THE EFFECT OF INCORPORATING THE SCIENCE WRITING HEURISTIC APPROACH TO INQUIRY ACTIVITIES IN A HIGH SCHOOL SCIENCE CLASSROOM

by

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

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ABSTRACT

Students often come to a high school science classes without the skills they need to be successful in an inquiry based science class. These skills include the ability to write about science procedures and findings, read about and connect science content, and work collaboratively through science inquiry processes. This research used the Science Writing Heuristic to provide students with a template for inquiry based activities. With the SWH, students worked collaboratively on in inquiry based activity and then wrote about the science they did including procedures, observations, data, and results. Students then compared their findings with the findings of other groups. They used this information to make a claim about the content and supported the claim with evidence or data. Students were then asked to make a connection between the content and the activity through a reading assignment that explained the concept further, described a model of the content, or was a real-world application of the content. The goal of SWH was to improve students' understanding of science by reading, writing and collaborating about science. After a nine week pre-treatment and treatment phase data was collected to compare the skills students had gained and to determine if their understanding of science content had improved. Various methods were used to collect and analyze data including student surveys, field notes with observations about student collaboration, exam, quiz and lab grades, and a teacher reflective journal. Based on the data gathered, the students' ability to collaborate improved and they learned more through guided collaborative work. Student quiz grades did not change based on the SWH template, but exam grades did improve. The reading component of the SWH template did not produce the results I expected and students did not relate the reading to any of the content questions and many students did not read the assignments. In conclusion, the SWH approach provided me with information I can use as a teacher in the future. Despite the approach not being a complete success, parts of it can be used to help increase the skills students need to be successful in a science classroom.

INTRODUCTION AND BACKGROUND INFORMATION

There seems to be a consensus among my colleagues that students are coming to high school less and less prepared with the skills they need to be successful in a classroom. This is also something that many of us hear in the media when it comes to students' readiness for college and the workforce. According to Kelsey Sheehy from the US News and World Report, in 2012 over 1.7 million students took the ACT exam. ACT reports, "Only 31% of the students demonstrated the level of science expertise needed to succeed in entry level college courses and more than a quarter fell short of college readiness benchmarks set by ACT for all four subject areas" (US News and World Report online, 2012). The same holds true for outcomes related to the SAT exam. According to Ben Wolfgang from the Washington Times, "SAT reading scores have plummeted to the lowest level in over four decades" (Washington Times online, 2012). It was reported that "57% of students taking the SAT in 2012 did not clear the tests 1550 point college and career readiness benchmark" (Washington Times online, 2012). As a high school teacher I find these numbers alarming and I see it as my responsibility to help students prepare for college and beyond.

Various programs have been instituted within the school I teach to help address this issue, but these programs seem to fall short because the content is taken out of context of the actual classroom. Programs such as AVID, (Advancement via Individual Determination) is one program that most definitely addresses skills students need in order to be successful. Reading, writing, inquiry, collaboration, and organization are the focus, and helping students purposefully learn how to best use these skills is the key component. Unfortunately all students are not exposed to the AVID strategies and instruction.

Currently only about 120 students of the 1600 plus students are enrolled in the AVID program. Northglenn High School will become a STEM (Science, Technology, Engineering, and Math) comprehensive high school in the fall of 2013, but will still remain a comprehensive neighborhood high school with about 85% free and reduced lunch and 65% Hispanic, many of whom are English language learners. The STEM focus will be problem-based learning, inquiry driven learning, and a trans- disciplinary approach. With this transition, the students will be expected to think on a much different level than they have in the past and work collaboratively to solve problems. As Northglenn High School began to make this transition during the 2012-2013 school year, it became even more apparent that students needed specific skills in order to be successful in the science classroom.

Preparing students for college and beyond has always been an important goal within my science classroom. I feel the science classroom is the perfect venue to be able to provide students with critical thinking skills, writing skills, inquiry skills, reading for understanding, and collaboration skills. The problem that arises with my goal is that many students need specific instruction in these skills in order to use them effectively. I wanted to find a way to teach my students these skills within the context of my high school science class so that it did not seem artificial to the students and it became part of the science classroom experience. My action research investigated what impact the Science Writing Heuristic (SWH) approach would have on the students. I wanted to see if this approach to learning science would provide students with these important skills within the context of my science classroom.

The Science Writing Heuristic (SWH) is an approach to science that breaks up a learning experience, whether it is a "cook book" type lab or an inquiry activity, into different sections, each of which provides opportunities for students to practice the previously mentioned skills. With an inquiry activity, there are beginning questions. This provides students an opportunity to develop their own questions, answer questions provided by teachers, or a combination of both. This helps access any previous knowledge and also provides a "hook" for the rest of the activity.

The next part of the SWH involves the activity or procedure. Students write down what they did in their own words. This is not a re-write of a procedure, but more of an informal explanation. The goal of this section is for students to understand the purpose behind the activity. Having students write about their experience helps the students to connect what they did with the "why." The next section is the observation. Here students describe what they saw or learned. Students discuss their observations and/or knowledge gained with other students. The goal is for students to become comfortable talking about science and using science language.

Next students are asked to make a claim. This requires critical thinking in order for students to link what they did, what they observed, and their data or answers to questions with a strong statement that can be supported with evidence. Students then read an article, text, or other source that relates the topic to the real-world or further explains the topic. Students are asked to read for understanding and then asked to write and discuss how the article related to the topic. The final stage of the SWH approach asks students to reflect on how all of the sections related to what they are currently doing in class, whether or not their previous ideas have changed, and/or what they learned from

the experience. In my action research I used the SWH approach throughout the school year to see what impact it had on students and me as a teacher.

Research Question:

My primary research question was: How does incorporating the Science Writing Heuristic (SWH) approach within a high school science class impact students?

Research Sub questions:

The main research question led to some additional sub-questions which are listed below.

1. How will the Science Writing Heuristic affect students' ability to work collaboratively?
2. How does the Science Writing Heuristic impact my students' ability to read science content and use that reading to answer questions about content, analyze data, and justify answers from a science activity in chemistry?
3. What are the effects of the Science Writing Heuristic on student understanding of science content as demonstrated on assessments?
4. How will the Science Writing Heuristic impact my teaching and evaluation of students?

CONCEPTUAL FRAMEWORK

Students often see science as these singular classes they take, and they do not see the connection between the different science classes they have taken and the world around them. One difficulty I have run into as a high school science teacher is that students often lack some of the skills necessary to access the science curriculum in a way that allows them to make connections between other science content and also the world

around them. By providing students with instruction and opportunities to use the skills they need, students will hopefully begin to see the connection and take a greater interest in science and begin to see success in their science class. In order to accomplish this task, I incorporated the use of the Science Writing Heuristic (SWH) approach to inquiry in my chemistry classes to see what impact this had on students and me as a teacher.

An important part of this process was a literature review. In order to gather information about the different topics my action research would explore and gather ideas for possible treatments and data collection methods, I performed a literature review. During this process I found a great deal of research on various topics related to my action research idea, some of which were very helpful, some not so much, and others that seemed to help me focus in on my topic. The research is expansive and this is just a small snapshot of information that guided my action research using the Science Writing Heuristic approach to inquiry.

My initial search was focused on information for WICR strategies (writing, inquiry, collaboration, and reading). The research on this was mostly limited to AVID (Advancement via Individual Determination) articles and the information seemed very biased towards the AVID program and was more informational. Despite AVID being a very successful program and the WICR strategies are AVID based, I wanted to find research that dealt specifically with writing, reading, inquiry, and collaboration in science classes and how to incorporate these into the science curriculum. Much of the research dealt with these strategies at the elementary level and also at the college level, and it was difficult to find research dealing with these strategies at the secondary level. While my literature review included a number of sources, I found two in particular that provided a

framework that I felt I could use in my action research, despite one being geared towards the elementary level and one towards the college level.

Reading comprehension is one skill most students need, so I wanted to see if there was research on explicit training in text comprehension and if this training would help students to better understand the content. Research around reading comprehension provided some views about what reading should be. One group of researchers viewed science reading as being descriptive, sequence oriented, compare-contrast, problem-solution, or causation (Williams, Stafford, Lauer, Hall, & Pollini, 2009). The research centered on ways to teach students how to read for each of these different purposes while still reading the science content. The different types of reading and strategies to teach these types of reading were explored. Students were given readings that were descriptive and they were asked to write about the descriptions. They were given readings that were sequence oriented, and they were asked to create a timeline. Students were given readings that were to compare and contrast, and students were asked to create a matrix or graphic organizer that demonstrated the compare and contrast aspect of the reading. Finally, students were given readings that required students to determine a problem and solution and the possible cause. Throughout this process students were instructed in what made each of the readings the specific type of reading. The authors' research mirrored the research of previous authors, who found,

> Students who were given explicit instruction about the structure recalled more information on an essay test than students who received more traditional instruction that included general comprehension questions and summation. They also showed that the students trained in text

> structure identified more main ideas, which indicated that the explicit instruction in structure facilitated the development of a well-structured mental representation (Anderson and Ostertag, 1997, p 2).

This research dealt with students at the primary grade level, and despite the difference in teaching high school students, I felt like this was information that would be helpful. Reading science content at the high school level still falls into these categories and it seems clear that students may need some additional skill in seeing these different categories and understanding writing in science for a purpose. This article helped me to think about the different types of reading I provide students and how to help them as they read for different purposes. It seems clear that students should be able to determine what the purpose of the reading is and by understanding the purpose, they might better be able to understand the content.

WICR (writing, inquiry, collaboration, and reading) skills are skills all students need in order to be successful in the science classroom and, the Science Writing Heuristic (SWH) approach to inquiry provides a way to incorporate all of these skills into a science classroom. Researchers in one study focused in on general chemistry classes at the college level, but I feel like the information provided is very applicable to high school students. This research used what is called a "science writing heuristic" in order to organize information gained in an inquiry or lab experience (Poock, Burke, Greenbow, & Hand, 2007). The science writing heuristic is a different approach to lab reports that is broken up into eight different parts. According to Poock et al. (2007), "The SWH approach helps students do inquiry science laboratory work by structuring the laboratory

notebook in a format that guides students to answer directed questions instead of using a traditional lab report format," (p. 1372).

I have always struggled with the traditional lab report format and was trying to find a way to use this in my action research in a more purposeful way. The SWH approach begins with beginning ideas where students explore what their questions are by writing them down and discussing them. Next students perform tests or experiments. Students then record their observations and more importantly record them so that the whole class can see the results everyone obtained. Next students make claims about their observations based on prior knowledge. Again they are writing this down and discussing it. Students provide evidence about their claims. Students then use readings or text to compare their ideas to the ideas of others. Following the reading students discuss how their claims and ideas might have changed or stayed the same. Finally, students independently write their best explanation for what they learned.

The SWH approach mentioned in this research incorporates all aspects of WICR in a very organized and systematic approach. Students are writing, students are using inquiry, students are working collaboratively together, and students are reading. The researchers in this study found, "Subjects who entered the course with a low level of beginning chemistry knowledge and who were taught with the SWH approach demonstrated a higher level of success in the course compared to students in previous years, with similar beginning chemistry knowledge and who were not taught with the SWH approach" (Poock et al., 2007, p. 1377). The researchers used pre and post test data and data from previous years in order to make these claims. After reading this research, I felt more focused on my action research purpose and questions and this

provided the framework I needed to move forward with a way to incorporate the skills I felt students needed, and I felt as if I had found a way to use this within science content in a way that did not take away from the science content.

As a teacher I understand the importance of reading and writing within all content areas, but convincing the students of this is very difficult. I often hear the comment, "Why do we have to write in complete sentences in science? It's not English class?" Students do not see science as science truly is; "An area of study where communicating your ideas and thoughts through writing, speaking, and collaborating with others is fundamental" (Hapgood & Palincsar, 2007, p 57). This article discussed the importance of building literacy in a science classroom. The authors of this article explain how a science class that is inquiry based "can provide a rich context in which to build language skills" (Hapgood & Palincsar, 2007, p. 56). They discuss how literacy and science intersect when students are using reading, writing and oral language to answer questions about science content. Hapgood and Palincsar (2007) also discuss how all of this can lead to, "an increased capacity to engage in scientific reasoning" (p. 56).

As I looked at my action research topic and the various ways I could collect data I realized how important it would be to collect various types of data and to analyze the data so that I could determine if my treatment methods were justified or if they needed to be modified. When I began my literary search for articles that were research based and connected to my action research topic, I initially became frustrated. Most of the research was done using elementary students and the classroom situations were nothing like mine. I was finally able to find a few articles that looked into my topic more closely, but used

the Science Writing Heuristic approach which is very similar to WICR, but more oriented towards science only, where WICR is transferable to all content areas.

The implementation of the science writing heuristic approach (SWH) to science was something I had never heard of, and I wanted to find ways to use this approach within my class, but I wanted to make sure data could be collected to analyze its effectiveness. One group of researchers used a summary writing test to evaluate student performance on the content they were studying. Students were asked to explain in writing to their friends what they knew about the content. Students were given one class period to write. The writing test was scored using four domains, "big idea, science concepts, argument, and writing" (Nam, Choi, and Hand, 2011). A scoring framework or rubric was used to score the writing test. Each of the components and subcomponents were divided into points and the writing was scored based on whether or not students discussed the topics in their writing. In order to compare data, teachers used the SWH approach on all but one class. One class was a control group. In all of the cases the groups that utilized the SWH approach as an instructional strategy performed better on the writing test. This article had a great deal of information, but what I found very interesting was that a school in another country also had similar concerns that I have and used a similar approach.

Student attitudes and beliefs regarding this approach were used to analyze effectiveness of the SWH approach to learning science. Student data was collected through laboratory notebooks and also attitude surveys using a Likert-type scale (Putti, 2011). The student attitude survey addressed issues such as whether or not the lab reports increased understanding, whether or not the pre-lab and post-lab discussions helped with

understanding of the concepts, and whether or not the reading and reflection part helped tie the material to concepts learned in class (Putti, 2011). Students responded with strongly agree, agree, disagree, strongly disagree, or no response. Putti then combined these responses into one of three categories, strongly agree and agree, strongly disagree and disagree, and no response (2011). According to Putti, "The results indicated that students had a belief that the SWH improved their conceptual understanding of the experiments" (2011, p. 520). This article was helpful as I tried to answer the question about whether or not the students feel the treatment was beneficial.

Data collection which utilized a science chemistry content exam to see what students understood was also used as a data collection method. The questions on the exam were multiple choices, but they required a deeper understanding of the content in order to answer them. Guzzetti and Bang (2010) used literacy based science instruction to encourage students to "link the literacy skills of reading, writing, listening, and speaking" (p. 45). These researchers used alternative texts and readings to drive their science instruction. They did this with all but one of their classes and used that class as a control group. Students in the test group were taught chemistry topics using a forensic science type unit that required more writing and reading. Students were asked to discuss the topics and worked collaboratively through the lessons. At the end of the unit both groups were given a post test and also a survey about their attitudes and thoughts on the unit. The students who took part in the literacy driven lesson did much better on the exam than the control group and their overall attitude was a positive one. This article provided me with another way to collect data, using a pre-test and post-test along with a survey in order to gain information about what students understood.

The literary review proved to be very helpful. I know there are a great deal more resources available, but this process helped me to focus in on my research topic a bit more. The literary review process also provided some insight on data collection and analysis. Guzetti and Bang (2010) provided a sample pre/posttest that was multiple choice, but specifically tested for a higher level of understanding. The literary review also provided me with some different survey options and how to collect and analyze the data. As I finished up the action research and data collection I began looking for additional literature on this subject to see if this approach to inquiry teaching is also something that will fit in with our new Science, Technology, Engineering, and Math focus.

The literary review also provided me with information that affirmed my reasoning for this action research. The information reviewed demonstrated a need for literacy in the science classroom and this should include reading, writing and discussion. As our school district and state move towards adopting the Common Core Standards and the Next Generation Science Standards, this action research literature review should provide useful information that I can use to meet the needs of those standards. These standards all have a much larger writing and reading and critical thinking component and my hope is that my action research will demonstrate how these concepts can be incorporated into a traditional science classroom and provide students with the skills they need to be successful science students.

METHODOLOGY

Treatment

In order to address the skills students need to be successful within a science class, I used the Science Writing Heuristic (SWH) approach for all lab experiences and inquiry activities within my sophomore level chemistry classes at Northglenn High School. Northglenn High School is located about fifteen miles north of Denver, Colorado. Northglenn High School is one of five high schools within the Adams Twelve school district. The school district has about 38,000 students with varied socioeconomic differences between schools. Northglenn High School is the second oldest high school within the district and during the eighties and early nineties was considered a "flagship" school for Northern Denver. As the district grew and new high schools opened, the demographics of Northglenn High School also changed. The current enrollment fluctuates between about 1600-1800 students with about 85% free and reduced lunch, 65% Hispanic, and about 20% English Language Learners. The fluctuation in enrollment is due to a large mobility rate. Many student choice into Northglenn High School from out of district because they have been expelled from their home schools, other students move, return, move again, and some students leave for lengths of time to go to Mexico with their families and then return at some point during the school year.

The classes involved in the treatment consisted of students who were required to take chemistry. Students in these chemistry classes had a varied math background including pre-Algebra, all the way to Calculus. Some students were considered "college bound" and others were taking the class because they were required to in order to meet district curriculum scope and sequences. The chemistry classes included students on

individual Education Plans (N=3), 504 plans (N=2), as well as English Language Learners (N=18). Other students within these classes were in special reading classes (N=8) as well as students who were labeled as gifted and talented (N=16).

The three classes used for the treatment were spread throughout the day and included a period one, period three and period seven class. Students were placed into groups of four and remained in these groups during the pre-treatment and treatment phase. I used our Infinite Campus Grading System to randomly generate a seating chart for each class. Each class began the year with 32 students each, but the numbers varied and by the beginning of the treatment, period one had 24 students, period three had 26 students, and period seven had 25 students. At the end of the nine week session these numbers had not changed. 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 (Appendix A).

The science writing heuristic approach (SWH) takes a lab or inquiry activity and makes it about the learning of the content by utilizing reading, writing, collaboration, and reflection. When using the SWH approach as a treatment within my classroom, labs and learning activities were completed using an inquiry based approach where students did the lab or activity prior to learning the content utilizing the SWH template. These activities took anywhere from one class period to two or even sometimes three class periods. The SWH approach provided students with a system to use as they went through an inquiry activity or laboratory activity. The SWH template I used was based on the work by Keys, Hand, Vaughn, and Collins (1999). Their template was based towards the post-secondary student, but I was able to modify their template in order to work within

the time constraints and abilities of my students. Students needed to learn how to use this approach as it was so different from many of the traditional teaching methods they were accustomed to.

The SWH template contains both a teacher and student component. The teacher component consists of eight different phases and describes what the teacher's role is in getting the students ready for the activity (See Appendix B). The first phase for the teacher explores pre-instruction understanding. During this phase I came up with prompt questions to use as a warm-up in order to look for any misconceptions students had and to gauge their current level of understanding.

The next phase looks at pre-lab activities. Because not all of my activities consisted of just labs, I came up with informal writing activities, brainstorming activities, and question posing activities the students would use. The third phase is the planning of the actual activity. In order to accomplish this phase, I came up with the different inquiry activities students would be using throughout the unit and treatment time period. The fourth phase is the Negotiation Phase I and describes how students will write personal meanings for their learning activity. I planned out how students would write about what they did and created a way for students to be able to do this within the science notebooks they had been using all year long.

The fifth phase is the Negotiation Phase II and includes finding a way for students to share and compare data. I planned how I could create class data lists using my interactive white board. I also planned how students could pair up with other student groups and best utilize time to share and discuss their findings. The next phase, Negotiation Phase III, includes the use of the textbook or other reading material to

compare science ideas. I spent a great deal of time on this phase searching for text material, reading material, and other sources that students would be able to read and use to make a connection between the inquiry activity and the reading. The seventh phase is the Negotiation Phase IV and allows for student reflection and class discussion. I knew this would be an area my students would struggle with, so I came up with a plan on what students would be doing during this phase. The final phase is the exploration of the post-instruction understanding. In order to make sure I was able to gauge student understanding, I developed quizzes, assessed the end of unit exam, and wrote lab rubrics to be used to grade student work.

The student component contains the same processes as the teacher component, but does so in a way that is very structured and simplified (See Appendix B). This allowed me to take an inquiry activity and/or lab experience and break it up into different parts that would work within my 55 minute class periods and still allow me to use the SWH approach. I used the teacher component phases to come up with a class format I used during all inquiry activities.

The first student component was the beginning ideas. This encompassed the first two teacher phases. Students were given a prompt about the topic to be covered. There were different ways I addressed this. Students were asked to free-write for three minutes in their notebooks. They were instructed to write everything they knew about the topic. If they did not know anything or ran out of ideas, they had to write questions about the topic. I then had students do a silent "class dump" where various students were asked to come to the interactive white board and write down a word or short phrase related to the topic. Students then were instructed to talk about the topic at their tables and come up

with three questions to be answered. One person was assigned the role of recorder and the questions were written down. I collected these questions in order to assess what students' levels of questions were.

The next student phase was the phase where they did the inquiry activity. This phase is often called the test phase and relates to the third teacher phase. Students were assigned roles within their groups; a reader, a recorder, and the other two were the students who carried out the procedure, tried to work out the problem, or were clarifiers. The roles were rotated so the same students did not always have the same roles. Students were given a procedure or instructions to follow for the lab or inquiry activity. Students worked together in their groups to complete an inquiry activity that was either a lab or an inquiry activity that asked students to solve problems and answer questions using models. This phase lasted one to two class periods.

After the students had completed each inquiry activity, they were instructed to write down what they did. I provided specific instructions to not write a formal procedure and not to repeat my instructions, but instead to reflect back on their process as a group and what they actually did. Students were given class time to work on this so that they could discuss this with their groups. If they did not finish during the class time they were instructed to finish this for homework.

Along with the writing component of the second student phase, students were also asked to write down what they saw. For lab activities, this included observations about the lab much like traditional data collection. For other inquiry activities where students were asked to solve problems using models, students were instructed to write down their observations about how the group worked to solve the problems. They were asked to

write about the process used and how they used the model. They were asked to reflect on what they noticed about this process. Students were given time to either complete a class data table or have discussions with other groups so that they could compare their observations with the observations of other groups. The observations and discussions from other groups were used in their own observations. Students were given instructions to make this informal writing in their journals and I made it clear I would not be grading them for content, spelling, grammar, sentence structure, etc. These two student components align with the fourth and fifth teacher phases.

The fourth student component of the SWH approach asks students to make a claim. After each inquiry activity, I posed the question, "What can I now say about this?" Students were given three to five minutes to reflect on what they now knew about the content they had been exposed to through the inquiry activity. They were told that their statement needed to be a strong claim that could be backed up using the fifth student component, evidence. Students had to justify their claim with a reason why using their data, observations from their group and others, and their personal account of what they saw and did. This writing component took place in class and following the writing, they discussed their claim within their groups. Each group had to come up with one strong claim they could share with the class and a justification for the claim. There was a class discussion about the claims made by each group.

Students began the next part of the SWH by reading from the text, an article, or some other type of reading. This student component stems from the work I did during the sixth phase of the teacher component, Negotiation Phase III. The readings dealt with the information presented in the lab or inquiry activity. Some of the readings dealt with

the concepts in a way that allowed students to see the application of the content. Some of the readings were readings that further explained the content such as passages from textbooks or internet sources. Students summarized the reading and wrote down questions they had about the reading or its relationship to the content. Students completed this in class or for homework. This part of the treatment focused on reading skills as well as helping to make the inquiry experience relevant. The next day, there was a class discussion about the reading and students had a chance to talk in their groups as well as with the whole class.

Following the reading, students reflected on their analysis based on the new information they gathered. This is the final phase of the SWH approach and from a teachers component is considered the Negotiation Phase IV. Students had a chance to write down any new ideas they had based on their group discussions, whole class discussions, and the reading. Students compared their reasoning and justification with the new information and wrote down any changes they would now make based on what they knew. This also included a class discussion where I posed the question, “What have you learned now?” I then posed the question, “What would you like to know?” This allowed students to ask questions they still had. I modified this from the SWH approach phase called Negotiation Phase IV where students reflect by creating a poster presentation or a report.

The final phase of the SWH approach involved an exploration of post-instruction understanding. There were various ways this was accomplished. I gave quizzes following each inquiry activity after all phases had been completed. Students were asked to write two different lab reports based on the SWH approach. These were graded using

a rubric. Finally, students were given an end of unit exam with a multiple choice component as well as a free response question section. The end of unit exam was the common course exam all students taking chemistry in our school district take after completing this unit.

In order to scaffold the students' learning and understanding about the SWH approach, I used the treatment following a pre-treatment phase where students learned in a more traditional style. This pre-treatment phase lasted for about nine weeks (quarter one) and included four traditional labs, notes, reading assignments, homework, some inquiry activities, quizzes and an end of the unit exam. Students kept science notebooks during this time and put all class work, homework, and labs in the notebook. The treatment phase lasted nine weeks (quarter two) where students participated in four labs and other inquiry based activities using the SWH approach. Students continued to use their science notebooks. During the treatment phase there were also quizzes and an end of the unit exam.

Data Collection Methods

In order to answer the research question; How does incorporating the Science Writing Heuristic (SWH) approach within a high school science class impact students, I utilized various data collection tools (Table 1). These data collection methods were also helpful in answering the additional research questions.

Table 1
Triangulation Research Matrix

	DATA COLLECTION METHODS					
DATA COLLECTION MATRIX	**SURVEY**	**FIELD NOTES**	**QUIZZES**	**JOURNAL**	**EXAMS**	**LAB REPORTS**
RESEARCH QUESTIONS						
Main Topic: How does incorporating the science writing heuristic approach within a high school science class impact students?	**A,B,D**	**A,B**	**B,C, D**	**A, B, D**	**C, D**	**B, C, D**
Sub-question #1 How does SWH improve the student's ability to work collaboratively?	**B,D**	**B**	**B, C, D**	**A, B, D**		**C, D**
Sub-question #2 How does the Science Writing Heuristic impact my students' ability to read science content and use that reading to answer questions about content, analyze data, and justify answers from a science activity in chemistry?	**A**	**A, B, D**	**B, C, D**	**A**	**C, D**	**C, D**
Sub-question #3 What are the effects of the Science Writing Heuristic on student understanding of science content as demonstrated on assessments?			**B, C, D**		**C, D**	**C, D**
DATA COLLECTION MATRIX	**SURVEY**	**FIELD NOTES**	**QUIZZES**	**JOURNAL**	**EXAMS**	**LAB REPORTS**
Sub-question #4 How will the Science Writing Heuristic impact my teaching and evaluation of students?	A, B, D	**A, B, D**	**B, C, D**	**A, B, C, D**	**C, D**	**B, C, D**

1. Key: used to identify the reasons why the data method selected is used.
2. A: Data will give qualitative information about student opinions, effectiveness, and motivation.
3. B: Data will give qualitative information about student learning, collaboration, and inquiry.
4. C: Data will give quantitative information about content understanding.
5. D: Data will give quantitative and qualitative data about student growth during the treatment.

A pre-treatment and post-treatment survey was used to answer the main question as well as most sub-questions (See Appendix C and D). It was important to develop a survey that looked at students' opinions about the treatment and whether or not they

perceived that it helped them to better understand the material. It was important to look at their impression of the treatment versus a more traditional approach to teaching science. I wanted to see if students recognized that they were learning in a different way. The surveys included questions about how students felt about group work, whether or not they were on task, whether or not discussion within groups occurred, whether or not reading assignments were completed, and what level of understanding students felt they had following the reading assignments. Prior to beginning the treatment phase of instruction, students were given the pre-treatment survey. This was an anonymous survey. Students were given time in class to complete the survey. Following the treatment phase students were given the post-treatment survey and again asked to complete this anonymous survey during class time.

In order to interpret and analyze how the students did with this process, I collected field notes. I used a field note journal (See Appendix E) that allowed me to quickly write notes on how effectively each group was working collaboratively during the process. I also collected information about the conversations students were having, including questions being asked, whether or not they were on task, and whether not they were working together utilizing the roles provided. The field note journal was completed while students were working independently, and I walked around the room providing assistance as needed. I added notes at the end of each period to make sure I did not forget what I had observed. It was determined if each grouping of students was on task, participating, and collaborating about the content. The field notes allowed me to collect data about the main research question as well as sub questions. It also allowed me to

compare how students worked in a more traditional approach to collaborative work and the SWH approach to collaborative work.

In order to determine whether or not the SWH approach helped students develop the skills they needed to be successful in a science class, I used quizzes, unit exams, and lab report grades. The quizzes consisted of five short constructed response questions that allowed me to assess the student's current understanding of the material. The exams used were the district common course exams that all chemistry students take. It was important to use these exams, because these exams are the ones the district uses to measures student success. The exams consisted of multiple choice and short constructed response or free response questions. Lab report data was collected utilizing a grading rubric for lab reports (See Appendix F). The rubrics were based on a standard four point system (4-advanced, 3-proficient, 2-partially proficient, 1-developing). The four point grading system was used because this is the system the district uses for standards based grading and the students are familiar with this. I felt it was important to include a grading rubric for the lab report so that I was consistent in my expectations. I used the data gathered both quantitatively (comparing scores) and qualitatively (depth of answers).

In order to assess whether or not the Science Writing Heuristic approach impacted me as a teacher (sub question number 4), I kept a reflective journal. Updating this journal provided me with the opportunity to look at how this process has changed my teaching, my current understanding of how students learn, and how I evaluate students. I used this journal to collect qualitative data about the process. Data from my field notes, quizzes, exams, lab reports, and also the student surveys were used to address how this approach

to teaching science changed me as a teacher and what information had I gained that would help me to grow as a teacher.

The main research questions as well as the sub questions were answered using a variety of data collection methods (Table 1). By using a methodological triangulation method of data collection I was able to ensure that the data gathered was reliable and I was able to compare both qualitative and quantitative results for each research question. Data collection was done for the same amount of time for both the pre-treatment phase and treatment phase and the same types and numbers of assignments, field notes, assessments, and lab reports were compared which also helped to ensure reliability. The triangulation data matrix also helped to ensure validity as data was compared both qualitatively and quantitatively and comparisons were made based on various data collection methods.

DATA AND ANALYSIS

The research questions and sub questions were answered by looking at each of the different research matrix data collection methods and then analyzing both the quantitative data and qualitative data. Data analysis was broken up into different components, student surveys, field notes, reflective journals, and quantitative data from exams, quizzes, and lab reports. The data from each of the different collection methods will be discussed and individually analyzed in the following sections. The research questions and sub questions will also be discussed as they relate to each data collection method.

Student Survey

In order to address how incorporating the Science Writing Heuristic impacts students, their ability to work collaboratively, their ability to read and understand science reading, and the impact this approach had on me as a teacher, I conducted a pre-treatment student survey and a post-treatment student survey (See Appendix C and D). I wanted to gain insight into the thoughts my students had about group work, whether or not they discussed science content within their groups, whether or not the work lead to a better understanding of the content, whether or not they were able to access the reading and if the reading helped them with the science content. All of the areas the surveys addressed are phases of the SWH approach, including collaboration, writing, reading, and discussion.

The survey was given to all three chemistry classes involved in this action research. In order to analyze the data, I grouped the research questions into specific categories based on their overall theme related to the SWH approach. The first category I analyzed dealt with student perceptions of group work. The pre-treatment survey asked the students to answer a yes or no question about whether or not they liked group work and to provide an explanation about what they liked and disliked about group work. Students were also asked a yes or no question about whether or not they learned better in a group or alone and to explain their answer. I wanted to see if there was a significant difference between how many students like or dislike group work and the number of students who feel they learn better alone versus in a group. Students were also asked to determine their level of on task behavior. They could rank this in the category 100% on task, 50-75% on task, or less than 50% on task. I wanted to see where students placed

themselves and why. Finally, students were asked to explain their understanding of the difference between collaboration and group work. I wanted to assess if students perceived there to be a difference between the two terms.

After looking at the data for all three class periods it seems apparent that students do like working in groups (See Figure 1). Data for all three classes demonstrates that the range of student who likes group work is 75%-85%.

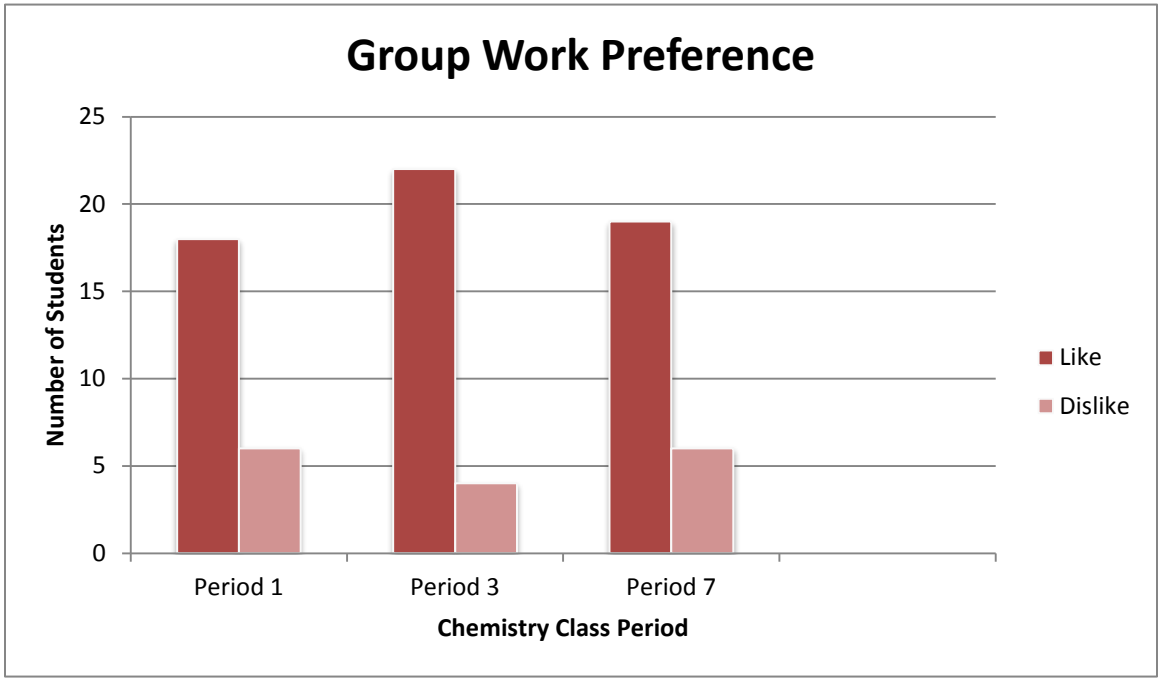


Figure 1: Group work preference, (*N*=24 period 1, 26 period 3, and 25 period 7*)*.

Students provided various reasons for why they either liked or disliked group work. I looked at the student explanations from the three different classes and came up with some common reasons for each. Students who did not like group work had a variety of reasons, but the main reason was that often times the group gets off task and is unable to complete their assignments. One student made the comment, “It is very frustrating when I know we need to work, but everyone else is just talking about stuff that is not

about chemistry." They also said that sometimes only one or two people do all of the work and the rest of the group gets credit. A number of students commented that group work is difficult if they do not know their group members because they feel uncomfortable working with students they do not know. A final reason that occurred time and time again was that they felt they worked and learned better on their own without distractions. One student said, "I get distracted and off topic way too easily when working in groups, but when I cannot talk, I just put my headphones on and do my work."

Students who said they liked group work had a much larger variety of reasons. The main reason students gave for liking group work was that they were able to learn from each other because with group work there are lots of opinions. They also said they can learn the material in a way that is sometimes easier for them to understand than when the teacher explains. Another common explanation was that they were able to complete the work faster than when they did the work on their own. Finally, a comment that occurred in many of the surveys, stated that they "liked being able to socialize while they worked."

The next set of data I analyzed dealt with whether or not students felt they learned better working alone or in a group. I wanted to see if despite the fact they liked working in groups, if a significant number of students still felt they learned better working alone. Data from this survey question demonstrated some difference in those who learned better in groups and those who learned better alone (See Figure 2).

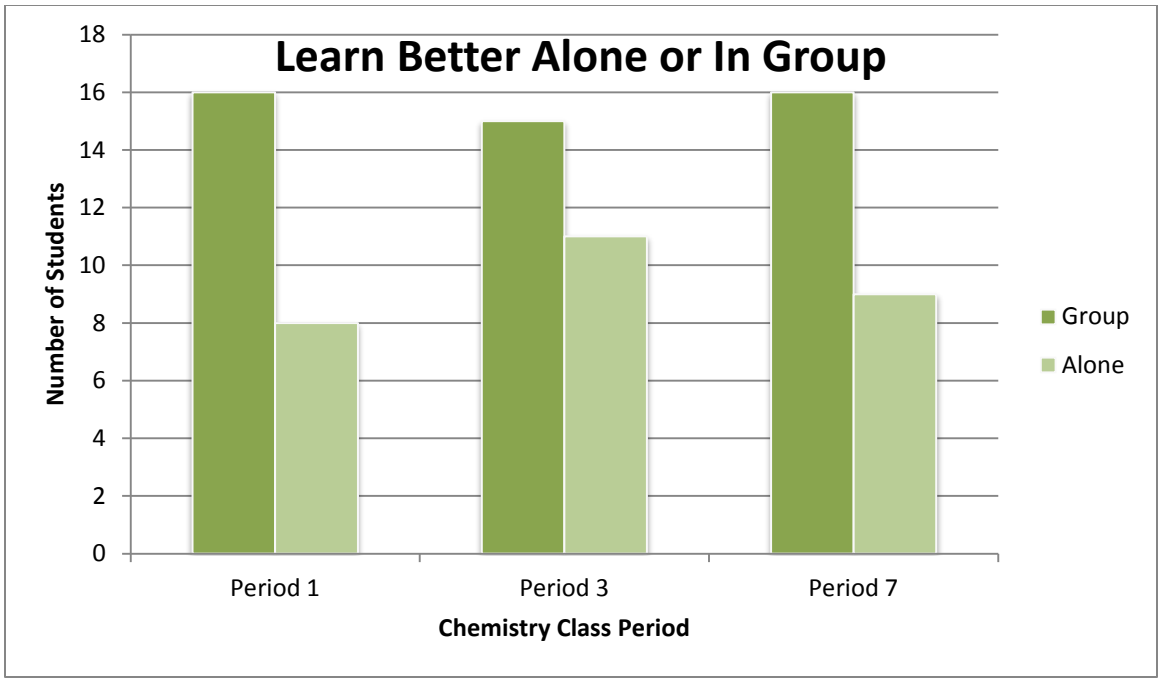


Figure 2: Learning preference, (*N* = 24 period 1, 26 period 3, and 25 period 7*).*

After looking at the data it seemed that a large portion of the students felt they learned better in a group situation. The range of values for those who felt they learned better working in a group was 58%-64%. In order to address the reason why, I looked at the explanations students provided for this. The students who preferred working in groups provided many of the same answers as previously mentioned. Students liked that they could help each other, were able to learn from each other, were able to socialize, and were able to learn the material in a way that was different and easier to understand. Students who felt they learned better working alone provided some of the previously mentioned reasons such as they got off task or distracted, they did all of the work, and they did not know their group members.

A new reason that surfaced as an explanation was that they did not like it when groups just split up the work. They did not feel like they learned as much because they

might miss some of the information. One student's comment specifically stated, "I always do my work so when we split things up I usually end up doing it all anyway. I might as well make sure I am learning it all alone."

This data lead to the next area of data I analyzed from the student survey. The question asked students to rate how often they are on task when working in a group. The students could pick 100% of the time, 75-50% of the time or less than 50% of the time. Student responses varied (see Figure 3).

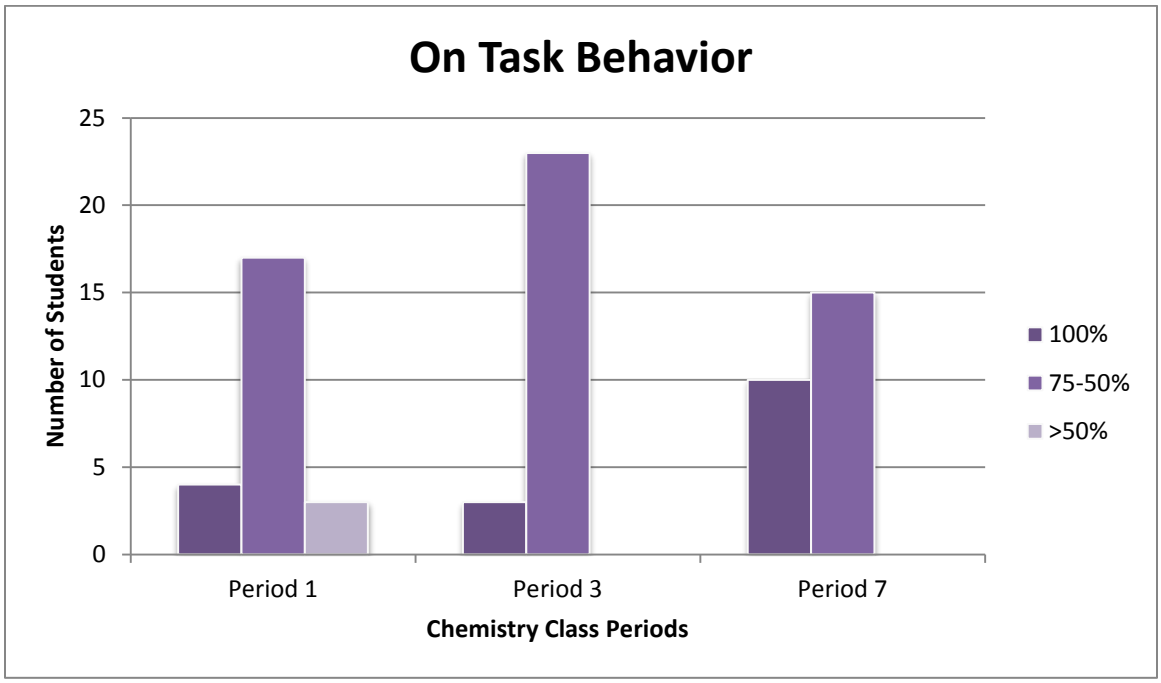


Figure 3: On task behavior, (*N* = 24 period 1, 26 period 3, and 25 period 7).

The majority of the students claimed to be on task at least 50-75% of the time. Student explanations for this were quite interesting to read and gave some insight on how different students perceive working with others. One comment that was repeated for the students who ranked themselves in the 100% category was, "I am always on task, even if others are not." Another comment that was repeated for this category stated, "Our group is a good one so we never get off task."

Students who ranked themselves in the 50-75% category also had a variety of reasons, but the one reason that stood out and was repeated was that the individuals felt as if they did get distracted, but they still got their work completed. One student made the comment, "It is human nature to get distracted, but is that really a bad thing? It helps us get focused when we take a little break." The three individuals from period one that said they were on task less than 50% of the time all said that they were at a table with their friends and they do a lot more talking than working. Even though this survey was anonymous, I was quickly able to determine which table this survey came from, and this group was very honest in their assessment of their behavior. After looking at this group's grades at the end of quarter one (pre-treatment phase), it seems apparent that this was indeed the case as the average grade for this table of students was 75%. Although this is a passing grade, I would be curious to see what the average grade might have been had they had been on task more.

As teachers we talk about collaboration and providing students with the skills they need to be able to work collaboratively. I was curious if students understood what the term "collaboration" meant and if students felt there was a difference between group work and collaboration. The survey addressed this question when it asked students to explain the difference between group work and collaboration. After reading through all of the responses from the different class periods, I found that the majority of the students felt like group work was just working together and collaboration was what one student so eloquently stated as, "Singular ideas coming together to be discussed and then creating an answer." Most students said collaboration meant there is more discussion and group work just meant everyone works together on the same thing at the same time. I found

this interesting because in reality they really are the same thing in my eyes. I was also surprised at how many students were able to describe collaboration and knew what the term meant.

The post treatment survey addressed many of the same issues regarding group work and student perceptions of group work. I wanted to compare their feelings after going through a period of time when their collaborative efforts were much more focused and directed using the SWH approach. With the SWH approach students were given roles when working collaboratively. Following the treatment period of nine weeks, students were asked if they liked group work when a role had been defined for each group. They were also asked if they learned better working in a group or alone using the SWH approach. Students were asked to provide explanations for each of these questions. For on task behavior they were asked if their group was on task 100% of the time, 50-75% of the time, or less than 50% of the time. I also included the question about collaboration versus group work on the post treatment survey, but student responses were not any different, so that data is not repeated in this section.

When asked whether or not students liked group work when their role was defined, student responses did not change too much from the pre-treatment survey results (See Figure 4).

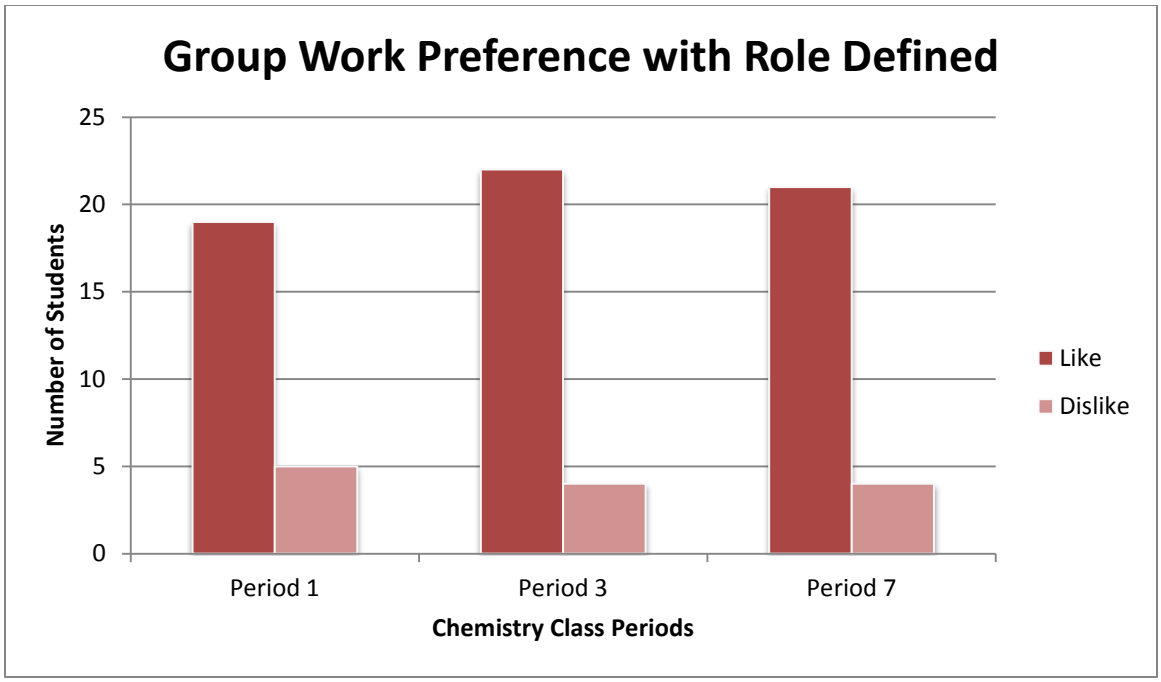


Figure 4: Group work role defined, (*N*=24 period 1, 26 period 3, and 25 period 7).

The range for the three class periods was 80-85% compared with a pre-treatment range of 75-85% of students who like the group work. The reasons students provided for liking group work did change from pre-treatment to post-treatment. Students reported that they liked that everyone was accountable for getting something done and they did not feel like they were doing all the work. Other students said they were able to get to work much quicker. One student commented, "There was very little wasted time and my group just started doing what they were supposed to do." Other reasons described far less off task behavior which made their group work more productive. Many students said they liked knowing what was expected of them and felt like it was more of a job and not just getting work done.

The reasons students provided for not liking the group work when a role was defined were also different from pre-treatment to post-treatment. Students said they did

not like having their roles switched because they did not like some of the roles. Other students said they would rather just do it all themselves because others did not know how to do their role correctly. One student said, "I seem to be the only one in the group who knows what to do, and I do not like having to rely on others to carry out the procedure. I wish I could switch roles." Finally, students commented, "It was difficult to divide the work up and we all had to go through the whole activity."

When students were surveyed about whether or not they learned better alone or working in a group the answers changed quite a bit from the pre-treatment survey to the post-treatment survey (See Figure 5).

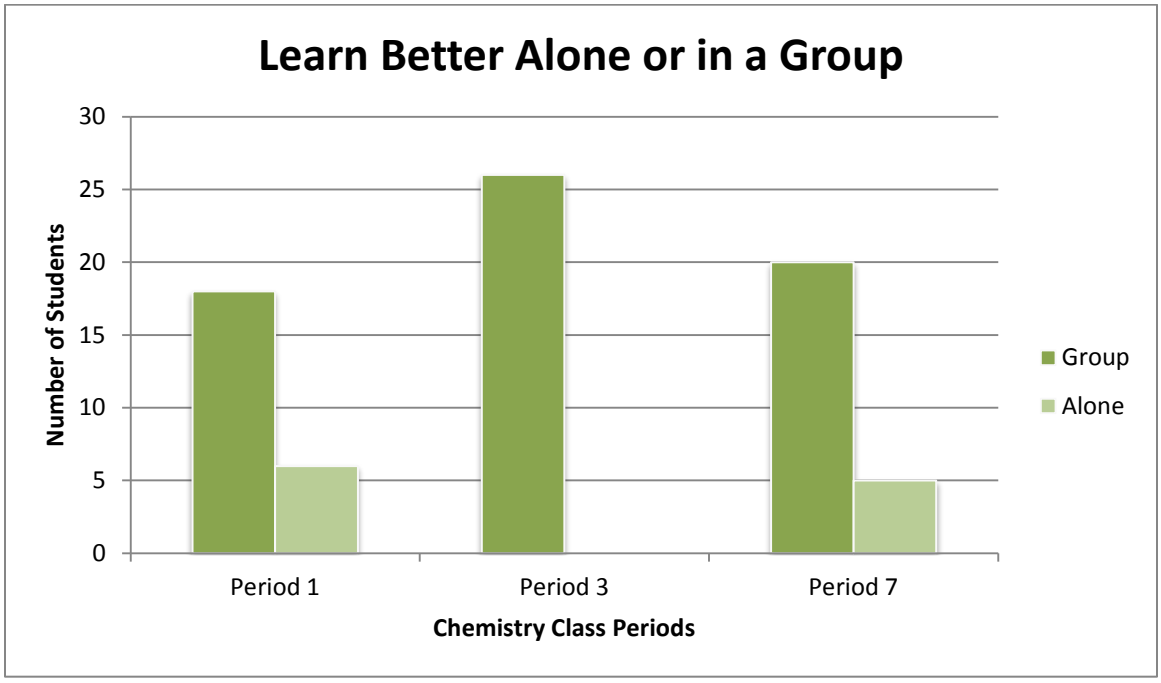


Figure 5: Group work preference treatment phase, (*N* = 24 period 1, 26 period 3 and 25 period 7).

The range of students who felt they learned better in a group changed from 75-100% post-treatment compared with 58-64% pre-treatment. This was a surprise and

when I looked at the reasons why, the students who felt they learned better gave reasons that centered on how much better they were working as a group. One student commented, “I was able to hear three other opinions about the question and it helped me to think about who was right and why.” Another comment from a student reflected on the fact that they were much more on task as a group and it helped the whole group to learn better. Student comments also suggested that they knew what was expected of them and it made the activity easier to follow. Students who did not feel they learned better in a group had similar ideas post-treatment as they did pre-treatment. They felt that they were not able to work with a group of students they did not know. Others felt like the group still got off task and it would have been easier to just complete the activity on their own. One student provided a different explanation that was interesting and something that will need to be explored in the future. This student said, “I do not work as quickly as the rest of my group members and I did not want to tell them I was unable to understand, so I just went along with them.” This is a concern and definitely something to think about as I look at how the SWH approach impacts me as a teacher as well as my students.

The post-treatment survey asked students to rate their on-task behavior. Students had the same options as the pre-treatment survey, 100% on task, 50-75% on task or less than 50% on task. Student responses varied from the pre-treatment phase (See Figure 6).

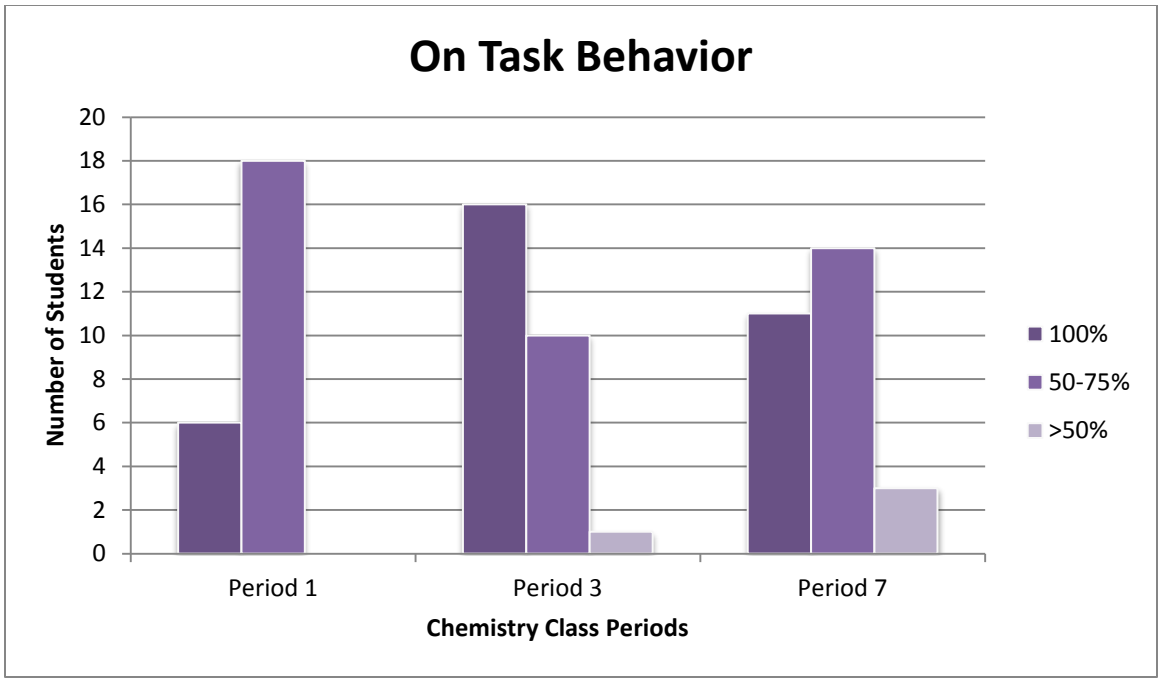


Figure 6: On task behavior treatment phase, (*N*=24 period 1, 26 period 3, and 25 period 7).

Class period three saw the biggest change from pre-treatment to post-treatment. This class went from three students saying they were on task 100% of the time to sixteen students claiming they were on task 100% of the time. This class period also dropped from twenty three students claiming to be on task 50-75% of the time to only ten students making this claim. This class also had one student claim to be on task less than 50% of the time. Periods one and seven really did not have a shift in student perceptions. Period one and period seven did not have any comments that were much different than their pre-treatment phase, but period three did. Students in period three commented that they needed the direction to stay on task. They felt like the structure kept them from getting off task. One student made the comment, “My group kept yelling at me to do my job, so I had to stay on task.” Another student said, “When I am given a job to do I just do it. I think when the teacher says to just get to work; I pretend she is not speaking to me.”

Finally, a large number of students in period three said they like the people they were working with which made working easier.

This part of the student survey was used to try and answer the main research question, how does incorporating the Science Writing Heuristic approach within a high school science class impact students, and the sub question, how will the SWH approach affect student's ability to work collaboratively. After looking at the student surveys both pre-treatment and post-treatment, some general ideas about the effectiveness of the SWH approach can be made. First of all, most students enjoy working in groups and feel that working in a group does benefit them. The difference that I noticed pre-treatment versus post-treatment was that students felt they learned better using the SWH approach. It seems that the SWH approach was much more structured and provided students with roles and guidance as they worked through collaborative inquiry activities. This approach held everyone accountable within a group which would lead students to take a more active role in the activity. The perception shared by many students pre-treatment was that they learned better in a group situation. It seems apparent that providing students with structure during collaborative work could lead to much better learning outcomes for all students and improved collaborative efforts.

When looking at the data for on-task behavior, students thought they were off task at various times during both the pre-treatment phase and treatment phase. I believe this is the nature of group collaboration. What I did find interesting was that most students were very open and honest about their behavior. Prior to giving the surveys, I predicted that a large portion of the students would say they were on task most of the time. This was not the case and the explanations students provided gave me a great deal of insight as a

teacher. I definitely saw trends within each class, and because the groups had been together since September, I believe there was some comfort level within the groups that could also have contributed to the students being off task at various times. Period one had the most students report on task behavior 50-75%, of the time and I do not necessarily believe this is because of the group dynamics, but instead is a result of the time of day. Often times students come in late, students are tired, or students are just not engaged in school yet. Period three had the most students report being on task 100% of the time. I believe this is a very good assessment as this class period works very well together and most of the groups work together when given specific instructions. This class period also had the highest overall grade point average of all my classes.

All in all, after analyzing this data, I think I can say that based on the student responses to the survey questions, the SWH approach did have a positive effect on the ability of my students to work collaboratively. The student surveys also demonstrated that the approach did impact my students as they felt they did learn better in a group rather than working alone, and analysis of grade data did demonstrate this, which will be explained further in this section.

The other research sub question the surveys were designed to address was the question, how does the SWH impact my students' ability to read science content and use that reading to answer questions, analyze data, and justify answers from a science activity in chemistry. There were six different survey questions that all dealt with this topic and asked students to respond to basic ideas about whether they read science content in their textbooks, readings assigned by the teacher, the internet, magazines, newspapers, or other sources. It also asked them to discuss whether or not reading science content helped them

to better understand the content in class. In order to analyze this data I took the six different questions and looked for some common themes apparent in student explanations. I also looked at the different yes, no, or sometimes responses and used the data to make some generalizations and to compare pre-treatment data with post-treatment data.

I decided with this data to group all classes together because the data was very similar from class to class. The first topic I analyzed was whether or not students read science content (textbooks, internet, readings, etc.). The findings demonstrated very little difference between pre-treatment and treatment (See Figure 7).

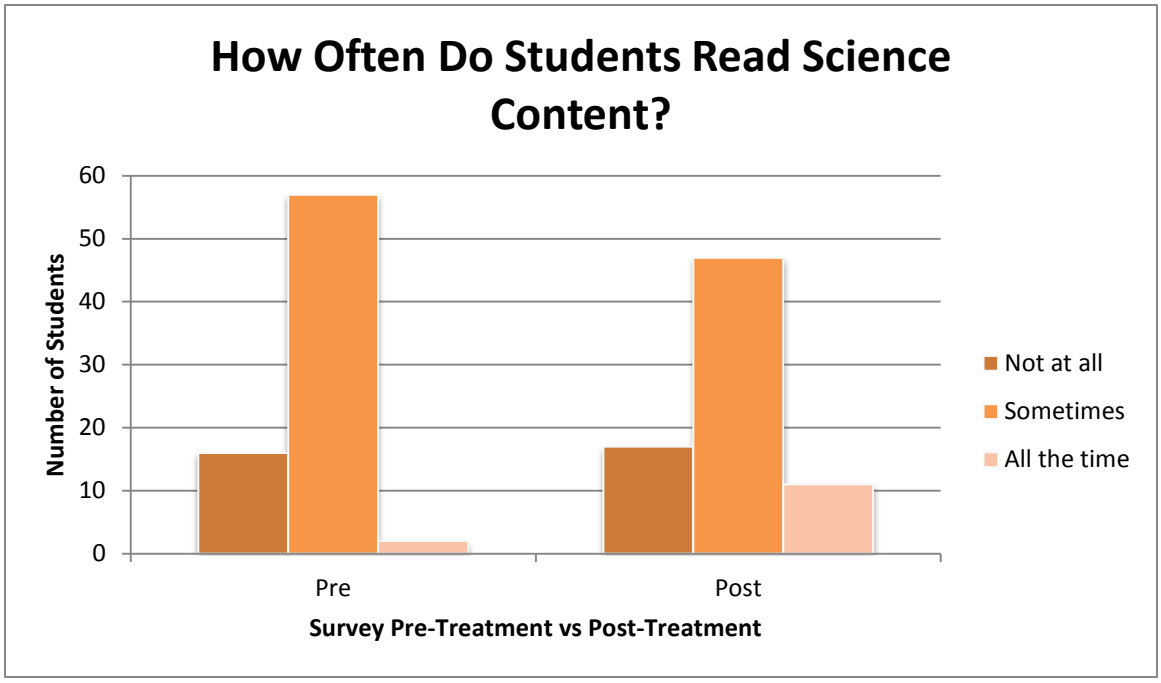


Figure 7: Science reading by students, (*N*=24 period 1, 26 period 3, and 25 period 7.

The one area where I did see some difference between the pre-treatment and post-treatment survey was for students who reported reading science content all the time. Pre-treatment survey results indicated that only two students read the content all the time.

Post-treatment survey results indicated that eleven students read the content all the time. After looking at the explanations, their reasoning was that it was assigned and they knew we would be discussing the reading in class the next day. One student said, "I did not read the assignment one night and everyone else in my group did and I felt like an idiot." Students who reported reading sometimes stated that they did so because it was assigned and they felt they needed to. Others said they did the reading because it helped them to understand. Others said they read parts of it, but maybe not the whole thing.

Students who did not read at all provided the explanation that they did not like to read, did not have their textbook at home, forgot the reading, or did not have access to the internet and forgot to go to the library at lunch. One student commented, "Why would I read anything when the teacher can just tell me what I need to know." Another student said, "This is science class and science class is not English. I do enough reading in English class." The results of this part of the survey did not surprise me and I expected results similar to this.

It is always a struggle as a science teacher to get students to read. I wanted to see if the survey could provide some information about why students might not read or reasons why they do. I also wanted to see if the readings provided using the SWH approach changed student perceptions of reading. One of the survey questions asked whether or not students understood the science content and if it helped them to better understand the classroom content. As I looked through the student surveys both pre and post-treatment, I found some recurring themes. Students read because it was assigned to them. Students used the internet over the textbook when looking for information. Students struggled with reading science content and often did not read it if it was too

difficult. Other students did not read science content because they thought it was boring. Students often did not feel the reading helped them to understand. One student made the comment, “If I could understand the reading, I might be able to understand the content, but it is too hard for me.” Another student said, “Why is science writing so boring? It makes me not want to read it.” Finally a student provided some additional insight, “If there were questions to go with the reading it would be much easier.” Students did have some different opinions following the treatment phase. They felt the readings were more interesting, more beneficial, easier to understand, and less “science reading.” They also said they liked the discussions we had after the reading. One student said, “The class talk about the reading helped me to understand it better.” Another student said, “I would read all the time if I could talk about it after.”

Despite this, most students did not feel like the reading helped them to understand the content or have any impact on their grades on exams, quizzes, or ability to answer questions. My hope was that the SWH approach would help students to become better science readers and help them to access content within the class. The SWH approach provided a template to be used to guide the reading because students were instructed to read the assigned reading and then write how their thoughts had changed based on the reading or what new thoughts they had based on the reading. This did not prove to be true based on the student responses to the survey questions. The data I did gather from this that proved to be beneficial was that students did like the discussion following the readings and felt this was beneficial. They also tended to like the reading passages associated with the treatment phase.

As I begin to plan lessons in the future, this information will be helpful and will really make me think about my selection of reading passages and how they are used within my science classrooms. I also think the template for the SWH approach could be modified to include more directed writing for each reading assignment as opposed to an open-ended question.

Field Notes

It was important for me to see how the SWH approach compared to a more traditional way of teaching students in an inquiry based science classroom. In order to accomplish this task, field note data was collected (See Appendix E) while students were working on different group/collaborative inquiry activities. Field notes proved to be useful in helping me to assess how groups worked together, conversations and questions students had, on task behavior, as well as being able to compare how a more structured approach with the SWH method differed from a less structured approach.

Field note data was used to look at the main research question as well as sub questions one, two, and four. I decided to use an analytic deductive coding system where I established codes for themes I would be looking for within the text of my field notes (See Appendix F). The main codes I determined would be useful were as follows: on task as a group, discussion, and utilizing roles. These codes were established prior to looking at my field note data. I then read through each field note entry with one of the codes in mind. These codes were used for both the pre-treatment phase activities and the treatment phase activities.

The first code I analyzed based on my field notes was on task behavior. For the pre-treatment phase field notes were taken on five separate occasions for each class

period utilizing the field note journal (See Appendix E). I collected data about on task behavior by putting a check mark in the journal if the group was on task when I walked by. In order to determine if each group of students were on task I would look for work completed by all group members, where they were in the process of whatever task was being done, and if all group members appeared to be engaged in the process. By looking at all of these factors to make my determination, I was able to base my judgment on multiple aspects and avoid students being on task just because they saw me coming.

Each class consisted of seven to eight tables of four students each. There were occasions where students were absent and the groups were not four students. The pre-treatment phase data demonstrated that most of the groups were on task 50-75% of the time (See Figure 8).

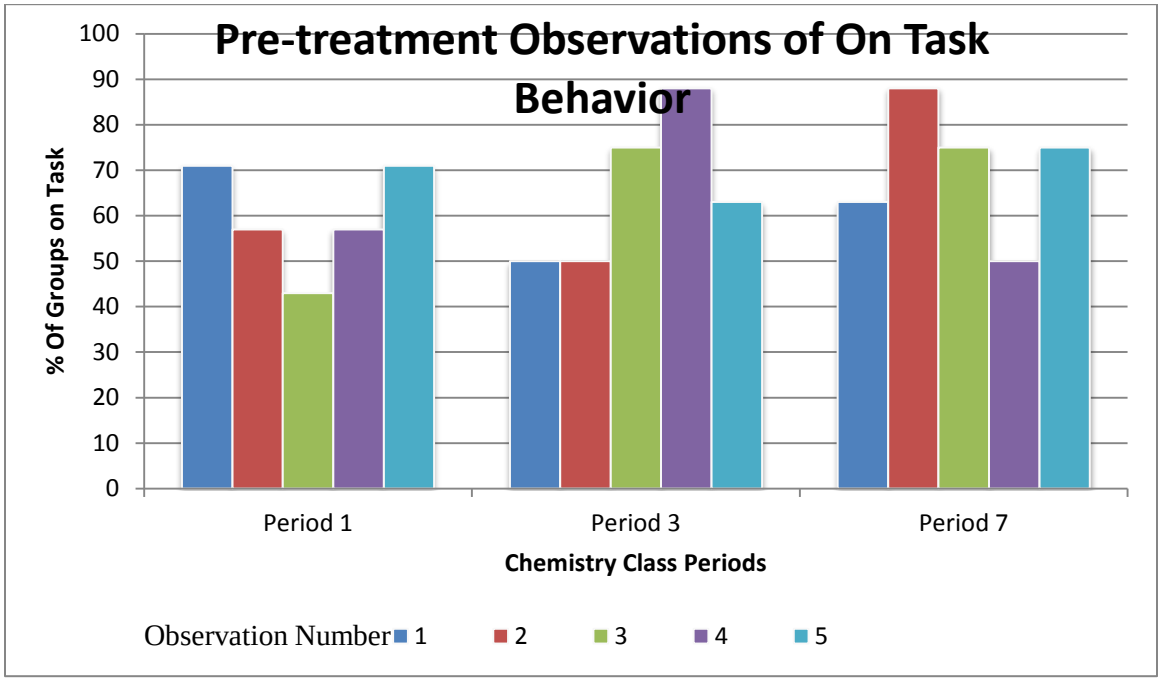


Figure 8: Pre-treatment observation on task behavior, (*N*= 24 period 1, 26 period 3, and 25 period 7).

The average on task behavior for the five different observations for period one was 60%, for period 3 was 65%, and for period seven was 70%. The field note data demonstrated that different groups within each class period were on task or off task from observation to observation, so this data was not included in this analysis. The data also did not demonstrate whether or not students were on task or off task varied based on the activity students were participating in.

Treatment phase observations also included five different observations with the same parameters as the pre-treatment observations. Data from these field notes showed a significant difference in on task behavior (See Figure 9).

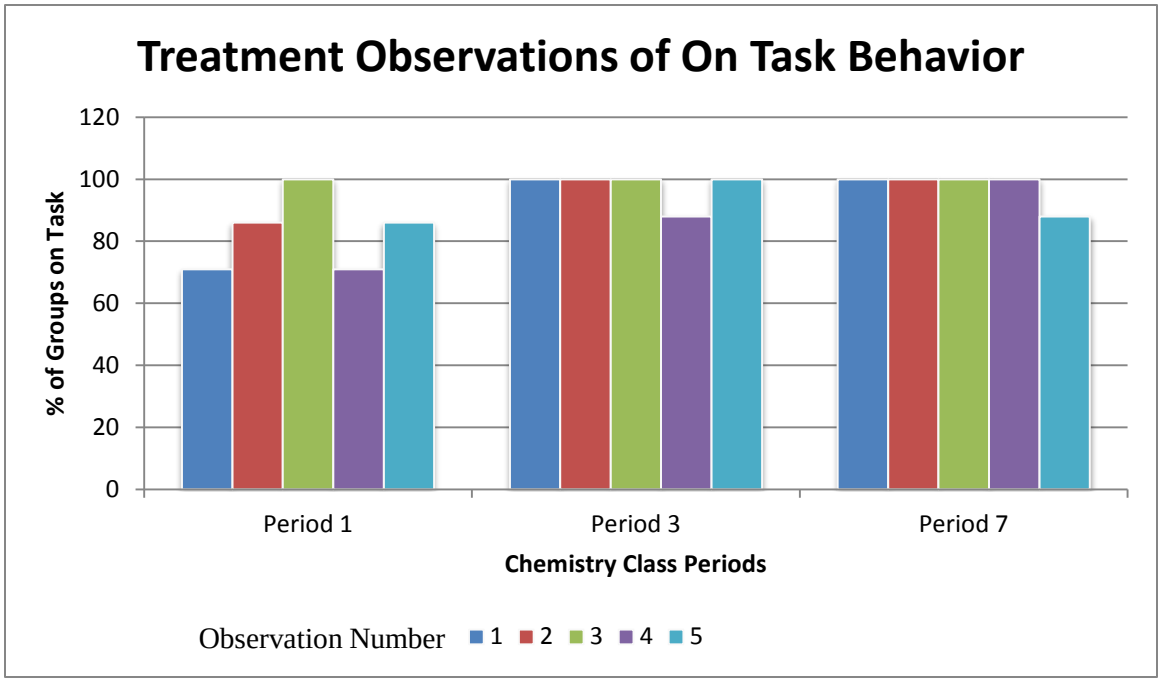


Figure 9: Treatment observations on task behavior, (*N*=24 period 1, 26 period 3, and 25 period 7).

The treatment data demonstrates that on average for the five different observations, period one groups were on task 83% of the time for a jump of 23% from the pre-treatment to the treatment phase. Class period three demonstrated an average for the

five different observations on task behavior of 98% which was a 33% increase from the pre-treatment phase. Class period seven also demonstrated an average of 98% on task for the treatment phase which was a 28% increase from pre-treatment to treatment. Period one saw the lowest jump in on task behavior, and I can contribute this to the fact that period one is a class where students are often late, students are often not quite awake, and students are often not quite ready to be a student so early in the morning. The dynamics of first hour class definitely plays a role in their collaborative efforts and class discussions.

As I began to take a closer look at this data and began to try and make sense for the reasons behind the jumps in on task behavior, I first looked at the different activities students were engaged in pre-treatment and treatment phase. These activities varied from work that was inquiry lab based to work that was problem solving and finally to work that required students to work together to answer questions. The differences in activities did not seem to make a difference in whether students were on task or not. The one conclusion I can make based on this data is that during the treatment phase, students were given various roles and specific instructions for each activity prior to beginning the activity. The SWH approach template has students working together and discussing the activity. If a student is not doing their part, the group as a whole is off task. It seems apparent that the SWH approach demonstrated an increase in the number of student on task as measured by my field notes. Because I measured on task behavior based on how much work was completed by each group, where in the activity each group was and finally the level of engagement of each group member, I feel confident that I was able to

make a good assessment of on task behavior for both the pre-treatment phase and the treatment phase of the field note data collection.

Another code I used as I analyzed my field notes was the type of discussions students were having. I wanted to collect data about how students work collaboratively (sub question number two), and how this will impact my teaching and evaluation of students. I wanted to see if students were able to learn some of the content by working collaboratively with me as a facilitator using the SWH approach. As I collected field notes, I would write a brief phrase or sentence describing what the group was discussing. This data collection method was not difficult, but analyzing the data was a bit more difficult as the discussions were all over the place. For that reason, I decided to use an analytical inductive coding system within my field notes and see if I could find some common themes. As I did this three main theme emerged, working together, arguing, and roles.

As I walked around the classes and observed students and recorded what I saw, I had comments that centered on the fact that some groups appeared to be working together. Comments I wrote down included, “Students are working together to solve the problem.” Other comments included, “Students seem to be utilizing their roles to work together.” These were comments noted during the treatment phase observations. Comments noted during the pre-treatment phase included, “Students do not appear to be working together as a group.” Another comment noted, “Students are arguing about who is going to perform the procedure.” Finally, a comment about how the students seem to be splitting up the work and then just passing their papers around is consistent with student comments about group work, “It is easier because we can split the work up.”

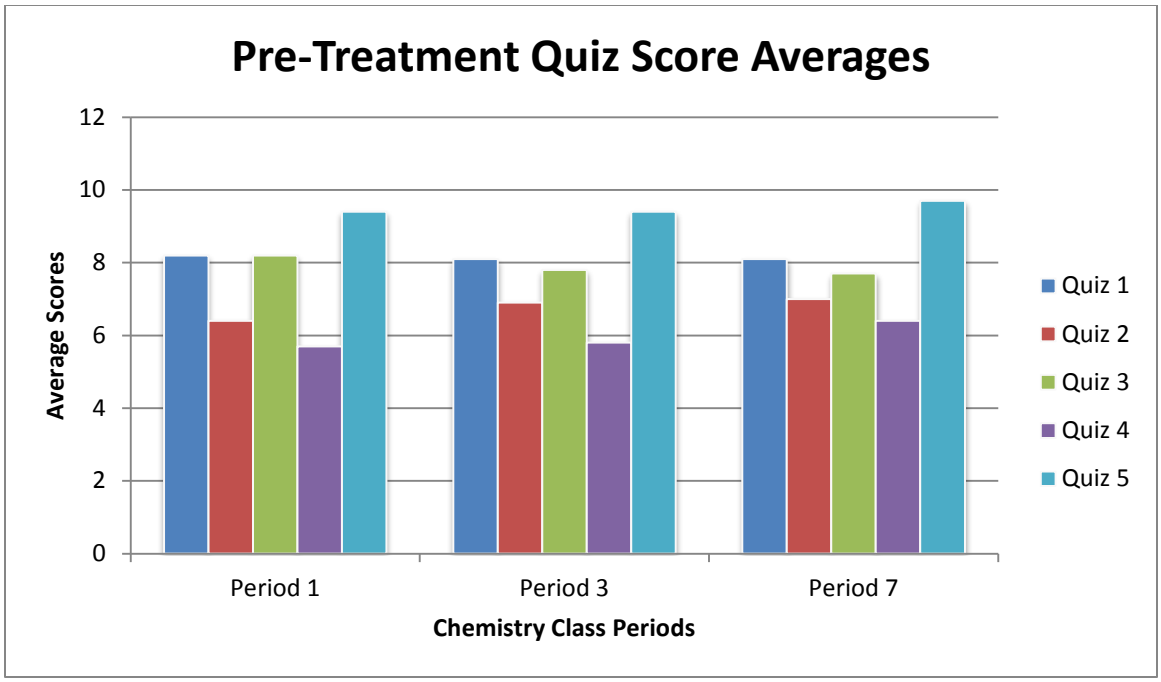
I did not collect information that could be analyzed quantitatively for this section of my field notes, but I do believe the qualitative data I gathered is useful. It demonstrated the different group dynamics when students are given specific tasks related to the SWH approach versus just being told to work with their tablemates to accomplish a task. It seems the more directed approach provides students with direction they need and holds every student accountable for some of the work. There were still some groups that struggled even when provided with structure, but I believe this is more about the nature of people and people working in groups and not the actual approach used. I also found that despite having roles assigned the nature of certain class periods can make collaborative work difficult. Some classes have more students who are outgoing and other classes have students who are much more reserved and do not want to spend time together eating and talking. Instead these groups are content working and maintaining, but not pushing things too much.

Quizzes

As a classroom teacher I give weekly quizzes in order to assess my students' current level of understanding, to provide the students feedback, and to give students an opportunity to see the types of questions they will be held responsible for on their unit exams. I used the quiz scores during this action research to compare the pre-treatment phase of learning with the treatment phase of learning. I wanted to see if there was a significant difference in the average scores after students completed an inquiry activity utilizing the SWH approach. This data collection method was used to answer the main research question as well as sub questions three and four.

In order to make sure I was comparing quiz scores in an equal way, during the nine week pre-treatment phase five quizzes were given and during the nine week treatment phase five quizzes were also given. These quizzes were given at the completion of learning a concept from that unit. For the pre-treatment phase the quiz was given following the completion of learning activities where student did an inquiry activity, I taught them the concept, and then students practiced and completed homework activities related to the concepts, or they read from an article or text. For the treatment phase, the quiz was given following an inquiry activity utilizing the SWH template and methods.

The unit of study for the pre-treatment phase dealt with parts the atom, the Periodic Table, and bonding. Quizzes were given on the parts of an atom, isotopes, ionic bonding, covalent bonding, and bonding geometry. Each quiz was worth ten points and included five short constructed response questions that included questions students had been exposed to during the inquiry activities. Data was gathered from each class for each quiz using my school districts Infinite Campus Grading System. I took a class average for each quiz and then took an average of the five quizzes combined (See Figure 10a). This data was compared to the quiz score averages for the five quizzes for the treatment phase (See Figure 10b). The treatment phase quizzes were on topics related to reaction rate, types of reactions, predicting products of reactions, balancing reactions, and energy of reactions.



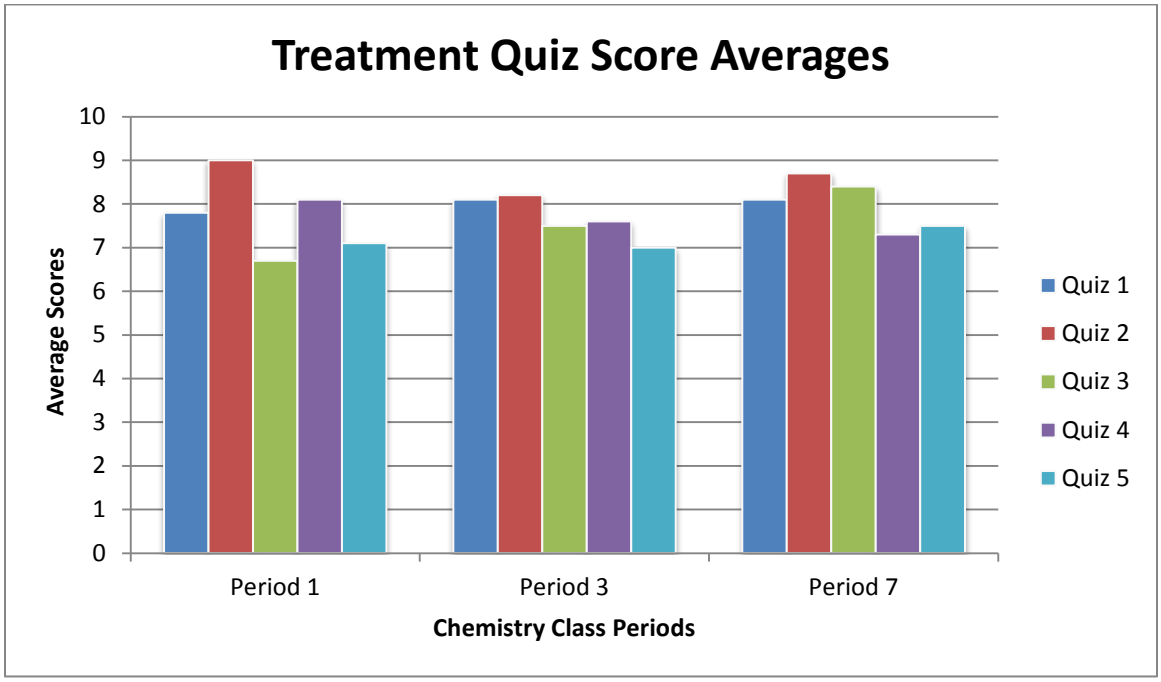


Figure 10a and 10b: Quiz score averages pre and treatment phases, (*N*=24 period 1, 26 period 3, and 25 period 7).

I took the data from the pre-treatment quiz scores and the treatment quiz scores and took an average of the five quiz grades to see if there was a significant difference (See Figure 11).

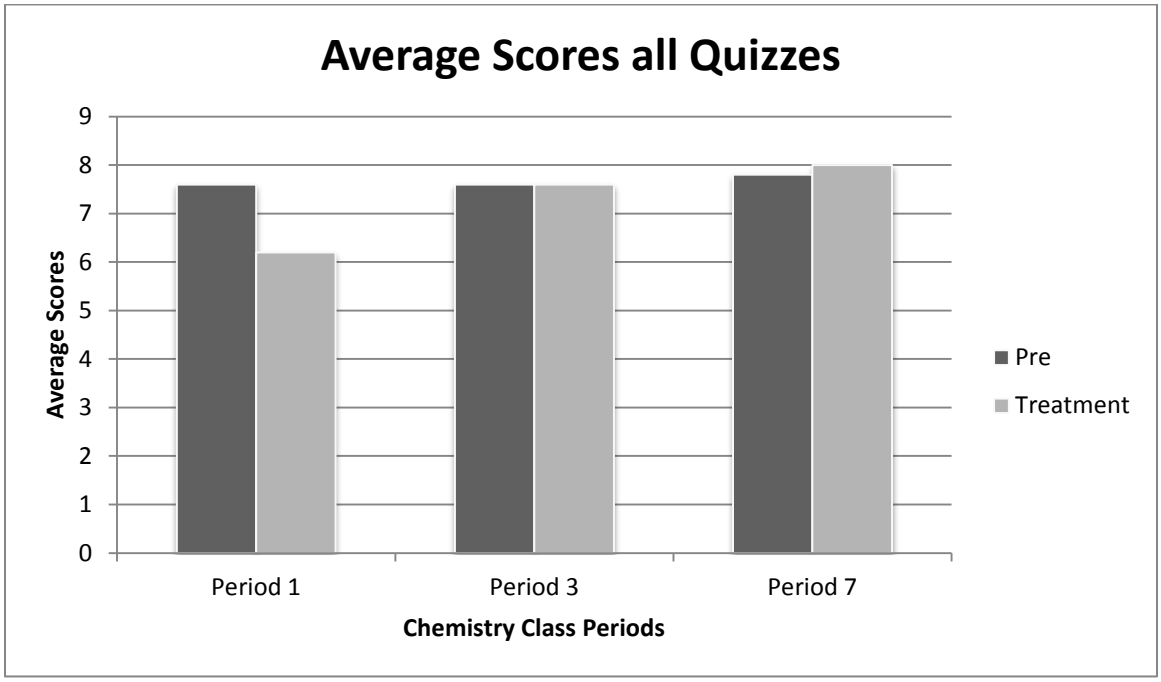


Figure 11: Average scores all quizzes pre vs treatment phase, (*N* =24 period 1, 26 period 3 and 25 period 7).

After looking at the quiz score data, there was not a significant difference between the quiz scores pre-treatment and treatment. I had anticipated there would be a difference, but the data showed that overall the scores were really close. Periods three and seven had an average for all quiz scores pre-treatment of 7.6 and 7.8. Their averages from the treatment quiz scores were 7.6 and 8.0. Period one did see a change in the overall average between pre-treatment and treatment, but not in the way that was anticipated. The class average for all quiz scores went from a 7.6 to a 6.2. I cannot contribute this to the SWH approach for a variety of reasons. Period one, as previously mentioned, is a class that has a great deal of students who come to class late, are

unfocused and often very sleepy. During the treatment phase, period one experienced a large rate of attendance issues due to a new school policy where students who were late were placed in detention for the whole class period. Because of this many students missed out on some of the work students did collaboratively and therefore were asked to complete the work independently. I believe this had an impact on their overall quiz scores and impacted the overall class average.

The data pre-treatment versus treatment demonstrated that the SWH method did not really make a significant difference in the learning outcomes for the students based on quiz scores. Quizzes reflected the learning that had taken place in class and oftentimes the questions were just a rewording of questions students had seen as warm-ups, within the inquiry lessons, or questions I posed to the class. I chose to look at this from a quantitative aspect only. Had I put some forethought into this as a data collection point, I would have chosen to look at this from a qualitative aspect as well as a quantitative aspect. Because these questions were short constructed response questions, I could have gathered data about the depth of answers students were providing pre-treatment versus treatment. Qualitative data was not collected after the fact since quizzes were returned to students within a day so that students could use the information for feedback and to study for their exams.

When this data was compared with the data from student surveys it appears that despite the fact students thought they were learning better in a group, their quiz scores did not reflect this. My teacher reflective journal also helped to explain quiz scores that did not change as I made the comment, “It sometimes appears that all students are working,

and in fact they are, but there are still students who seem to be just copying or appear to act as if they understand, but are really just writing what the rest of the group is writing."

Exams

Data was gathered from the exams students took during the pre-treatment phase and also the phase following the use of the SWH approach. The exam used for each phase was the district common course exam that all students who are enrolled in chemistry in the school district are required to take. I chose to use these exams as my data points because this is the measure the district has teachers use to determine if students are proficient in the content. Both exams consisted of a multiple choice section as well as a free response section. These exams reflected material that was covered during the class activities both pre-treatment phase and the treatment phase. The exams are not included in the appendix of this paper as our district does not allow them to be released. Data gathered was based on scores from the combined multiple choice and free response question sections for each exam and was a percentage score out of one hundred.

Data for each class was compared based on the average score of all test scores. The number of students used for data collection for each class period was 24 for period one, 26 for period three, and 25 for period seven. There were additional students for each class period who took the first exam, but their data was not included as they were no longer in the class for the second exam. Pre-treatment (exam 1) and treatment phase (exam 2) data was compared (See Figure 12).

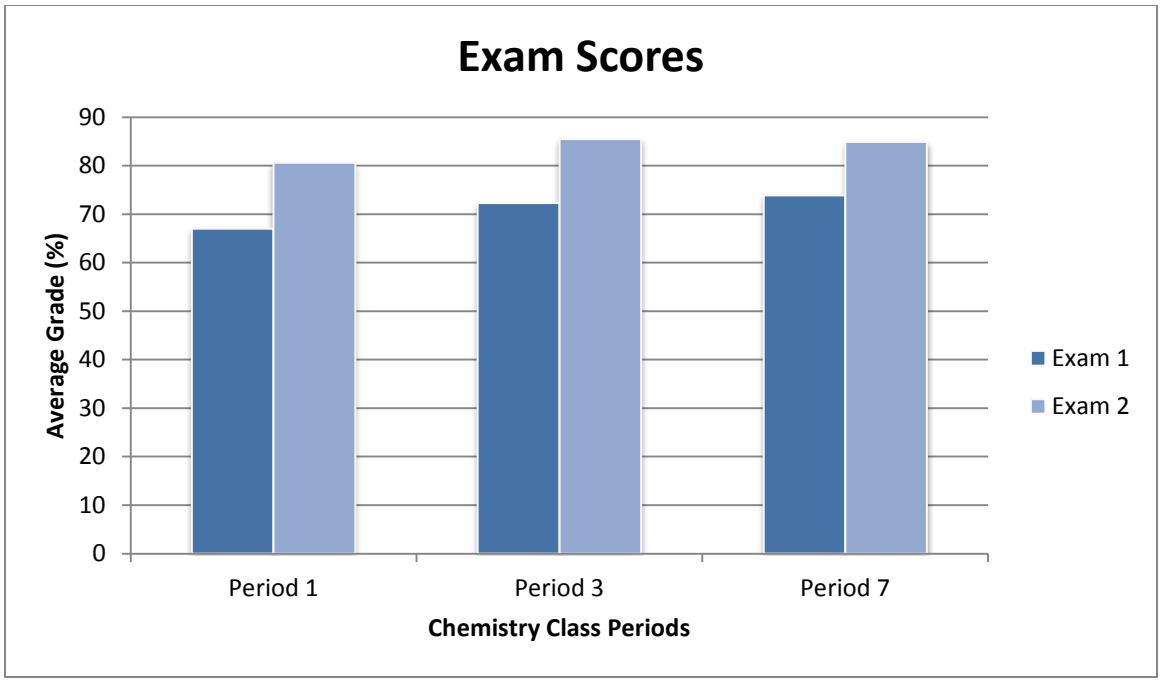


Figure 12: Exam scores, (*N*=24 period 1, 26 period 3, and 25 period 7.)

The data demonstrated that each class period saw an increase in exam scores from the pre-treatment phase to the SWH approach phase. Period one had a 13.6% increase and went from 67% to 80.5%. Period three had a 13.2% increase and went from 72.3% to 85.5%. Period seven had an 11% increase and went from 73.9% to 84.9%. Based on this data it seemed that students performed better on the exams after using the SWH approach to learning the content which would make answering my main research question and question number four relatively easy.

I was not convinced that this data was due to the SWH approach alone, so I looked at some individual student data from each class period. I picked students who had been absent a significant number of times during the SWH process and had to complete the collaborative assignments alone. There were four students in period one who had been absent at least five different times during the nine week period and had to complete

at least one of the assignments independently. One of the students had a pretty large decrease in their exam score. This student went from an 86% on exam one to a 74% on exam two. The other three students did not see as drastic a change, but there was not really an improvement in their test scores. One went from a 72% to a 71%, another went from a 78% on exam one to a 79% on exam two, and the third student went from a 50% to a 59%.

Period two had five students who had been absent at least five times and had to complete at least one assignment independently. Of these students the changes in scores were a drop of 10% and 14%. Two of the students did not have any change in their scores. Period seven had three students who had been absent more than five times and had to make up work independently. The data from these students showed similar results. One student went from a 64% to a 48%. Two students had scores that changed by less than two percent. From this data it seemed that the SWH approach had helped students to improve their scores, but I still wanted to explore this further. Students who are routinely absent tend to have lower grades due to the nature of the exam, so I wanted to see if this added onto my explanation.

I decided to look at students who had been present with no absences during the time frame of data collection. When looking at the data from period one there were fourteen students who were present for all of the treatment and pre-treatment phases. These students all saw an increase in their exam scores (See Figure 13).

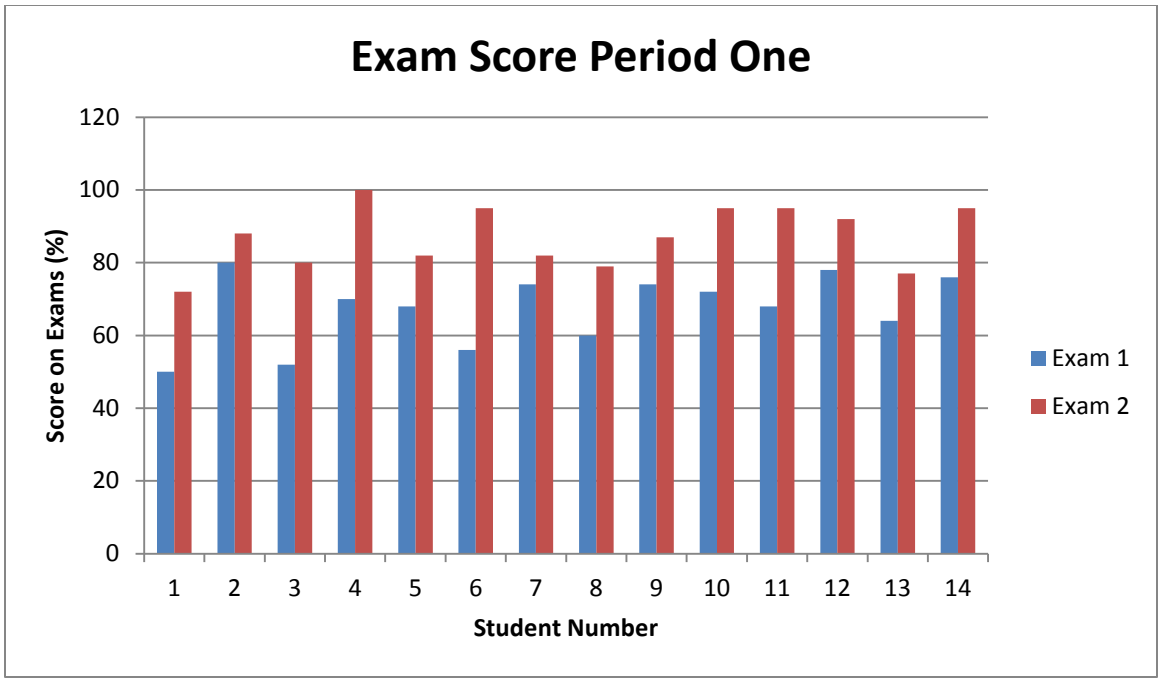


Figure 13: Exam scores period one, (*N*=14.)

The range of increase seen by students in period one was an increase of 8% all the way to an increase of 39% for one student. Period three had ten students who were present for all aspects of the study period. The data demonstrated similar results for this class period as well with a range of 9% all the way to a 57% increase (See Figure 14).

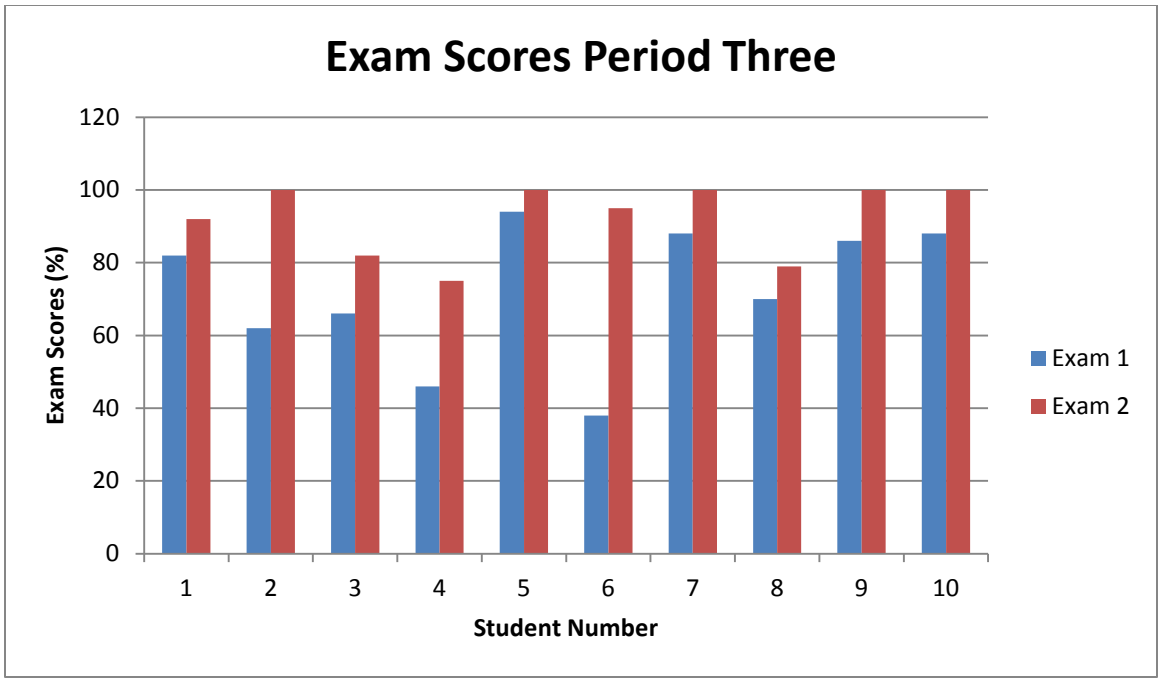


Figure 14: Exam Scores Period 3. (*N*=10).

The student who saw the largest increase for this class period with an increase of 57% was a student who is in a special reading class and is also an English Language Learner. This student was in a pull-out class for English Language Learners and this class often focused on work they had done in class. This student's grade increase could have been due to having someone focus on the content individually outside of class time, leading to increased contact with the material and extra help. When I asked this student about this he commented, "I sometimes work on homework, but I am not sure if I worked on the stuff from class." Period seven had 12 students who were present for all aspects of the study, but the data revealed some interesting results (See Figure 15).

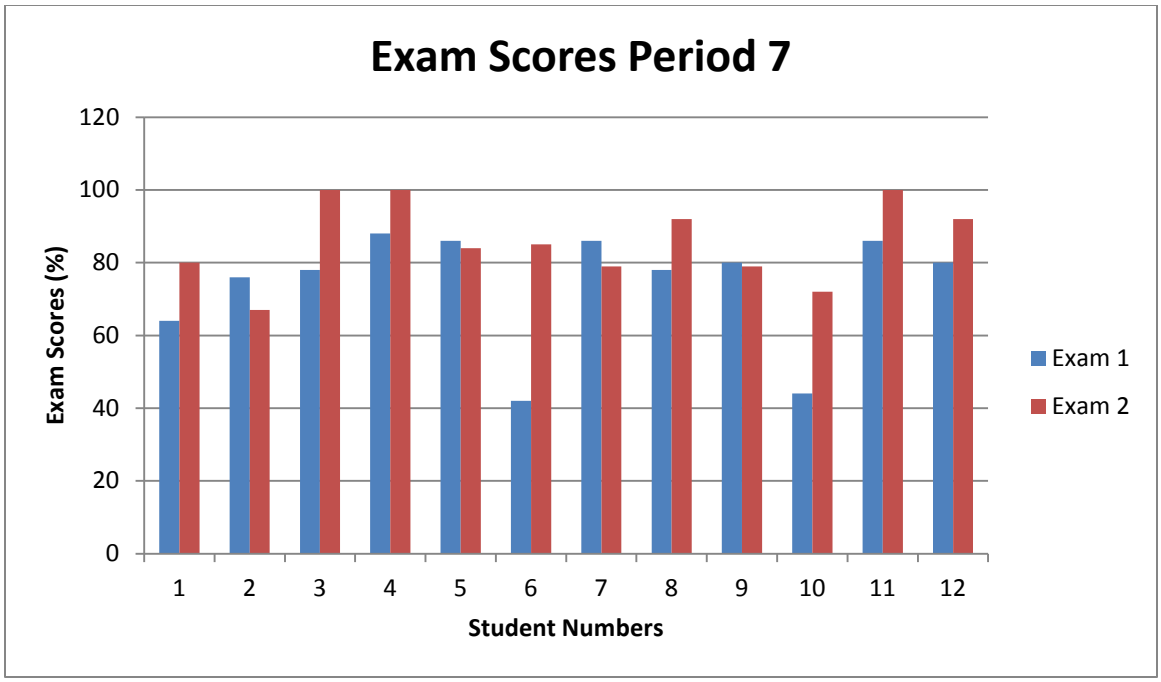


Figure 15: Exam Scores Period 7, (*N*=12).

This class period had four students who saw a drop in their exam scores. The range in drop was 1% to 9%. Although this drop was not significant it was a drop compared to the range of increase for students who were also present for all aspects of the study. When I looked at who the students were that had a drop in their exam scores, I realized these students all sat at the same table. I looked back at my field notes for this table and realized this group of students was one group that was often arguing about what to do, did not seem to work together as well as the other groups, and whenever there was a group off task during period seven, it was this group.

Based on the data I analyzed for exam scores, it seems that the SWH approach might have been a contributing factor in helping students to learn and understand the content. I wanted to make sure to not only look at just exam scores, but also to look at scores for individual students. When looking at this data for all three class periods, there

was a consistent increase in scores for students who were present for all aspects of the study. There was also a decrease in scores for those students who missed parts of the SWH treatment phase. Some students did not see any significant change from one exam to another. It would have been interesting to use the survey results to compare this data for individual students, but the surveys were anonymous so this was not possible. Exam data is always difficult to analyze as the content on each exam is very different, but after comparing the data for those students who were present for all aspects of the study with those students who were not, it seems that the SWH approach could have contributed to the increase in exam grades. The question remains which aspect of the approach had the biggest impact on overall student achievement? Exams were given at the conclusion of the unit, so determining which approach had the biggest impact was not conclusive. Another question to consider is that the exam following the treatment phase was the second district common course exam and students may have been more familiar with the format of the exam than they had been for the first exam.

Lab Reports

Students performed four inquiry lab experiences during the pre-treatment phase as well as four inquiry lab experiences during the treatment phase. Two of the inquiry lab experiences for each treatment phase required students to write a formal lab report based on a grading rubric (See Appendix F). There were two different rubrics that were used, one based on a four point standard based grading scale that allowed for total points of twelve and another that allowed for total points of twenty eight. The lab reports were graded using the rubrics and the rubrics allowed me as a teacher to assess how the students had comprehended the concepts. The rubric also allowed me to analyze depth of

answers and content as well as their understanding of what they did and why. Grades were given for the two different lab reports for each phase based on a score of twelve for one and a score of twenty eight for the other.

In order to analyze the data from the lab reports, I looked at the total score each student received out of either twelve or twenty eight for each of the four lab reports written. As I began to look at the data it was all over the place and there really was not a trend apparent. I decided to look at a straight class average of scores for each lab report in order to begin to see if there was a difference in student responses overall from pre-treatment phase to treatment phase (See Figure 16).

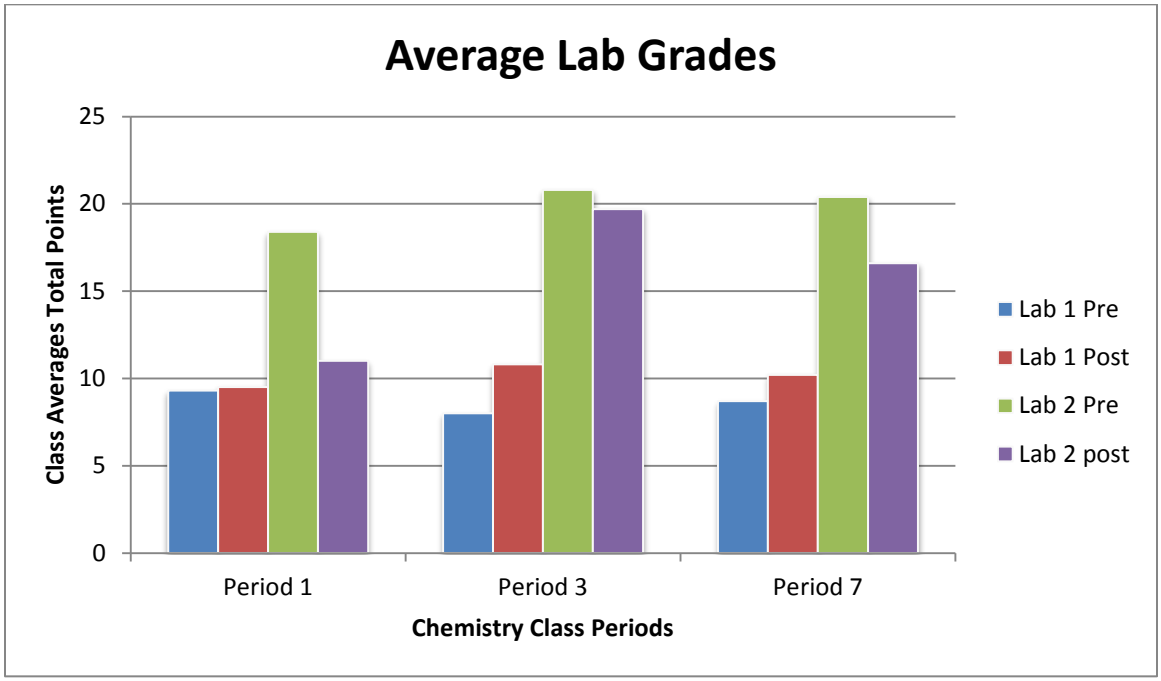


Figure 16: Average Lab Grades, (*N*=24 period 1, 26 period 3, and 25 period 7).

Period one did not have any change in the lab report graded on the 12 point rubric and a significant change in the 28 point rubric grade from pre-treatment to treatment phase. The class average dropped from an 18 to 11 from pre-treatment to treatment. In

order to determine if this change was due to the SWH approach or some other factor, I looked at individual scores for students to see if there was a trend. When looking at individual data for period one, there were six students who did not turn in the lab report pre-treatment and 11 who did not turn in the lab report during the treatment phase. This was recorded as a missing grade in the grade book and averaged in as a zero grade. This factor definitely contributed to the lower class average. Period seven also had a drop in the average grade for the 28 point rubric, from 20 to almost 17. For this class there were four students who did not turn in a lab report pre-treatment and seven during the treatment phase. These zero scores contributed to the class average dropping. As I continued to look at other individual scores, there really was not a trend that would answer whether or not the SWH approach contributed to an increase in understanding as seen in lab reports graded on a rubric. Students who did well on the lab reports pre-treatment phase also did well on their lab reports treatment phase. Students in the middle stayed in the middle and students who did not do well or did not turn in a report also did not do well or did not turn one in during the treatment phase.

As a science teacher, I have always struggled with finding ways for students to make connections between a lab or lab inquiry experience and the content we are covering in classes. Having students write formal lab reports is an expectation within our department and my hope was that the SWH approach to learning content would lead to increased understanding of science content as demonstrated by the grading of lab reports based on the rubric used. The data did not demonstrate that there was an increase in the understanding, but I cannot make a clear statement as to whether or not the SWH approach did or did not contribute to this. Many students did not turn in their reports,

students stayed the same, and on a whole the class averages did not move a great deal. Despite the data not providing a great deal of information about the benefits of the SWH approach, it did demonstrate that students still struggle with lab reports and making those connections and this is an area that I need to focus on as a teacher.

Teacher Reflective Journal

Throughout this process I kept a teacher reflective journal where I entered information, thoughts, and ideas about how the lessons went, my personal thoughts, and ways I might improve on or change things in the future. I tried to write in this journal each day during the treatment phase and the pre-treatment phase, but there were many days when this did not happen. During the total capstone research time of approximately eighteen weeks, journal entries were completed about 50 times. I knew that reading through all of these entries would provide valuable information, but I wanted to make sure I had a focus in mind; therefore I utilized the analytic deductive coding system (Zhan, 2011) to look through my teacher reflective journal. Two major themes seemed to appear over and over again within my journal entries; "worked well" and "next time I would." It was important to look at the entries to see what changes needed to be made and what things about the pre-treatment or treatment phase could be used in the future.

In order to answer the main research question, how does incorporating the SWH approach to science impact students and the sub question, what impact does this have on me, the teacher reflective journal provided information about what "worked well." In looking at the pre-treatment phase there were some things that went well. A journal entry that occurred consistently was that I was able to walk around and help students as they worked. I commented, "After instruction I was able to work my way around to each

grouping of students to make sure each group understood and was able to complete the activity. I was able to help students as needed." I also commented that students were asking me questions when they did not understand how to do something or did not understand something they were seeing. For one of the inquiry activities I commented, "It is nice to see students working together to solve a problem." Another time I commented, "Students were frustrated with the activity and wanted me to give them the answer and when I did not they worked together to figure out a solution."

When looking at the pre-treatment phase and journal entries regarding what I would do next time, I was surprised at how my journal entries seemed to guide the SWH approach without me even intentionally doing this. One topic that seemed to appear over and over again was the concept of collaborative work. In many of my journal entries, I was concerned that students were not working together in their groups. Comments included, "Students are in groups, but many are just socializing and not working." Another comment that occurred, "Students need more direction when given an inquiry task to work on as a group." As I looked back at my journal entries there was concern over and over again as to whether or not all students were being held accountable for the work being done in a group. I also had entries about the writing students were doing in their science journals. One such comment was made in my journal after grading notebooks while students were working independently. I stated, "Many of the students are writing notes, but did not write all the notes or did not complete the practice problems." I also stated, "Students do not write down their data for the inquiry labs." After such comments I reflected that I needed to make sure and do check-ins along the way to ensure students were doing what they were supposed to do. I also reflected on the

fact that I needed to find a way to make the groups more accountable so that all students were getting something out of the collaborative work.

During the treatment phase my journal entries about what worked well not only centered on the students, but also on myself. Many of the journal entries were focused on the fact that students got to work on the task immediately after instructions were given and roles were defined. One comment that sums this up nicely, "It usually takes students a long time to get working, but today they all got right to work." I also commented that as I walked around to check in on groups, the groups were asking each other questions and not asking me questions. When groups did ask me a question, it was usually after they had all tried to answer the question as a group. I also noticed that students were asking other groups what they thought as well and I commented, "Normally I would be upset that a student was talking to another group, but today they were asking questions about the data gathered in order to see if their data was correct." As I looked at the journal entries from the days where I had checked student work in their science journals, I reflected on the fact that students had written the background questions, they had written down what they did as well as observations. I made note that their writing was more complete and I did not have to search for information. I also commented that students were highlighting concepts in their notebooks, drawing pictures, as well as adding titles, dates and the notebooks appeared to be more organized.

The journal notes also dealt with what I would do next time. Looking at the treatment phase notes provided me with some insight as to how the SWH approach would allow me to do things differently in the future. This centered mostly on collaborative work. One comment that appeared over and over again was the comment that I would

make sure I took time prior to a lesson to define specific roles so that students knew the expectations. I stated the importance of pre-planning roles into my lesson plans for all activities. Along with this, my journal notes discussed the differences I saw when each section of the inquiry activity was planned out. My notes mentioned that, "The inquiry activities seemed to take the students longer because they were taking the time to work together." I also made the comment, "Students are taking the time to show each other the observations and discussing this with other groups." These reflections were followed by comments that it seems the very detailed way students were going through the activity with the SWH approach was worth the pre-planning on my part. I also noted that the activities take much longer. I commented, "In the past this would have taken one day, but now it is two days in. As I plan for next time I will need to take into account the amount of time these activities will take."

The journal entries did not provide me with quantitative data that I could use to say whether or not the SWH approach had a large impact on the students, or even me as a teacher, but the entries did give me qualitative data that I can use as I plan lessons in the future. The data demonstrated the impact the SWH approach had on the students mostly in the way they worked collaboratively. Based on my observations, students worked better with the SWH approach because a role was defined. Students also organized their notebooks better and seemed to take ownership of the work. The students were also working through problems together and the questions that were asked of me were only after the group had already tried to figure things out on their own. The data also demonstrated that the pre-planning I used during the SWH approach phase paid off because the lessons seemed to "work well" and students were engaged in the process of

learning and I was more of a facilitator. Because of this, there will be an impact on me as I plan lessons in the future.

INTERPRETATION AND CONCLUSION

Preparing students for college and beyond has always been a goal of mine. I see myself as a science teacher, but students cannot learn science or actively participate in science thinking if they cannot read science content, cannot write for understanding, and cannot collaborate. My action research set out to answer the question of whether or not the SWH approach to science inquiry would impact students in a high school science class. It also set out to answer questions about how the SWH approach would impact the ability of students to work collaboratively, read for understanding, demonstrate their understanding of science content, and finally how the SWH approach would impact me as a teacher. Looking back on this process and the time I have spent reflecting on numerous days of instruction, as well as analyzing the data, I have some conclusions about the SWH process and its impact on me and the students.

Collaborative Work

One of the questions I set out to answer was how the SWH approach would affect my students' abilities to work collaboratively. The SWH approach did have a positive impact on students' collaborative skills (23%-33% range increase of on task behavior pre-treatment to treatment phase). The SWH approach provided direction and a template students followed as they worked through inquiry activities. This approach made my job as a teacher take on a different role. As students were working through the different phases of the approach, I was able to help whole groups and I felt like I was spending less

time explaining concepts and much more time helping students to figure out concepts. Students were okay with this shift (10% more reported liking group work) and the classroom felt much more like a learning environment where all students were involved in the learning process. Whether I use the SWH approach for all inquiry activities or not, I will make sure to utilize roles when students are working in groups (23% increase in group work preference with role defined). This provided students with clear expectations and I believe high school students do better when they know what is expected of them. The SWH approach provides those expectations in a way that fits within the lessons and activities and does not feel artificial.

The one thing I can say about the SWH approach is that it takes a great deal more time. Lessons that normally would take one day and at the most two days, often took two and even three to four days to complete. At first I was concerned about taking so much longer to complete lessons, but in the end I think the skills the students gained through this process outweighed the length of time the lessons took. Students were collaborating much better not only within their groups, but also with other groups. Students writing and notebook organization improved. Finally, students did score higher on the district common assessment for the treatment phase versus the pre-treatment phase (12.6% average increase for all classes). As I plan lessons using the SWH approach in the future I will need to take into account the amount of time the lessons take and weigh the pros and cons of this. I think the students gained an understanding of the content by working through it on their own. This is a difficult skill and one that often times frustrated the students, but it is a problem solving and thinking skill the students all need to have as they move forward in their education.

Reading Science Content

The next question my action research set out to answer was whether or not the SWH approach would allow my students to read science content and use the science content to answer content related questions in chemistry. I had hoped the SWH approach would help students develop the skills they needed to read science content and use the reading to answer questions, justify answers, and analyze data. The SWH approach did not accomplish this. Students did not read the readings, did not understand them, and did not reference them in their answers to questions. Data from surveys demonstrated that only about three students increased their reading of the content during the treatment phase. The same number of students (N=18) did not read at all pre-treatment to treatment phase. There was a shift from the students who sometimes read and those that read all the time (8%), but the reasons were because it was assigned. The SWH approach had students read, but I do not feel students know how to read and the SWH approach does not do anything to address this issue. The approach just had students read, but I did nothing to help my students through that reading process. I do not think students understood the reason for the reading or the objectives behind it. I also think the readings might have been too high level or readings that did not directly relate to the content and students were not able to make the connections. We did have group and class discussions following each of the readings, but I do not see that students actually used this in any way. There was no reference to the readings on any of the exam free response questions. I think the reading component of the SWH approach is valid and could be very beneficial, but I think I need to find a way to instruct the students in reading for understanding. I need to instruct students how to read an article and make a connection between the

content and the article. I need to take time to make sure the reading component will accomplish its intent and that each reading is worth the time they take.

Assessment Grades

The impact that the SWH approach had on student understanding of science content as demonstrated on assessments was a third focus of my action research. The data that was analyzed in regards to quiz scores and lab scores did not demonstrate that the SWH approach had an impact on student grades. Period one grades on quizzes dropped from an average of 7.6 to 6.2, period three and period seven had no significant change. Period one data had some outliers as a new school tardy policy was implemented during the treatment phase and students who were tardy were not allowed in class. Students who were absent missed some of the collaborative work and this may have contributed to the decrease in quiz scores. The lab reports demonstrated a drop in average lab report grades (average of 18 to 11), but during the treatment phase there was an increase of five students who did not turn in a lab report and these grades count as zeros in the grade book. The exam grade data did demonstrate the SWH approach might have contributed to an increase in grades (11-13% increase pre-treatment to treatment). After looking at the data and the process involved in the SWH approach, I feel like students demonstrated a better understanding of the content mainly because they were talking about the content and were given numerous opportunities to discuss the content. I feel this helped them with their exams and not their quiz grades because the quizzes were taken after completing a section of the lessons only. As I graded the free response questions for both exams, I also noticed that the writing students did to explain their answers was much more complete.

In the end, I feel the SWH approach to science is definitely a benefit to the students and myself, but I do not feel I could use all aspects of the approach all of the time. I think the collaborative component involved is one aspect I will continue to use whenever doing an inquiry based activity. I also feel the directed writing involved in the SWH approach is one aspect that is beneficial and will be used. The reading component is one area that I feel needs to be modified to work within my classes. I think it is more about me taking the time to teach students how to read for understanding. With some modification and some modeling, I think that this could be a component that would work in the future. I also think I will have to really think about when and how to use the SWH approach because of the time it takes. I do not want to sacrifice content, but on the other hand I want students to learn the content in a very complete way. I look forward to planning future lessons using the SWH approach. Through this process, I feel like I have a better understanding of the process and how to best utilize aspects of this in my classes.

VALUE

My Classroom

The final question I hoped to answer with my action research was what impact the SWH approach would have on my teaching and evaluation of students. In the end, I feel the SWH approach to science is definitely a benefit to the students and myself, but I do not feel I could use all aspects of the approach all of the time. I think the collaborative component involved is one aspect I will continue to use whenever doing an inquiry based activity. I also feel the directed writing involved in the SWH approach is one aspect that is beneficial and will be used. The reading component is one area that I

feel needs to be modified to work within my classes. I think it is more about me taking the time to teach students how to read for understanding. With some modification and some modeling, I think that this could be a component that would work in the future. I also think I will have to really think about when and how to use the SWH approach because of the time it takes. I do not want to sacrifice content, but on the other hand I want students to learn the content in a very complete way. I look forward to planning future lessons using the SWH approach. Through this process, I feel like I have a better understanding of the process and how to best utilize aspects of this in my classes.

Being the instructional leader of the science department within my school, it is my responsibility to help the other science teachers with best practices. It is because of the conversations I have had with department members that I looked at the SWH approach and looked at the problems students face when confronted with science inquiry lessons. My hope is that I can share what I have learned from this experience and open up the conversation about how we as teachers approach collaboration, writing, reading, and inquiry within each of our classes. It is my plan to share my findings and lessons so that they can try them within their classes and we can collect more data to see if this was something unique to my classes or if the trends I noticed occur within their classes as well. I would also hope that the conversations we have can center on other ways to provide these skills to students. Often we discuss these issues, but we never take the time to look at what we can do about this.

As our school district adopts the Common Core Standards and the Next Generation Science Standards, all of the science teachers within my department will need to look at the skills students need to be successful in school and beyond. Teachers will

need to reflect on how they can provide opportunities for students to practice these skills. As our school makes a shift to becoming a STEM high school with a problem based and inquiry focus these skills will become even more important and I would like to explore other ways these skills can be incorporated into the classroom besides the SWH approach. I think the SWH approach has provided me with a foundation I can use and expand on.

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APPENDICES

APPENDIX A

IRB APPROVAL

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Lori Egan and Walter Woolbaugh

FROM: Mark Quinn, Chair Mark Quinn Chy

DATE: November 13, 2012

RE: *"The Effect of Incorporating the Science Writing Heuristic Approach to Inquiry Activities in a High School Science Classroom"* [LE111312-EX]

The above research, described in your submission of November 13, 2012, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

SCIENCE WRITING HEURISTIC TEACHER VS STUDENT COMPONENTS

Teacher Components	Student Components
Exploration of pre-instruction understanding	Beginning ideas (What are my questions?)

Lab activities: Planning for teacher
• Informal writing
  o What will students write down?
• Making observations
  o What should students see?
  o What do I want them to see?
• Brainstorming
  o How will students compare data?
  o How will data be displayed?
• Posing questions
  o How will I determine what students know?
	Lab activities: Writing component for student
	• What did I do
	• What did I see (observations)
	• How do my observations compare with other groups?
	• How can I interpret what I see?

Interpretation • What should students determine? • What is objective or goal?	Claim • What can I claim based on my observations and data? Evidence • How can I support my claim?
Science Reading • What reading will connect material and content?	Science Reading • How do my ideas compare to ideas from reading?
Presentation • How will students present their findings?	Reflection: • How have my ideas changed? • What have I learned
Post-instruction understanding • How will I determine what students have learned?	Post-instruction understanding • What did I learn and how does it relate to content?

APPENDIX C

STUDENT PRE-TREATMENT SURVEY

Post-Treatment Student Survey: Participation in this survey is voluntary and participation or non-participation will not affect a student's grade or class standing in any way.

Directions: Read each question and circle a response. If the question asks for an explanation, please provide one.

1. Do you like group work or working alone?
    a. Yes
    b. No
    Explain:

2. Do you learn better working alone or working in a group?
    a. Alone
    b. Group
    Explain:

3. When working in groups, how often are you able to perform your role?
    a. 100% of the time
    b. 50-75 % of the time
    c. Less than 50% of the time
    Explain:

4. During the lab activities, did you discuss the activity with your group members and/or other groups?
    a. Yes
    b. No
    Explain:

5. Does discussing the results with other groups help you to understand the content?
    a. Yes
    b. No
    Explain:

6. When doing group work, are you aware of the expectations for the group?
    a. Yes
    b. No
    Explain

7. Explain what you like about group work and what you do not like about group work.

8. Describe the difference between group work and collaboration.

9. How often did you read the science related content?
    a. Not at all
    b. Sometimes
    c. All the time

    Explain:

10. Were you able to understand science content when you read it?
    a. Yes
    b. No

    Explain:

11. Did you read textbooks, internet sites, articles, etc to help you understand the science content?
    a. Yes
    b. No

    Explain:

12. Did you use reading materials and/or the internet to help you answer science questions and/or write conclusions?
    a. Yes
    b. No

    Explain:

13. Did you use information from group work to answer questions on quizzes and tests?
    a. Yes
    b. No

    Explain:

14. Did you use information from readings, labs, conclusions, etc. to study for exams?
    a. Yes
    b. No

    Explain:

APPENDIX D

STUDENT POST-TREATMENT SURVEY

Post-Treatment Student Survey: Participation in this survey is voluntary and participation or non-participation will not affect a student's grade or class standing in any way.

Directions: Read each question and circle a response. If the question asks for an explanation, please provide one.

1. Do you like group work when a role has been defined for each student?
    a. Yes
    b. No

    Explain:

2. Do you learn better working alone or working in a group?
    a. Alone
    b. Group

    Explain:

3. When working in groups, how often are you able to perform your role?
    a. 100% of the time
    b. 50-75 % of the time
    c. Less than 50% of the time

    Explain:

4. During the lab activities, did you discuss the activity with your group members and/or other groups?
    a. Yes
    b. No

    Explain:

5. Does discussing the results with other groups help you to understand the content?
    a. Yes
    b. No

    Explain:

6. When doing group work, are you aware of the expectations for the group?
    a. Yes
    b. No

    Explain:

7. Explain what you like about group work and what you do not like about group work.

8. Describe the difference between group work and collaboration.
9. How often did you read the science related content?
    a. Not at all
    b. Sometimes
    c. All the time

    Explain:

10. Were you able to understand science content when you read it?
    a. Yes
    b. No

    Explain:

11. Did you read textbooks, internet sites, articles, etc to help you understand the science content?
    a. Yes
    b. No

    Explain:

12. Did you use reading materials and/or the internet to help you answer science questions and/or write conclusions?
    a. Yes
    b. No

    Explain:

13. Did you use information from group work to answer questions on quizzes and tests?
    a. Yes
    b. No

    Explain:

14. Did you use information from readings, labs, conclusions, etc. to study for exams?
    a. Yes
    b. No

    Explain:

APPENDIX E

TEACHER REFLECTIVE JOURNAL NOTE ORGANIZER

Teacher Reflective Journal (Pre-Treatment)			
Activity	What went well? Not so well?	What would I change in the future?	What questions do I have now?

APPENDIX F

CODES FOR TEACHER REFLECTIVE JOURNAL

Code	Reflective notes
Collaboration	
Inquiry **Key words:** ***Struggle*** ***Direction***	**Reflective notes on how students handle inquiry activities:**
Discussion **Key Words:** ***Argued*** ***Worked alone*** ***Followed*** ***Discussed***	
Guided Questions **Key Words:** ***Background***	

APPENDIX G

LAB REPORT GRADING RUBRICS

	1 Developing or incomplete	2 Partially Proficient	3 Proficient	4 Advanced
Introduction	Very little background information provided or information is incorrect	Some introductory information, but still missing some major points. Purpose is not clearly written or absent.	Introduction is nearly complete, missing some minor points. Purpose present, some organization	Introduction complete and well-written; provides all necessary background principles for the experiment. Purpose of the lab is clear.
Materials	Materials are missing or missing many of the key materials	Some materials are missing and/or names are incorrect	Most of materials are present and/or most written with correct names and amounts/units	All materials listed with correct name, units and amounts
Experimental procedure	Missing several important experimental details and difficult to follow.	Missing some important experimental details	Important experimental details are covered, some minor details missing	Well-written, all experimental details are covered, easy to follow.
Results: data, figures, graphs, tables, etc.	Figures, graphs, tables contain errors or are poorly constructed, have missing titles, captions or numbers, units missing or incorrect, etc.	Most figures, graphs, tables OK, some still missing some important or required features	All figures, graphs, tables are correctly drawn, but some have minor problems or could still be improved	All figures, graphs, tables are correctly drawn, are numbered and contain titles/captions.
Conclusions	Does not include a claim and/or claim is found at the end of the conclusion. No evidence/data. Evidence has little to do with claim. No justification and/or minimal attempt.	Claim does have any relation to concept and/or cannot be supported with data. Minimal evidence and/or not related or doesn't support the claim. No organization to use of data/evidence. Reason provided, but is not tied to content.	Uses Claim, Data, and Justification. Strong statement Can be supported with data. Uses "I claim" Uses evidence /data but does not provide an organization that supports the claim. Related to the claim**.** Provides a reason why, but does not demonstrate an understanding of the content using concepts from notes, reading, etc.	Uses Claim, Data, and Justification. Strong statement. Can be supported with data. Answers the question fully (if applicable) Does not use "I claim" Uses multiple evidences/data to support claim. Discusses evidence in an organized way. Related to the claim. Provides a reason for the claim and how the evidence supports the claim based on content material, class notes, reading, etc. Demonstrates how concepts relate to the claim and data.
Spelling, grammar, sentence structure	Frequent grammar and/or spelling errors, writing style is rough and immature	Occasional grammar/spelling errors, generally readable with some rough spots in writing style	Less than 3 grammar/spelling errors, mature, readable style	All grammar/spelling correct and very well-written
Appearance and formatting	Sections out of order, sloppy formatting	Sections in order, contains the formatting but is rough but readable	All sections in order, formatting generally good but could still be improved	All sections in order, well-formatted, very readable

	1 Developing or incomplete	2 Partially Proficient	3 Proficient	4 Advanced
Introduction	Very little background information provided or information is incorrect	Some introductory information, but still missing some major points. Purpose is not clearly written or absent.	Introduction is nearly complete, missing some minor points. Purpose present, some organization	Introduction complete and well-written; provides all necessary background principles for the experiment. Purpose of the lab is clear.
Results: data, figures, graphs, tables, etc.	Figures, graphs, tables contain errors or are poorly constructed, have missing titles, captions or numbers, units missing or incorrect, etc.	Most figures, graphs, tables OK, some still missing some important or required features	All figures, graphs, tables are correctly drawn, but some have minor problems or could still be improved	All figures, graphs, tables are correctly drawn, are numbered and contain titles/captions.
Conclusions	Does not include a claim and/or claim is found at the end of the conclusion. No evidence/data. Evidence has little to do with claim. No justification and/or minimal attempt.	Claim does have any relation to concept and/or cannot be supported with data. Minimal evidence and/or not related or doesn't support the claim. No organization to use of data/evidence. Reason provided, but is not tied to content.	Uses Claim, Data, and Justification. Strong statement Can be supported with data. Uses "I claim" Uses evidence /data but does not provide an organization that supports the claim. Related to the claim. Provides a reason why, but does not demonstrate an understanding of the content using concepts from notes, reading, etc.	Uses Claim, Data, and Justification. Strong statement. Can be supported with data. Answers the question fully (if applicable) Does not use "I claim" Uses multiple evidences/data to support claim. Discusses evidence in an organized way. Related to the claim. Provides a reason for the claim and how the evidence supports the claim based on content material, class notes, reading, etc. Demonstrates how concepts relate to the claim and data.