Firstly, although differentiated lessons were slightly more time consuming to plan, surprisingly, this was not consistently true. I sometimes spent just as long planning for nondifferentiated activities as differentiated ones. Also, once the activities had been initially created, I was easily able to adapt them to different concepts, which lessened my future planning time. Secondly, I enjoyed the differentiated activities more due to the allowance for student creativity and the opportunity to speak and work with students on a more individual basis. Thirdly, I found that students participated more equally when grouped based on common ability levels or interests than when they were randomly grouped. In this setting, it appeared that students divided the work more evenly among group members.

A negative aspect of differentiated activities indicated from both my personal reflection and student data collection was their lack of evident effectiveness. After reading in-depth about the philosophy behind differentiation, I predicted the effect of these activities to be more positive. However, the way I implemented my

differentiated activities and the way I collected my data may have had negative influences on my results.

The first reason positive results were not achieved may have been that the scaffolding provided to students, especially in labs, was solely in written form. This method was effective for students who were strong readers, but challenging for low readers. If students were not able to read and follow the information and instructions, they were not receiving the additional needed scaffolding. To remedy this problem, I would research other methods of scaffolding such as through diagrams or audio and multimedia methods and use these to create scaffolded instructions that are more accessible to all students.

In addition to independence in reading, students also needed to be more mature and independent in their work habits when participating in differentiated instruction. Because various activities were happening simultaneously, greater independence was needed in reading instructions carefully, using rubrics, self-monitoring understanding, and staying on task. Struggling readers as well as students with weak motivation and work habits therefore needed more support.

Since various activities were happening simultaneously, this required efficient classroom management strategies. A huge amount of organization was needed with giving varied instructions, managing materials, getting students into groupings, and checking their understanding. Trying to implement this during the midyear meant students and myself needed to adjust already established classroom routines and procedures. Many of the negative comments I made in my journal about differentiated activities dealt with classroom management, which I believe will improve as these activities are used more.

Similar to managing classroom routines, another result of students not always receiving full class instruction and needing to work more independently meant I needed to be much more proactive in consistently checking in with students to fill in gaps in understanding and ensure misunderstandings were not developing as students worked. Erroneously, more of my effort was spent trying to manage the various activities I was implementing for the first time rather than helping students summarize and solidify their understanding. Students needed more individual feedback from me than they would during whole class, direct instruction. This was particularly lacking at the initial implementation of treatment unit 1, and might explain why student results from treatment unit 1 were sometimes lower than both nontreatment unit and treatment unit 2

Another adjustment that I would make to increase the likelihood of positive effects from differentiated instruction would be to increase the amount of teaching days for each unit. For each nontreatment or treatment unit, the number of teaching days was only eight. Eight days was not much time for students to be exposed to new information in this new way. It was evident from my journal reflection that differentiated instruction required more class time than nondifferentiated instruction. Since high-achieving students had more challenging tasks than usual and low-achieving students did not have the support of the high-achieving students doing the work for them, students needed more time to complete class work. Longer amounts of time for each unit needed to be factored into my planning.

Like the lab experiments needed improvement in my method of scaffolding, the tiered homework method implemented also needed improvement. High-achieving students choose to answer higher cognitive-level questions, but classroom instruction did not always provide these students with the understanding needed to answer the

questions accurately. Since various students had completed different homework, follow-up took a long time and should not have been done in a classroom discussion format. A good strategy was needed for checking the accurateness and understanding of all students. These types of questions also provided additional challenge in that there was not usually a specific correct answer, which meant each student's responses needed to be checked for accuracy individually.

Reflecting on the data collection instruments used, several changes might have yielded more accurate results. Firstly, students wrote the pre and posttests on the same document. At the beginning of the unit, students completed a written pretest. At end of the unit, students were given back their original pretest and told to make corrections. Unfortunately, students were not able to self-correct responses they had previously written. If students had responded to a question on the pretest, they usually did not change it on the posttest even if it was fully incorrect. Students were much more likely to correctly answer questions they had previously left blank. Providing students with a blank postassessment to complete would have been best.

Additionally, because both the posttest and journal entries were not summative assessments, many students did not take them seriously and rushed through their answering. In the future, I would come up with a way of motivating all students to do their best on each data collection source.

The interview questions used were also lacking. A concept map helped me assess students' understanding of concepts. However, the terms in the word bank for each unit needed to be more carefully considered. The bank for treatment unit 1 was quite small. The bank for treatment unit 2 was quite large and allowed for many very similar connections. Concept map data was, therefore, not beneficial in determining

students' understanding and was not used in the analysis. Subsequently, interview data about understanding of concepts was not as accurate as possible.

VALUE

One realization from this project's data analysis is not to assume that strategies researched by others and implemented by me will automatically be beneficial to my students. According to my data collection and analysis, as well as my personal reflection, differentiated instruction was not effective for my students. However, as I reflected on the above, I recognize that time and practice is needed to develop effective understanding and management in order to design and implement differentiated instruction effectively. I must be continually reflective and observant when implementing new strategies to gauge their impact on my students' learning. I would like to continue to more closely analyze pre and posttest information, journal responses, and individual conversations with students to be aware of their learning progress.

A second implication was the positive aspect of grouping students according to ability level or interest within the classroom. I found that students were more comfortable, confident, and motivated when they worked with those they had commonalities with. In the future, I will put more thought into how I group students for activities instead of only using random or behavioral groupings.

Lastly, I recognize that for students to learn concepts more deeply with differentiated instruction, I need to allow more time. Students need more time to complete differentiated assignments, and I need to spend more time after a differentiated lesson checking in with them. In the future, I will allow more time for each activity when I'm implementing differentiated instruction. A positive result

found about differentiated activities was that students had the time they needed to process new information. Students were not forced to leave a task before understanding because the class was moving on or remain on a task waiting once they already understood because others in the class did not yet understand.

The audience beyond myself that I was hoping to benefit was my sixth-grade math/science teaching team. I had hoped to be able to give these colleagues effective strategies and activities for our introductory chemistry unit to be used in their classrooms. Unfortunately, at this time, I need more practice and research with differentiated instruction before recommending to my colleagues the activities used in this project. However, I think it is still valuable to share with them my strategies, observations, and results from this project.

My results are generalizable to other classrooms or schools that are similar in resources and type of students. Differentiated instruction was possible for me to implement due to the plentiful resources, available support, and small class size. It would be more challenging for a teacher without a lab technician due to the additional time needed to scaffold the lab as well as purchase and set up all the lab materials. It would be more challenging and chaotic for a teacher with a class size larger than 22 students to divide the class into similar leveled groups and have students working on different assignments. Also, my students are fairly motivated and well behaved. Since differentiated instruction required students to be more mature and independent, this might be more challenging in an environment where students are not motivated to work hard and stay on task with their assignments.

Lastly, this capstone project taught me the process and value of doing an action research project. Life in the classroom speeds by and often I do not take the time to stop and be reflective. This project helped me see the importance of

collecting data from a variety of sources and sitting down to analyze it and see what is working in my classroom. I learned that teaching methods that I use and believe are effective are not always as effective as I perceive them to be.

If I were to continue my capstone project, the next steps in this research process would be to focus on just one of the four types of differentiated activities I used and try to perfect its use. I used scaffolded instructions, alternative assessments, tiered homework, and graphic organizers. Using four separate pieces that I was unfamiliar with, and only using each piece twice, I was unable to fix any faults. By choosing one type of activity and doing similar research about its effectiveness, I could adjust my management and methods to implement it more successfully.

Lastly, another continuation of this project might be to research how ability grouping students without differentiated instruction influences their understanding and success. A grouping from this project that appeared beneficial to my students was separating by reading level during the supported reading and by ability level in the lab. I would study how much success was from the different instructions and graphic organizers the groups received in comparison to being with others of their same ability level.

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APPENDICES

APPENDIX A

PROJECT CONSENT FORMS

Hong Kong International School
1 Red Hill Road
Tai Tam, Hong Kong
November 5, 2010

Dear Principal Passamonte,

As part of my master's degree program through Montana State University, I am conducting a piece of action research studying how differentiated instruction affects middle school students' conceptual understanding of science concepts. I would be grateful if you would give your permission and support for this project.

My data collection methods will include audio recordings of the students and myself in conversation, journals, surveys, field notes, and written assessments. I guarantee that I will observe good ethical conduct throughout. Student participation will be voluntary, and I will secure permission from parents and students to involve them in the research. I guarantee confidentiality of information and promise that no names of colleagues or students will be made public.

Participation or non-participation will not affect the students' grades or class standing in any way.

I would be grateful if you would sign and return the slip below at your earliest convenience.

Sincerely,

Robin Scardino

To whom it may concern,

I, Paul Passamonte, Principal of Hong Kong International School, give my permission for Robin Scardino to undertake her research in her classroom and in the school.

Signature: _____

Printed name: _____

Hong Kong International School
1 Red Hill Road
Tai Tam, Hong Kong
November 5, 2010

Dear Parents,

As part of my master's degree program through Montana State University, I am conducting a piece of action research studying how differentiated instruction affects middle school students' conceptual understanding of science concepts. I would be grateful if you would give your permission for your child to take part in this project.

My data collection methods will include audio recordings of the students and myself in conversation as well as written journals, surveys, and assessments. Student participation in the project is voluntary, and I guarantee confidentiality of information and promise that no names of students will be made public. Participation or non-participation will not affect the students' grades or class standing in any way.

I would be grateful if you would sign and return the slip below at your earliest convenience.

Yours sincerely,

Robin Scardino

To: Robin Scardino,

I give my permission for my child, _____, to take part in your research.

Parent Signature: _____

Student Signature: _____

APPENDIX B

NONTREATMENT LAB WORKSHEET: WAT-AR DENSITIES?

Wat-ar Densities?

Key Question: What is the density of water?

Learning Goal: Students will determine the density of water

Procedure:

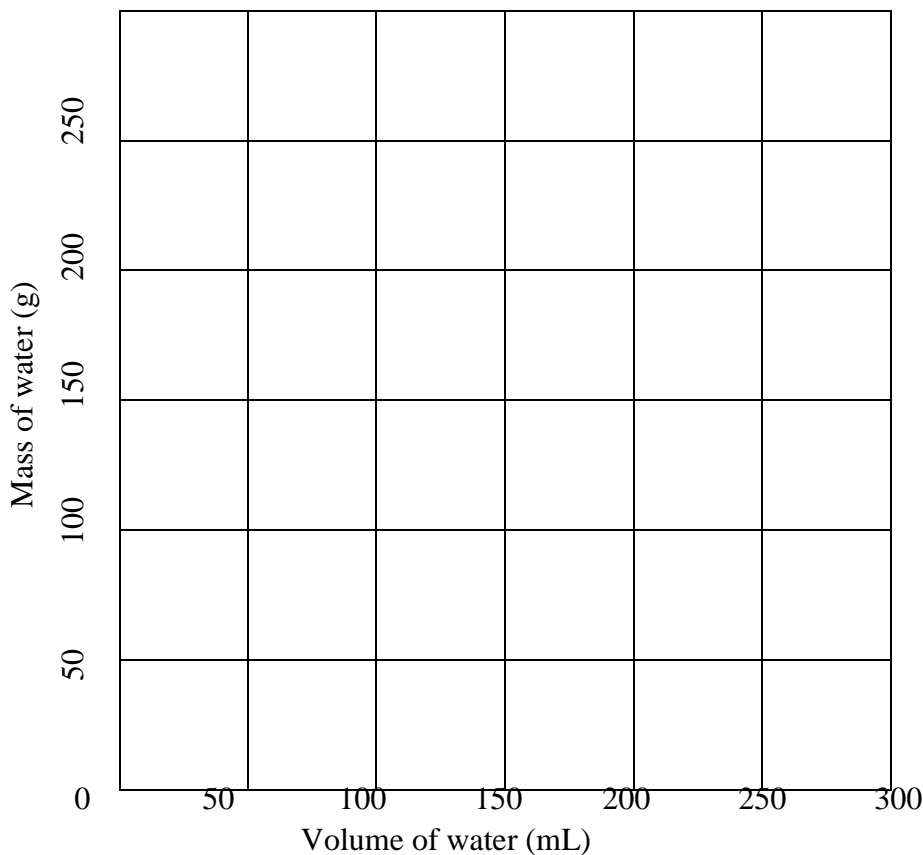
1. Record the mass of your empty graduated cylinder on the chart below.
2. Measure 50mL of water into your graduated cylinder.
3. Record the mass of the graduated cylinder with the water in it.
4. Subtract the two masses to find the mass of the water. Record this under the heading Mass of Water.
5. Divide the mass of the water by the volume of the water to find its density and round to the nearest hundredth.
6. Repeat using the indicated volumes of water.
7. Find the average of the densities.

Volume	Mass Empty	Mass Filled	Mass of Water	Density of Water
50mL				
100mL				
150mL				
200mL				
250mL				

The Standard Density of Water at room temperature is 1g/cm³ (or 1g/mL).

How close did you come?

Graph your data.



Youngs, D., Wiebe, A., Lile, D., Landon, K., McKibban, M., Laidlaw, W., et al. (2004). *AIMS floaters and sinkers: Mass, volume, and density*. New York, NY: AIMS Education Foundation.

APPENDIX C

PREUNIT AND POSTUNIT TEST FOR TREATMENT AND NONTREATMENT UNITS

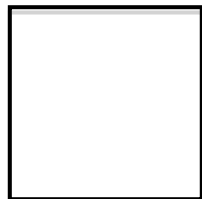
Name: _____

Number: _____

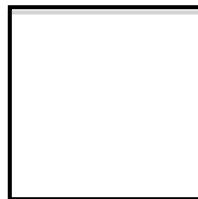
“Properties of Matter”
Density Pretest & Posttest

1A) Define density.

B) Draw the particle arrangement of a substance that is dense, such as gold, and one that is not dense, such as wood.



Gold



Wood

2. Calculate the density of an object with a mass of 30g and a volume of 44mL.

3. Design an experiment you could carry out to determine which of two objects had a greater density.

Name: _____

Number: _____

“Properties of Matter”
Buoyancy Pretest & Posttest

1. An object that sinks in water must have a density that is...

A) Less than 1 g/mL

B) Equal to 1 g/mL

C) Greater than 1 g/mL

Explain your choice:

2. An object with a mass of 45g and a volume of 35mL was dropped in water. Predict whether the object will sink or float and explain your reasoning.

3. Is it possible for a substance with a density of 3g/mL to float? Explain your reasoning. Design an experiment that could prove your answer. You may use the list of substances and their densities to help you.

Substance	Density
Chlorine	0.00321 g/mL
Water	1 g/mL
Ethanol	0.789 g/mL
Mercury	13.55 g/mL

Name: _____

Number: _____

Boiling Point Pretest & Posttest

1. Define the following terms: Melting Point and Boiling Point

2. Explain why a substance changes from one state of matter to another. Draw a graph representing the time and temperature as the state change takes place. You may use the list of substances and their boiling points to help you.

Substance	Boiling Point
Chlorine	-35°C
Water	100°C
Ethanol	78°C
Mercury	357°C

3. Sharon wrote an answer on her science test that said, "A liquid boils at 100°C". Evaluate Sharon's answer by explaining to her whether her answer is fully correct, partially correct, or fully wrong. Justify your choice with scientific facts and vocabulary.

APPENDIX D

STUDENT LEARNING PROFILE SURVEY

Student Learning Profile Survey

Directions: Rate each statement below using the following scale:

1	Rarely true of me
2	Occasionally true of me
3	Sometimes true of me
4	Usually true of me
5	Almost always true of me

Your answers will indicate which of the following strengths you have:

Musical, Logical, Service, Interpersonal, Kinesthetic, Verbal, Visual

	1	2	3	4	5
1(m). I am good at playing an instrument.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2(l). I can complete calculations quickly in my head.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3(e). I often think about the influence I have on others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4(i). I don't like to work alone.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5(k). I consider myself an athlete.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6(ve). It is easy for me to explain my ideas to others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7(vi). I remember things as mental pictures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8(m). Music is very important to me in daily life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9(l). Math has always been one of my favorite subjects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10(e). I believe that I am responsible for my actions and who I am.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11(i). I like to be with all different types of people.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12(k). Doing hands-on activities helps me learn best.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13(ve). I enjoy learning new words and do so easily.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14(vi). I enjoy creating my own works of art.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15(m). I am good at singing.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16(l). I am known for being neat and orderly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17(e). I enjoy discussing questions about life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18(i). I enjoy new or unique social situations.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19(k). I have a good sense of balance and like to move around a lot.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20(ve). I love to read and do so daily.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21(vi). I understand and remember better when I have a picture to look at.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22(m). I have a very good sense of pitch, tempo, and rhythm.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23(l). Problem solving comes easily to me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24(e). I can sort out arguments between friends.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25(i). I like to talk about and listen to ideas when I work in a group.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- 26(k). I enjoy making things with my hands.
- 27(ve). I like to keep a journal of my daily experiences.
- 28(vi). My ability to draw is often complimented by others.
- 29(m). I enjoy listening to lots of different kinds of music.
- 30(l). Using numbers and numerical symbols is easy for me.
- 31(e). I like to be involved in causes that help others.
- 32(i). I learn best interacting with others.
- 33(k). Sitting still can make me more tired than being very busy
- 34(ve). I read and enjoy poetry and occasionally write my own.
- 35(vi). Rearranging a room and redecorating are fun for me

Shelton, L., Heavenridge, P., & Beckerman, C.D. (n.d.) *Multiple intelligences for adult literacy and education*. Retrieved from <http://literacyworks.org/mi/assessment/findourstrengths.html>

McKenzie, W. (1999). *Multiple intelligences inventory*. Retrieved from <http://surfaquarium.com/MI/inventory.htm>

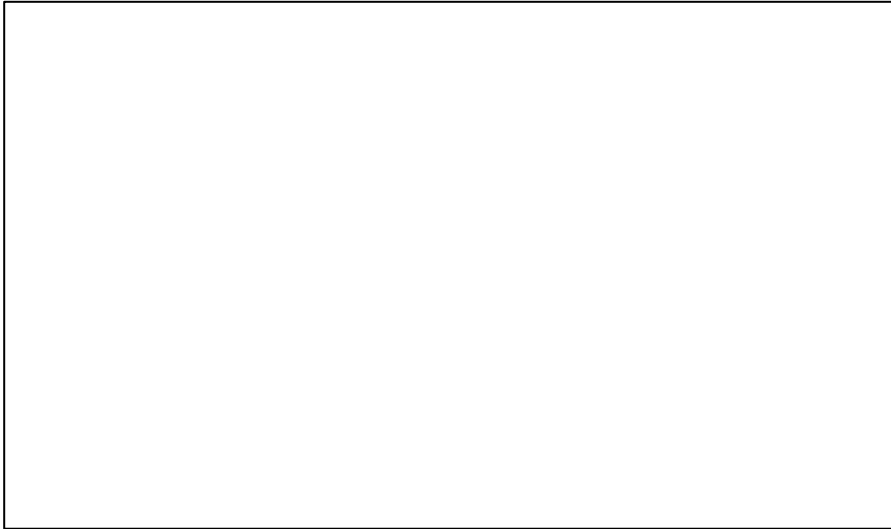
APPENDIX E

GRAPHIC ORGANIZERS FOR STATES OF MATTER AND CHANGES OF STATE TEXTBOOK
READINGS FROM TREATMENT UNIT 2: BOILING POINT

Graphic Organizer for textbook pp. 32-35

Topic:

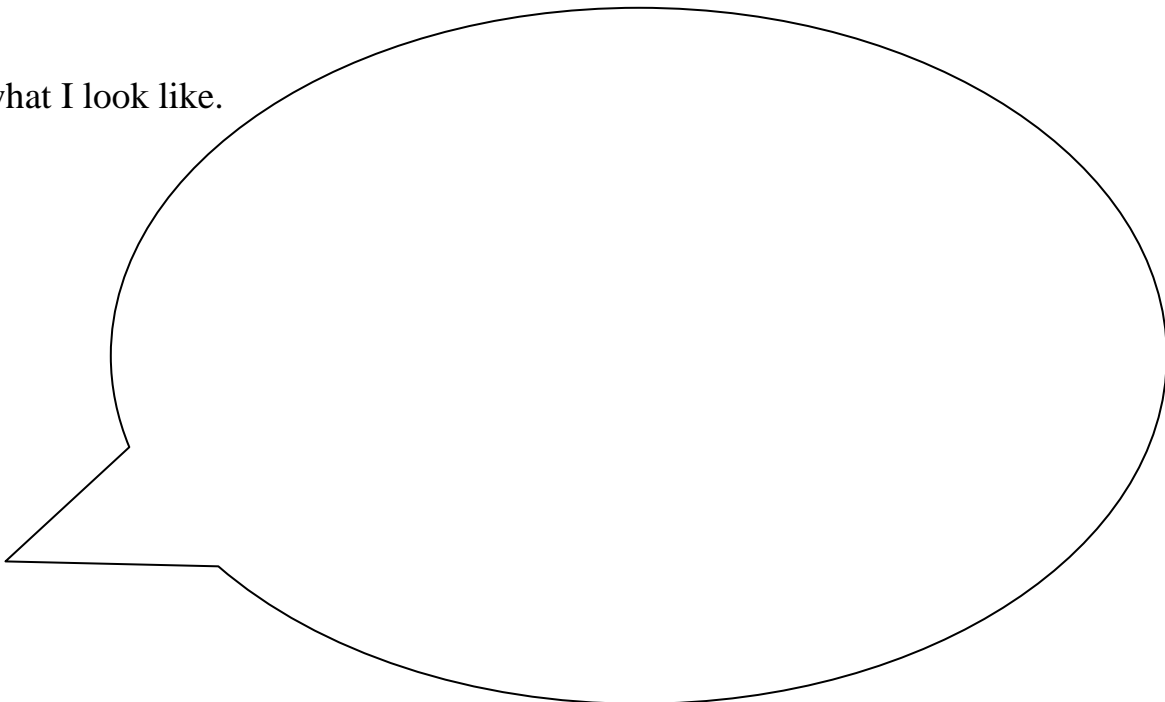
I am a solid. What are my characteristics?



Draw what I look like.

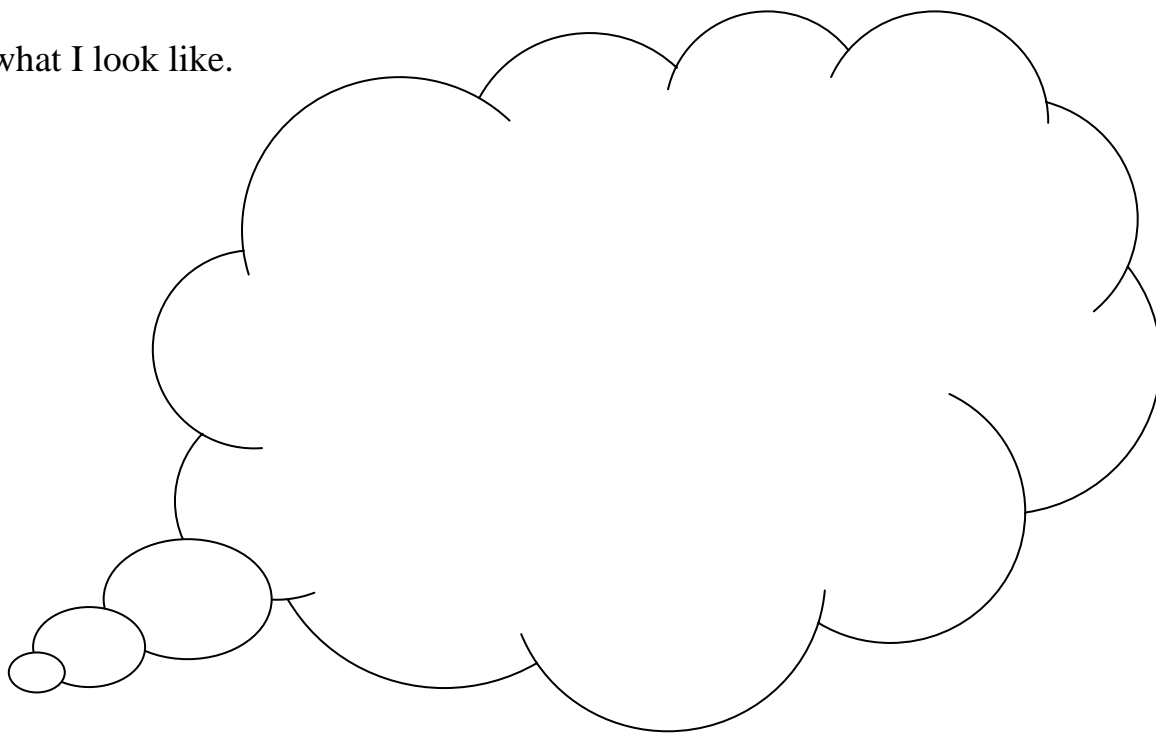
I am a liquid. What are my characteristics?

Draw what I look like.



I am a gas. What are my characteristics?

Draw what I look like.



Summary:

Name: _____

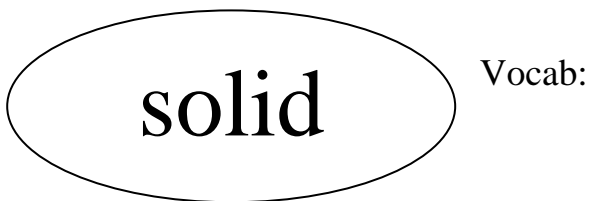
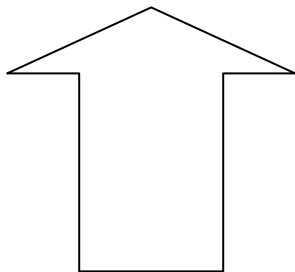
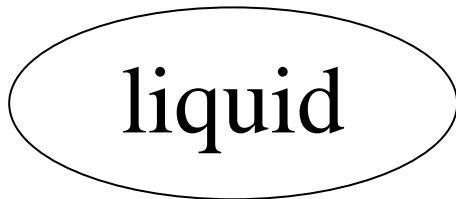
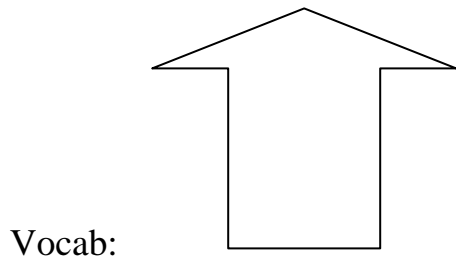
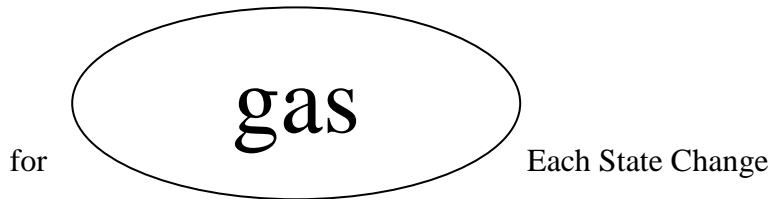
Number: _____

Topic:

is about...

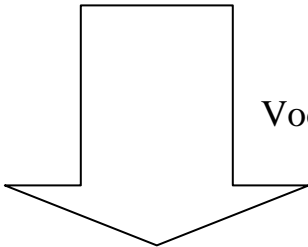
Graphic Organizer for textbook pp. 40-45

Facts About Energy and Particles



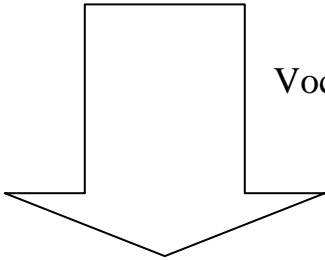
Facts About Energy & Particles for Each State & Change:

gas



Vocab:

liquid



Vocab:

solid

Summary:

It is important for me to learn about this topic because....

APPENDIX F

FLINKER SCAFFOLDED LABORATORY ASSIGNMENT FOR TREATMENT UNIT 1:
BUOYANCY

Group Members' Names: _____

FLINKER: Making an object NEUTRALLY BOUYANT (SCAFFOLDED FOR LOW-ACHIEVING STUDENTS)

Objectives: Today you will make adjustments to the mass and/or volume of a given object until the object becomes neutrally buoyant.

You will collect data using a provided data collection table.

Using this document and PhotoBooth, you will also document the steps of your experiment and your reasoning behind these steps through writing and photos.

Directions:

Step 1: a. What are two ways you know when an object will sink and when it will float?

□

□

b. What is the formula for calculating the density of an object?

Step 2: In PhotoBooth, take a photo of the materials you will be using in this experiment. Drag and drop your photo into the box on the left. Next, list the materials in your photo in the text box on the right.

Step 2 Photo: Materials being used in this experiment

Step 2 Written: The materials being used in this experiment are...

Step 3: a) Complete column one in the chart below. **You will also use this chart for steps 4-8** to keep track of your tries at making your object neutrally buoyant. b) Take a photo of your group member as he or she finds the mass and the volume of the object. Drop the photos into the boxes below. Also take a photo of just the object.

	Original Object	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
mass (g)									
Volume (mL)									
Density (g/mL)									
Sink or float?									

Step 3 Photo: Finding the mass

Step 3 Photo: Finding the volume

Step 3 Photo: The Original Object



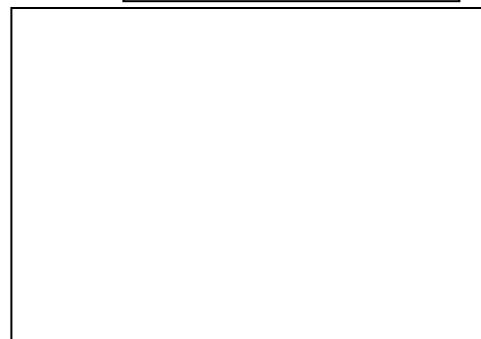
Step 4: Now, decide what your first **small** change will be towards making your object neutrally buoyant. Explain your change, reasoning, and result in the text box on the left. (Remember to record your results under trial 1 in the data table above.) Next, take a photo of trial 1.

Written: The first change we made to our original object was....

The reason we made this change was....

Our result was...

Step 4 Photo: Trial 1



Step 5: Most likely, your object is not yet neutrally buoyant. Make another **small** change and document your change, reasoning, and result with written text, data in the data table, and a photo.

Written: The second change we made was....

The reason we made this change was....

Our result was...

Step 5 Photo: Trial 2

Step 6: Continue with this same procedure until your object becomes neutrally buoyant. Document your trials as explained in steps 4 & 5 using the table. **Remember to record your data in the data collection table on page 2!**

The change we made was	The reason we made this change was	Our result was

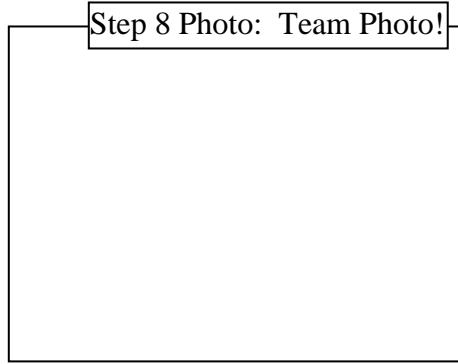
Step 7: Record the final result of your experiment. If your team did not get your object to become neutrally buoyant, explain what your next step would have been if you were to continue the experiment.

Written: The final result of our experiment was....

If we were to continue our experiment, we would.....

Step 7 Photo: Final Result

Step 8: Take a photo of the group members you worked with to complete this experiment.
Good job team!



Name: _____

Number: _____

FLINKER: Making an object NEUTRALLY BOUYANT (SCAFFOLDED FOR MIDDLE-ACHIEVING STUDENTS)

Objectives: Today you will make adjustments to the mass and/or volume of a given object until the object becomes neutrally buoyant.

You will collect data using the data collection chart below.

Using this document and PhotoBooth, you will document the steps of your experiment and your reasoning behind these steps through writing and photos.

DATA COLLECTION

Original Object	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8

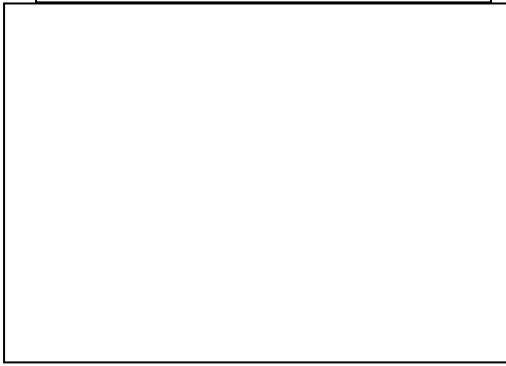
Written/Visual Documentation of Experiment

Picture 1: Materials used in this experiment

Write an explanation of what you captured IMMEDIATELY AFTER taking the photo. Justify your step by writing your reasoning.

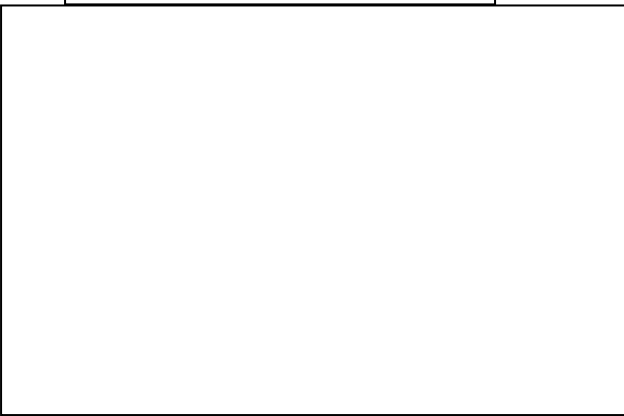
Picture 2: Original Object

Picture 3: Finding the mass

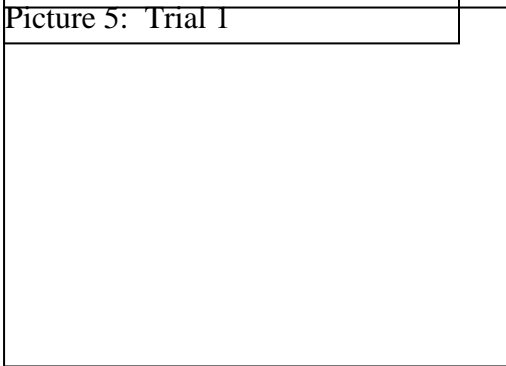


Write an explanation of what you captured IMMEDIATELY AFTER taking the photo. Justify your step by writing your reasoning

Picture 4: Finding the volume



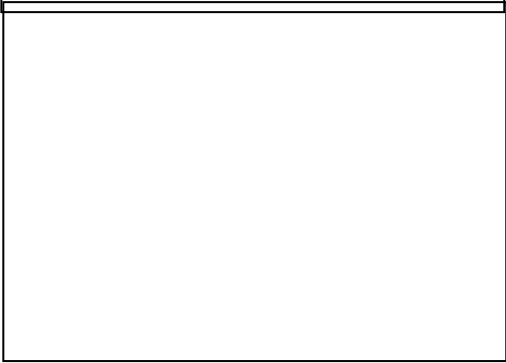
Picture 5: Trial 1



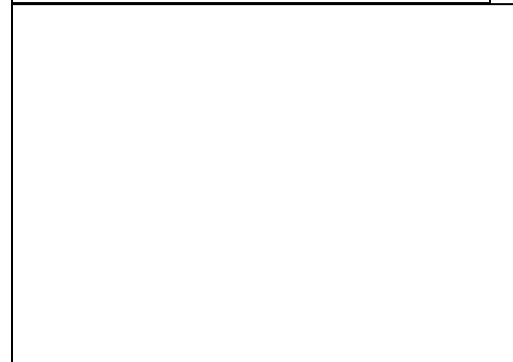
Picture 6: 1st Adjustment we made



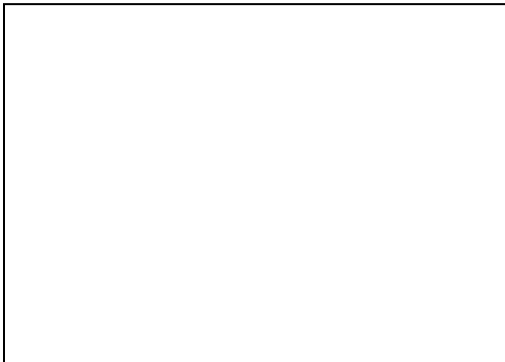
Picture 7: 2nd Adjustment we made



Picture 8: 3rd adjustment we made



Picture 9: 4th adjustment we made



Picture 10: Final Result



Picture 11: Our Lab Group



Group Members'

Names: _____

FLINKER: Making an object NEUTRALLY BOUYANT (UNSCAFFOLDED FOR HIGH-
ACHIEVING STUDENTS)

Objectives: Today you will make adjustments to the mass and/or volume of a given object until the object becomes neutrally buoyant.

You will collect and record data in a table that you create.

You will document the steps of your experiment and your reasoning behind these steps through writing and photos.

Written Parts:

1. A data table that neatly records the data collected
2. Explanations of what is in each photo
3. Explanations of your reasoning for each adjustment
4. Summary of your final results.

Photos:

1. All materials used in the experiment
2. The original object by itself
3. Measuring the mass and volume (1-2 photos)
4. Each alteration made to the object (4-6 photos)
5. The final result
6. A team photo

*Suggestion: Insert a textbox outlined in black. Drop each photo into the textbox.

APPENDIX G

TIME TO BOIL LABORATORY ASSIGNMENT SCAFFOLDED FOR LOW, MIDDLE, AND HIGH-ACHIEVING STUDENTS FOR TREATMENT UNIT 2: BOILING POINT

Group Members' Names: _____



Time to Boil: (SCAFFOLDED FOR LOW-ACHIEVING STUDENTS)

Objective: Today you will figure out if water's volume affects its boiling point.

You will collect data of the boiling point (temperature boiling begins) for at least 3 different volumes of water.

You will collect data of the time it takes to reach the boiling point for at least 3 different volumes of water.

Hypothesis/Prediction: Make a prediction by choosing one of the following statements.

- I think that the volume of water (having more or less of it) **will not affect** at what temperature it boils (boiling point)
- I think that the volume of water (having more or less of it) **will affect** at what temperature it boils (boiling point).

Review of Activity One

Water changes from liquid → gas at _____ °C.

This is called water's _____



Activity Two: Does volume affect Boiling Point?

Step 1- Volume:

Today's experiment will see if a liquid's volume affects the temperature that it boils (Boiling Point).

Reminders:

- Volume is... _____.
- Units for volume of a liquid..._____.
- Draw and name the measuring tool used to find the volume of a liquid

Step 2- Materials: The materials you will use for this lab are on your table. You will also be bringing your beakers of water to the hot plate watched by Ms. Scardino at the front of the room. Draw the materials you will be using.

Step 3- Methods & Procedures: Now you will begin the experiment!

Your team will heat different *volumes* of water in beakers using the hot plate in the front of the room.

You will use the stopwatch to time how long it takes each volume of water to reach its *boiling point*.

Your team will use the data table in Step 4 to record the data you collect.

Check off each step as it is completed.

- a) Use the graduated cylinder to measure 50mL of water from the sink.
Carefully pour this water into one of the beakers.
- b) Use the graduated cylinder to measure 200mL of water from the sink.
Carefully pour this water into the other beaker.
- c) Choose a member of your team to be in charge of the stopwatch. This person will be the timer.
Write this person's name here: _____

Please read before continuing: Just like in the previous experiment, the timer will tell your team every time a minute has passed. When each minute is called, you will send one of your team members up to observe the two beakers on the hot plate. This observing team member will report back the temperature of the water and whether or not it is boiling.

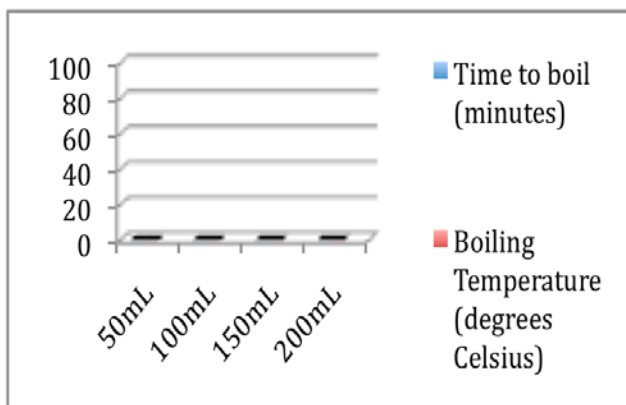
- d) Carefully bring the two thermometers and the two beakers up to the hot plate, then return to your table. Tell the timer to start the stopwatch.
- e) Record the temperature of the water at each minute and highlight whether the water has reached its boiling point

Temperature (°C) / Boiling? (Yes/No)															

- f) Once you have a free beaker, use the graduated cylinder to measure 150mL of water from the sink. Carefully pour this water into the free beaker and bring it to the hot plate.
- g) Once you have a free beaker, use the graduated cylinder to measure 100mL of water from the sink. Carefully pour this water into the free beaker and bring it to the hot plate

Step 4- Data Collection: Use the data table below to summarize your group's information from above. (Right click on the graph and click "edit data" and input your values to complete the graph)

Time and Temperature of Boiling Water



Amount of water (VOLUME)	Temperature at which water boiled (BOILING POINT)	Time it took to heat the water to the boiling point (TIME in minutes)
50mL		
100mL		
150mL		
200mL		

Step 5- Conclusion:

- At what temperature does water boil?
- How does the data you collected in your experiment support or disprove your original prediction? Was your original prediction correct?
- In your own words, summarize what you learned from today's experiment.

Challenge Questions:

- * Do you think that volume will or will not have an effect on the boiling point of liquids other than water? Explain.
- * Are there other factors besides volume that have an effect on the boiling point of a liquid?
- * What is another variable about boiling you would like to investigate? Explain why you would like to investigate that. Design an experiment that you could do to investigate that variable.

Group Members' Names: _____

Time to Boil (UNSCAFFOLDED FOR HIGH-ACHIEVING STUDENTS)

Objective: Today you will figure out if water's volume affects its boiling point.

You will collect data of the boiling point (temperature boiling begins) for at least 3 different volumes of water.

You will collect data of the time it takes to reach the boiling point for at least 3 different volumes of water.

Requirements:

- 1) **SUMMARY OF PREVIOUS LAB:** Write a brief summary of what you learned from the previous lab about *changing states of matter*.
- 2) **HYPOTHESIS:** An initial hypothesis/prediction of whether you think water's volume (the amount of water you have) will affect its boiling point and your reasoning for this prediction.
- 3) **EXPERIMENT:** An outline of an experiment that will test this hypothesis meeting the objectives above. (Can only have two beakers on the hot plate at one time)
- 4) **MATERIALS:** A list of the materials needed to complete your experiment.
- 5) **DATA TABLE:** A table that organizes the data you collect from your experiment meeting the objectives above.
- 6) **GRAPH:** A graph that visually represents the data from your table. (Suggestion: Go to "insert" then "chart" and choose an appropriate graph for your data)
- 7) **CONCLUSION:** An explanation of whether your data supports or disproves your initial hypothesis/prediction. Please also include a summary of what you learned from your experiment. Lastly, explain any real-world applications you can think of that relate to this scientific fact.
- 8) **CHALLENGE QUESTIONS:**
Do you think that volume will or will not have an effect on the boiling point of liquids other than water?
Are there other factors besides volume that have an effect on the boiling point of a liquid?
What is another variable about boiling you would like to investigate? Explain why you would like to investigate that. Design an experiment that you could do to investigate that variable.

Group Members' Names: _____

Time to Boil (SCAFFOLDED FOR MIDDLE-ACHIEVING STUDENTS)

Objective: Today you will figure out if water's volume affects its boiling point.

You will collect data of the boiling point (temperature boiling begins) for at least 3 different volumes of water.

You will collect data of the time it takes to reach the boiling point for at least 3 different volumes of water.

Hypothesis/Prediction: Make a prediction by choosing one of the following statements.

- I think that the volume of water (having more or less of it) **will not affect** at what temperature it boils (boiling point) because...
- I think that the volume of water (having more or less of it) **will affect** at what temperature it boils (boiling point) because....

Review

a) Define **boiling point** and explain what you learned about it in the previous lab.

b) Define **volume** and explain what you know about it from previous lessons and experiments.

Materials: The materials you will use for this lab are on your table. You will also be using the hot plate watched by Ms. Scardino at the front of the room. Record these materials on the lines below.

_____ (1) hot plate _____

Please read through the **methods** and **data collection** sections before beginning your experiment.

Methods:

*Your team will **heat at least 3 different volumes of water** in beakers using the hot plate in the front of the room. (You are only allowed two beakers on the hot plate at the same time.)

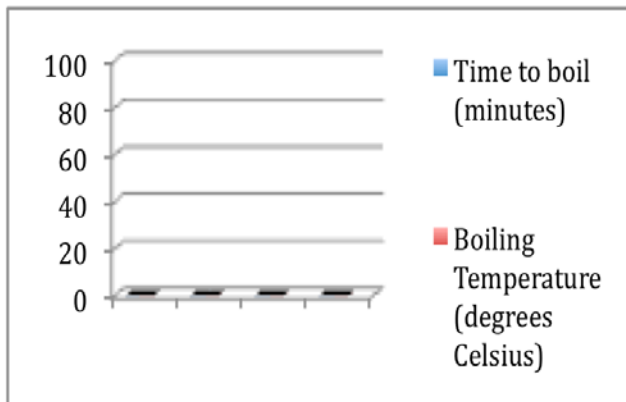
*You will use the stopwatch to **time how long it takes each volume of water to reach its boiling point.**

*Your team will **fill in the data table in Step 4** to record the data you collect.

*Just like in the previous experiment, the timer will tell your team every time a minute has passed. When each minute is called, you will send one of your team members up to observe the two beakers on the hot plate. This observing team member will report back the temperature of the water and whether or not it is boiling.

Data Collection: Use the data table below to summarize your group's information from above.
(Right click on the graph and click "edit data" and input your values to complete the graph)

Time and Temperature of Boiling Water



Volume of water	Boiling Point	Time it took to heat water to boiling point

Conclusion:

- At what temperature does water boil?
- How does the data you collected in your experiment support or disprove your original prediction?
Was your original prediction correct?
- In your own words, summarize what you learned from today's experiment.

Challenge Questions:

- * Do you think that volume will or will not have an effect on the boiling point of liquids other than water?
Explain your reasoning.
- * Are there other factors besides volume that have an effect on the boiling point of a liquid?
- * What is another variable about boiling you would like to investigate? Explain why you would like to investigate that. Design an experiment that you could do to investigate that variable.

APPENDIX H

RUBRIC FOR LEARNING PROFILE ALTERNATIVE PRODUCTS

Name: _____

Density Review and “Some Like it Salty” Demonstration of Learning**Directions:** You will have 45 minutes to design a presentation that answers the following questions:

- 1) What did we already learn about density that we applied in this “Some Like it Salty” experiment?
- 2) What new idea(s) did we learn from this “Some Like it Salty” experiment?

Presentation Rubric

	4	3	2	1
Content	Clearly explains all necessary information and procedures. Includes appropriate facts and details.	Explains most necessary information and procedures. May include appropriate facts or details.	Explains information and procedures. May leave out, key information. Missing important scientific facts or details.	Does not explain information and/or procedures. No scientific facts or details.
Vocabulary	Appropriately uses relevant scientific vocabulary.	Appropriately uses some scientific vocabulary.	Uses scientific vocabulary. Words may be used incorrectly.	No scientific vocabulary used.
Understanding	Demonstrates a full understanding of density applied to Some Like it Salty.	Demonstrates a partial understanding of density applied to Some Like it Salty.	Slight understanding of density applied to Some Like it Salty is demonstrated.	Misunderstanding or no understanding of density demonstrated.
Presentation	Engages/interests audience.	Mostly engages /interests audience.	Somewhat engages/interests audience.	Audience not at all engaged or interested.
Group Participation	All group members participated. Group planning sheet completed fully.	Most group members participated. Group planning sheet completed mostly.	A few group members participated. Group planning sheet somewhat completed.	One group member did everything.. Group planning sheet not completed.

Group Planning Sheet

Group Members' Names:

Type of Product (Circle): Song Data Analysis Real-life Example Skit Speech Cartoon

Step 1: Brainstorm (5 minutes)

Step 2: Project Outline/Timeline

Step 3: Group Members' Responsibilities

Name: _____

“Changing States of Matter Lab” Demonstration of Learning**Directions:** You will have 30 minutes to design a presentation that answers the following questions:

- 1) What did we already know about the properties of solids, liquids, and gases that helps us explain what happened in the lab?
- 2) What important scientific concepts did we see in this experiment?

Presentation Rubric

	4	3	2	1
Content	Clearly explains all necessary information and procedures. Includes appropriate facts and details.	Explains most necessary information and procedures. May include appropriate facts or details.	Explains information and procedures. May leave out, key information. Missing important scientific facts or details.	Does not explain information and/or procedures. No scientific facts or details.
Vocabulary	Appropriately uses relevant scientific vocabulary.	Appropriately uses some scientific vocabulary.	Uses scientific vocabulary. Words may be used incorrectly.	No scientific vocabulary used.
Understanding	Demonstrates a full understanding of changing states of matter applied to Boiling Point Lab.	Demonstrates a partial understanding of changing states of matter applied to Boiling Point Lab.	Slight understanding of changing states of matter applied to Boiling Point Lab is demonstrated.	Misunderstanding or no understanding of changing states of matter demonstrated.
Presentation	Engages/interests audience.	Mostly engages /interests audience.	Somewhat engages/interests audience.	Audience not at all engaged or interested.
Group Participation	All group members participated. Group planning sheet completed fully.	Most group members participated. Group planning sheet completed mostly.	A few group members participated. Group planning sheet somewhat completed.	One group member did everything.. Group planning sheet not completed.

Group Planning Sheet

Group Members' Names:

Type of Product (Circle): Song Data Analysis Real-life Example Skit Speech Cartoon

Step 1: Brainstorm (5 minutes)**Step 2: Outline (script, lyrics, basic sketch of idea, etc)****Step 3: Group Members' Responsibilities**

APPENDIX I

TREATMENT UNIT 1: TIERED HOMEWORK ASSIGNMENET

Name:

Date:

Some Like it Salty Questions HW3

Directions: Thinking about what you've learned from today's "Some Like it Salty" Experiment, answer any 4 questions from the list below.

Level 1	<ol style="list-style-type: none"> 1. Describe what happened at the end of today's experiment. 2. Which of the following statements is true? <ol style="list-style-type: none"> A. The more salt you add to a beaker of water, the greater the water's density becomes. B. The more salt you add to a beaker of water, the less the water's density becomes. 3. What could have happened if a team started with 1000mL of water?
Level 2	<ol style="list-style-type: none"> 4. How was this experiment similar to last week's "Sink or Float" lab? How was it different? 5. Thinking about what you've learned from today's experiment, what questions would you ask someone who was going scuba diving? 6. Do you know another instance where adding more mass affects the density of a substance?
Level 3	<ol style="list-style-type: none"> 7. Can you create a new and unusual use for what you've learned? 8. What would happen if you used another liquid instead of water in this experiment? 9. Is there a better way of making the egg float instead of adding salt?

APPENDIX J

STUDENT WEEKLY JOURNAL PROMPTS

Student Weekly Journal Prompts

- 1) What was the major topic of today's lesson? Explain what you learned about this topic.
- 2) Which activity or assignment from today's lesson helped you understand the new information best? Briefly explain why.
- 3) What is one thing you want to know or don't understand that relates to today's topic? Briefly explain why.

APPENDIX K

PREUNIT AND POSTUNIT STUDENT INTERVIEW QUESTIONS

Nontreatment Pre and Postunit Student Interview Questions

- 1) Define density.
- 2) Given the following word bank terms, create a concept map that shows the relationships between the terms. Be able to explain the reasoning behind the way you connect the terms. You may add extra terms to your map if you would like.

density, matter, size, volume, mass, grams, milliliters, physical property, characteristic property, weight
- 3) Give an example of an experiment you could do to demonstrate density to a person who did not understand the definition.
- 4) Why is it important to learn about density?
- 5) What was the hardest part of the unit? Why?
- 6) What was the easiest part of the unit? Why?
- 7) What part of the unit did you find the most meaningful or enjoyable? Why?
- 8) Is there anything else you'd like to tell me? Is there a question you think I should have asked? If so, what is the question and answer it please.

Treatment Unit 1: Buoyancy Pre and Postunit Student Interview Questions

- 1) Define buoyancy.
- 2) Given the following word bank terms, create a concept map that shows the relationships between the terms. Be able to explain the reasoning behind the way you connect the terms. You may add extra terms to your map if you would like.

buoyancy, neutrally buoyant, sink, float, density, mass, volume, characteristic physical property, formula, water
- 3) Give an example of an experiment you could do to demonstrate buoyancy to a person who did not understand the definition.
- 4) Why is it important to learn about buoyancy?
- 5) What was the hardest part of the unit? Why?
- 6) What was the easiest part of the unit? Why?
- 7) What part of the unit did you find the most meaningful or enjoyable? Why?
- 8) Is there anything else you'd like to tell me? Is there a question you think I should have asked? If so, what is the question and answer it please.

Treatment Unit 2: Boiling Point Pre and Postunit Student Interview Questions

- 1) Define boiling point.

- 2) Given the following word bank terms, create a concept map that shows the relationships between the terms. Be able to explain the reasoning behind the way you connect the terms. You may add extra terms to your map if you would like.

melting point, boiling point, state, solid, liquid, gas, characteristic physical property, evaporation, condensation, freezing, melt, energy

- 3) Give an example of an experiment you could do to demonstrate boiling point to a person who did not understand the definition.

- 4) Why is it important to learn about boiling point?

- 5) What was the hardest part of the unit? Why?

- 6) What was the easiest part of the unit? Why?

- 7) What part of the unit did you find the most meaningful or enjoyable? Why?

- 8) Is there anything else you'd like to tell me? Is there a question you think I should have asked? If so, what is the question and answer it please.

APPENDIX L

TEACHER ATTITUDE SURVEY

Teacher Attitude Survey

Survey Instructions: Read each statement carefully. Select a number from 1-5 to indicate the degree to which you agree or disagree with each statement below.

- | | |
|---|-------------------|
| 1 | Strongly disagree |
| 2 | Disagree |
| 3 | Uncertain |
| 4 | Agree |
| 5 | Strongly agree |

	1	2	3	4	5
1. I felt fully prepared for today's lesson. (Preparation Time)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Planning for today's activities took a reasonable amount of time. (Preparation Time)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. The students worked harder than I did today. (Teaching Methods)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. My teaching methods were effective to help students learn new content. (Teaching Methods)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. I was a sage on the stage. (Role)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. I was a guide on the side. (Role)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Today's instruction was enjoyable for me. (Attitude)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. I would not have minded if an administrator or visitor had been present in my room today. (Attitude)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. I will use the same or similar activities in future lessons as used today. (Motivation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. I would teach this lesson over again with minimal to no alterations. (Motivation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

National Science Foundation. (n.d.) *OERL: Teacher education instruments*. Retrieved from <http://oerl.sri.com/instruments/te/teachsurv/instr49.html>

APPENDIX M

TEACHER JOURNAL PROMPTS

Teacher Journal Prompts

- 1) (Preparation Time) Planning for today's activities did/did not take a reasonable amount of time. Explain
- 2) (Teaching Methods) My teaching methods were/were not effective to help students learn new content. Explain.
- 3) (Role) One a scale of 1-10 (1= fully sage on the stage and 10= fully guide by your side) indicate my overall role in today's lesson. Explain.
- 4) (Attitude) Today's instruction was/was not enjoyable for me. Explain.
- 5) (Motivation) I would/would not teach this lesson over again with minimal to no alterations. Explain.
6. Are there any other things that come to mind today?

APPENDIX N

TEACHER PLANNING LOG

APPENDIX O

PROJECT TIMELINE

Project Timeline

- January 3: Analyze standardized test reading scores & Get parental permission
- January 5: Give student learning profile survey
- January 6: Nontreatment pretest
- January 6 & 7: Nontreatment preunit interviews
- January 13: Introduce matter- unscaffolded textbook reading with questions
- January 17: Physical Properties Lab
- January 18: Wat-ar Densities Lab & Student Journal
- January 19: Volume measurement lab
- January 20: Density practice, video, and discussion & Student Journal
- January 21: Oranges lifejacket lab
- January 24: Post it notes lab
- January 25: Test Review & Student Journal
- January 26 Density Test
Nontreatment Unit postinterviews & Treatment Unit 1 preinterviews
- January 27: Nontreatment Posttest
Treatment Unit 1 Pretest
Sink or Float Lab
Nontreatment Unit postinterviews & Treatment Unit 1 preinterviews
- February 7: Some Like it Salty
Assign tiered homework
- February 8: Learning Profile Alternative Lab Product
Student Journals
- February 9: Denser Sensor Lab
Assign tiered homework
- February 10: Test Review
Treatment Unit 1 postinterviews & Treatment Unit 2 preinterviews
Student Journals
- February 11: Sink or Float Test
Treatment Unit 1 postinterviews & Treatment Unit 2 preinterviews
Treatment Unit 1 posttest & Treatment Unit 2 pretest

February 14: Flinker Lab with readiness grouping and scaffolded instructions

February 15: Student Journal

February 17: Temperature and Density Lab

February 21: States of Matter- scaffolded textbook reading with questions
Student Journal

February 22: Make Room for Me Lab
Assign Tiered Homework

February 23: Changes of State- scaffolded textbook reading with questions
Student Journal

February 24: Oobleck Making Lab

February 25: Oobleck Testing Lab

February 28: Boiling Point Lab
Assign Tiered Homework

March 1: Learning Profile Alternative Lab Product
Student Journal

March 7: Time to Boil Lab with Readiness Grouping and Scaffolded Instructions
Assign Tiered Homework

March 8: Altitude and pressure

March 9: Mystery substances activity

March 10: Boiling Point Test

March 11: Treatment Unit 2 Posttest
Treatment Unit 2 Postinterviews

*Teacher reflection journal, teacher time-log, and teacher attitude survey daily throughout
End Project Implementation: March 11, 2011