

INTERACTIVE SCIENCE NOTEBOOKS IN THE SECONDARY CHEMISTRY
CLASSROOM

by

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ABSTRACT

Interactive science notebooks are a popular tool in many science classrooms across the country. However, each teacher should evaluate carefully if interactive science notebooks are the right choice for his or her classroom. The purpose of this project was to evaluate the effectiveness of interactive science notebooks in one science classroom as well as student opinions on the use of interactive science notebooks. The interactive science notebooks were implemented for two and a half months. Also, students were surveyed and interviewed before and after the implementation of the interactive science notebooks. The results were then compared to the traditional classroom model that was used previously. It was determined that the students liked the interactive science notebooks. They also had a positive effect on classroom achievement as pre- and post-test results were highly consistent throughout the use of the interactive science notebooks. This consistency was not seen with the traditional classroom model.

INTRODUCTION AND BACKGROUND

Bell City High School is a pre-K to 12 school of 715 students located in an unincorporated area in rural southwestern Louisiana. The student population is 90.5% Caucasian, 5% Hispanic, 3.8% African American, and 0.7% other ethnicities (R.S. Nunez, personal communication, February 6, 2017). I have taught at Bell City High since graduating from college with my bachelor's degree in 2012. Currently, I teach four subjects, including Biology II, chemistry, physical science, and physics. I typically teach between 85-100 students per year. My average class size tends to fall around 16, but I have had classes as small as 3 students and as large as 27 students.

Although I teach in a small school, the district is much larger. Calcasieu Parish School Board has 13 high schools and over 32,000 students in grades pre-K to 12 ("Calcasieu Parish School Board Quick Facts", n.d.). Each August, the high school teachers begin the year by meeting in groups according to the subject area they teach. At the in-service that started the 2015-2016 school year, the science department was given a brief presentation on resources available regarding interactive science notebooks (ISN). We were encouraged to try the notebooks in our classrooms. I was left intrigued, but skeptical, as no evidence of the effectiveness of ISNs was included. After this presentation, several colleagues from multiple schools attempted to integrate ISNs over the following school year. As I found out at various meetings during the school year, they experienced varying degrees of success.

Throughout that year while others were utilizing ISNs, I maintained my current approach of allowing my students to determine for themselves how to keep track of their

notes and work. Students used a variety of methods including binders, folders, and notebooks; some even used nothing at all. However, my curiosity regarding the ISN remained. I made the decision to attempt the use of ISN in my own classroom. I chose my chemistry courses for this trial because, apart from transfer students, I was already familiar with the students in this course. When I previously taught many of them physical science, I noticed that this group of students could use help with organizational skills.

As a direct result of these events and observations, in addition to conferring with my supervisors, I composed the following focus question for my research, *how will integration of interactive science notebooks affect student achievement in my secondary chemistry classroom?* In addition, the following subquestions were researched

1. Will the use of interactive science notebooks be more effective than allowing students to determine their own form of record keeping?
2. What are student opinions regarding interactive science notebooks, and do those opinions change as a result of their integration into my classroom?

CONCEPTUAL FRAMEWORK

Waldman and Crippen (2009) stated that an interactive science notebook (ISN) provided techniques and opportunities for students to create an organized, documented record of their personal learning. Roberson and Lankford (2010) added that any notebook, including ISNs, used during laboratory work gave students the opportunity to explore the nature of science. Additionally, notebooks allow students an opportunity to practice their scientific communication skills. Ruiz-Primo et al. preferred the use of the term science notebook rather than the term science journal as the latter could possibly be

misunderstood to be a diary. They added that science notebooks are simply a log of what students do when they are in science class. Each entry in an ISN will vary as a reflection of the many diverse types of activities that are typically carried out in a science classroom. (Ruiz-Primo, Li, Ayala, & Shavelson, 2004).

Some of the most effective ISNs included a three-part learning cycle of in activities, out activities, and through activities that created a daily rhythm to each class. In activities serve as beginning of class activities to review previously taught concepts, to introduce the new material to be covered that day, or to assess students' prior knowledge on a topic. Waldman and Crippen (2009) recommend that these activities last no more than five minutes. The activities could be done alone or in small groups while the teacher circulates around the room to provide feedback prior to using the activity as a launching point for the day. Through activities follow in activities in the classroom routine. Through activities are designed to cover course content. The methods used to cover the content may vary with lectures, discussions, labs, and the viewing of videos all meeting the standards for through activities. The out activities follow the through activities to end the class period. Out activities are used to practice and apply key ideas or to create connections among ideas. Teachers begin out activities by providing the prompts to get students started, but students direct the activities through their responses to the teacher's prompt. The in and out activities work together to provide the power of the ISNs as a teaching tool. These activities are meant to assess student understanding throughout the learning process, to engage students with new material by allowing them to demonstrate learning by creating responses that prove their understanding, and to encourage

metacognition. Additionally, in and out activities are made unique by allowing students critical time to synthesize information and demonstrate that synthesis with their finished products. The strategies used for in and out activities are interchangeable and include drawings, writing opinions, compare/contrast, making connections between the classroom and the real world, practice problems, and reflections (Waldman & Crippen, 2009).

There is some variation in this three-step process and different variations may work better for some teachers. According to Young (2003), the right side of an interactive notebook is best used for input activities, such as lectures and labs, while the left side is used for output activities, such as drawings, reflections, and worksheets. In Waldman and Crippen's (2009) process, the in and out activities would be on the left side of the notebook, while through activities would be on the right side of the notebook. Chesbro added to Young by stating an output activity should promote higher-order thinking skills. The student should be allowed to demonstrate that they understand the material using a method that works for them (Chesbro, 2009).

According to Lener (2010), ISNs can be a good long term record of student activities. As she pointed out, scientists do not throw out their old notebooks and start over again from scratch at the end of every year. Yet, many schools expected their students to start fresh with a new notebook every year. But this decision is left to the discretion of the individual teacher. In fact, the teacher's attitude towards the ISN, the directions given to the students, and areas of emphasis all directly influenced the quality, quantity, and organization of the student work that resulted (Butler & Nesbit, 2008).

Students who have no prior experience with ISNs will need guidance to use them effectively. A class discussion of the importance of keeping a science notebook is a good place to begin guidance. When the ISNs are first introduced, students may need guided reflections to get them started on the process (Young, 2003). Waldman and Crippen (2009) believe that time for self-reflection is critical as it allows students to identify areas where their understanding is still weak. This allows them to establish relevance of the material presented by the teacher to their everyday lives outside of the classroom.

Writing is a powerful tool for student learning, and the ISN gives students more opportunities to write. ISNs are particularly powerful when they are used for laboratory work. Scientists use notebooks to record their questions, experiments, data, observations, analysis of data, and conclusions. Students get an authentic science experience when notebooks are used in the classroom. Keeping a notebook during laboratory activities allows students to develop and practice both observation skills and experimental design skills (Roberson & Lankford, 2010). According to Butler and Nesbit (2008), typical lab report entries include “date and time, question, prediction, procedure that includes collection of data, conclusions, and line of learning” (p. 137). The line of learning takes place when students apply their understanding of a concept to new and different situations while increasing their knowledge of science vocabulary. The process of writing to make sense of the experiments they have carried out helps students move from simply writing down what they remember to constructing their own knowledge (Butler & Nesbit, 2008).

Providing time to write in the notebooks daily can be challenging, especially when the notebooks are first introduced. Planning is important, but the integration becomes easier over time. The amount of time needed will depend on the day's activities. During some activities, such as labs, it may be important for students to pause during their work and take time to reflect. At other times, it may be easiest to write at the end of the activity. Regardless, a few minutes at the end of class should be set aside for students to write about what they have learned, reflect, and ask lingering questions they have (Young, 2003). Weekly journaling is one way of incorporating additional writing practice into the science classroom. The journal entries give students an opportunity to synthesize in their own words the material covered in science class that week. In addition, the prompts can allow students to discuss the science they are interested in at the moment, even if it is not necessarily a part of the curriculum (Fingon & Fingon, 2008).

Of course, all this writing means nothing if it is not organized. Personal classroom research showed that the increased organization of materials that ISNs provided led to students having a positive perception of ISNs as tools for learning science. ISNs also allowed students to express their personal views of topics. When they know how to locate the materials they need quickly, students feel more confident in their abilities in the science classroom. Over time, students learn how to control their learning, which can contribute to student confidence and ownership of work (Waldman & Crippen, 2009).

An ISN can be used over the course of multiple years if it is not filled up in a single year. Lener (2010) and her colleagues use the same notebook from third grade to sixth grade. The notebooks are collected at the end of every year. The material of

previous years becomes reference material for students. As all teachers use the same system of organization, students are familiar with how to organize their ISNs each year.

While ISNs tend to be used primarily at the elementary, middle, and secondary levels as seen so far, they can also be used at the post-secondary level as well. For example, in college biology students can add color to their ISN, as this helps improve the level of organization. At the most basic level of supplies required, Stencil (1998) recommends that students have access to red, green, blue, and black colored pencils during activities to draw attention to important facts or color and label drawings.

While it is important as a teacher to have the skills necessary to help students with organizational skills, it is just as important to be able to successfully assess students' work and provide appropriate feedback. Using ISNs as an assessment tool allows teachers to embed the assessment into instruction and have a source of student understanding that can drive decisions on adjustments that may need to be made to instruction (Morrison, 2005). According to Ruiz-Primo et al. (2004), students who score high on science notebook assessment tended, on average, to also score high on performance assessments. But to score high on science notebook assessment students should be made aware early on exactly how their ISN will be assessed. Some of the things to be considered include the completion of the entries, as well as the effort and thought that has been put into the writing. Student notebooks should be held to the appropriate writing standards for the student's grade level. They should be checked often to ensure that they meet these standards. Collaboration with an English teacher may be necessary as confusion may be the result if the writing standards vary across classes. In

addition, the method of feedback will vary per teacher preferences. Some teachers may prefer to use sticky notes (Young, 2003). Waldman and Crippen (2009) emphasized that all feedback on assessments should be in one place in all notebooks for long term storage. Chesbro (2006) agreed and preferred students leave the first page empty for the use of marking scores for notebook assessments. His students have an assessment rubric taped inside the front cover. When it comes to the composition of the feedback given, Fingon and Fingon (2008) recommended the use of both general praise and more specific questions designed to either encourage continued discussion or to guide students who need more support.

However, Ruiz-Primo, et al. presented a word of caution on assessment of writing skills. They contend that many teachers do not know how to provide useful, quality feedback to students. They add that this can diminish the effectiveness of the ISN because the feedback, or lack thereof, does not redirect students to address shortcomings in their work. In fact, the group attributes this lack of feedback on writing by the teachers in their study to the lack of improvement in students' writing skills. The students in their study declined in communication skills from the fall semester to the spring semester (Ruiz-Primo et al., 2004).

In addition to assessment of writing skills, general assessment of ISNs should take place often. Assessment should include both quick checks and more in-depth evaluations. Examples of quick checks include visual inspection by the teacher (either through walking around the classroom or having all students hold up their notebooks), student completion of a short self-evaluation form that the teacher has designed, or the use of a

simple three-point rating scale. On this scale, exemplary work receives a three, adequate work receives a two, and incomplete attempts receive a one. For more in-depth evaluation, rubrics should be used to assess quality, completion, organization, effort, and improvement (Waldman & Crippen, 2009). According to the Ruiz-Primo et al. (2004) study, it is possible for notebooks to be scored consistently by different teachers if a sound grading framework is in place. This is good for larger schools where subjects have multiple teachers.

Feedback, assessment, and grades should all combine cohesively for ISNs to have the greatest impact on student learning. Feedback should be both positive and constructive. Grading should be based on completeness and effort according to a rubric (Young, 2003). Waldman and Crippen (2009) observed a proportional increase in students' overall quarter grades as their notebook scores for the same time period increased. They believe that ISNs have a significant effect on the increase of student learning.

When it comes to student learning and grades, self-assessment can become a very powerful tool if implemented correctly. Chesbro (2006) encouraged students to complete self-evaluations of their ISN. While this can be done at any time, he chooses to implement them at the end of the school year. He found that the self-evaluation scores were very close to the scores that he assigned the same work when grading it himself after the self-evaluation. The students were very honest with their comments and feedback on their own work.

As the research demonstrates, ISNs can be a powerful learning tool. However, it is critical that the ISN be integrated with the proper training on use, grading, and regular feedback. In fact, Morrison (2005) found that pre-service teachers who were trained in the use of science notebooks stated they were very likely to use them as a formative assessment tool for assessing both science and writing in their future classrooms. This training required no additional courses, as it was integrated as a component of the science teaching methods courses the students were already required to take.

METHODOLOGY

Incorporation of the interactive science notebooks (ISN) took place during the second half of the 2016-2017 school year, with two pre-treatment units taking place during the first half of the year. The 47 chemistry students were supplied with notebooks to use during the treatment phase. These students were split into two classes. The 5th period chemistry class had 21 students with 2 students exempt from final data. The 7th period chemistry class had 26 students with 4 students exempt from final data. The use of these notebooks began on January 3, 2017, which was the day that students returned from Christmas break. 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). Consent from the school principal for the research was also obtained (Appendix B).

Two pre-treatment units took place during the first half of the school year. Data collected during these units included pre- and post-test data as well as teacher journaling. There was no change in the teaching methods that were normally used during the pre-

treatment units. The first of these two units took place during the month of October with the pre-test administered at the end of September. The Periodic Trends Pre- and Post-Test was used with this unit (Appendix C). This content test covered electron configurations, electron energy and light, and the trends of the periodic table because of its organization by increasing atomic number. Both the pre- and post-tests were administered as all tests are in my classroom with students recording their answers for the test on a separate piece of paper. The test questions included a mixture of multiple choice and various forms of short answer questions. After the pre- and post-tests were graded, the results were analyzed for normalized gains to assess students' growth in knowledge as a result of the unit. The normalized gains were placed into one of three categories. Low gains were all those lower than 0.3. Medium gains were all those between 0.3 and 0.7. High gains were all those higher than 0.7 (Hake, 1998).

The second of these two units took place during the months of November and December with the pre-test administered in mid-November. The Chemical Names and Formulas Pre- and Post-Test was used with this unit (Appendix D). This content test covered naming and writing formulas for ionic compounds, covalent compounds, and acids. Both the pre- and post-tests were administered with students recording their answers for the test on a separate piece of paper. The test questions included a mixture of multiple choice and various forms of short answer questions. After the pre- and post-tests were graded, the results were analyzed for normalized gains to assess students' growth in knowledge as a result of the unit. The normalized gains were placed into one of the categories of low, medium, and high gains as described by Hake (1998).

In mid-December, the Pre-Treatment Interactive Science Notebook Survey and Interview took place. The Interactive Science Notebook Survey was administered to the students (Appendix E). This Likert survey asked students about their attitudes toward science and interactive science notebooks. In this scale, a score of four represented they *strongly agree* with the statement, a score of three represented the students *agree* with the statement, a score of two represented the students *disagree* with the statement, and a score of one represented the students *strongly disagree* with the statement. The students were given the Interactive Science Notebook Surveys and instructed to complete them without discussing the questions with their classmates. They were permitted to ask for clarification if they did not understand what a statement meant. After the pre- and post-treatment Interactive Science Notebook Surveys were complete, the results were analyzed using the Wilcoxon Signed Rank Test.

After the pre-treatment Interactive Science Notebook Survey, five students from each class were randomly selected to take part in the pre-treatment interview, which used the Interview Questions (Appendix F). These interviews took place during the school's daily 30-minute Response to Intervention period. Each of the two class period's students were interviewed in separate groups of five to foster conversation in the smaller groups. The interviews were recorded on a school-issued iPad and were later transcribed. After transcription was complete, a student from each interview group was selected to delete the recording so that the students could feel comfortable that recordings no longer existed once they were not necessary. The pre-treatment interviews were analyzed for themes and used to support other data.

The ISNs were used for three units during the second half of the year. The notebooks were assessed once a week using the Rubric for Interactive Science Notebook Assessment (Appendix G). This rubric looked for completion of the notebook activities for the week with fidelity. The rubric also looked at organization and creativity as necessary. The ISNs were analyzed quantitatively using the Rubric for Interactive Science Notebook Assessment to look for themes and evidence of student understanding. This data was also used for comparison with the results of the content pre- and post-tests.

The first of the three units for the treatment used the Chemical Quantities Pre- and Post-Test (Appendix H). This content test covered the mole, mole to representative particle conversions, molar mass, mole to molar mass conversions, molar volume, mole to molar volume conversions, and density of gases using molar volume. The second of the three units for the treatment used the Chemical Reactions Pre- and Post-Test (Appendix I). This content test covered writing and balancing chemical equations, the five types of chemical reactions, and net ionic equations. The third of the three units for the treatment used the Stoichiometry Pre- and Post-Test (Appendix J). This content test covered basic stoichiometric calculations including the concept of limiting reagent.

For each of the three treatment units, the same test administration procedures were followed. Both the pre- and post-tests were administered as all tests are in my classroom with students recording their answers for the test on a separate piece of paper. The test questions included a mixture of multiple choice and various forms of short answer questions. After the pre- and post-tests were graded, the results were analyzed for normalized gains to assess students' growth in knowledge as a result of the unit. The

normalized gains were placed into one of the categories of low, medium, and high gains as described by Hake (1998).

A final data source for the treatment units was the teacher journal, which was kept in a basic notebook with no specific labeling on the cover to discourage students from looking in the journal. The journal entries noted the date, the topic being taught, and any issues or notes about the day's events. The journal entry had one entry for each chemistry class. If possible, the entry was completed immediately after class ended. If that was not possible, the entries were completed at the end of the school day, which was no more than three hours after the first chemistry class. The teacher journal was analyzed for themes and used to support other data.

In March, as the end of the third treatment unit approached, the post-treatment Interactive Science Notebooks Survey and Interview took place. The Interactive Science Notebook Survey was again administered to all 47 students (Appendix E). This Likert survey asked students about their attitudes toward science and interactive science notebooks. In this scale, a score of four represents they *strongly agree* with the statement, a score of three represents the students *agree* with the statement, a score of two represents the students *disagree* with the statement, and a score of one represents the students *strongly disagree* with the statement. The students were given the Interactive Science Notebook Surveys and instructed to complete them without discussing the questions with their classmates, but were permitted to ask the teacher for clarification if they did not understand what a statement meant. After the pre- and post-treatment Interactive Science

Notebook Surveys were complete, the results were analyzed using the Wilcoxon Signed Rank Test.

After the post-treatment Interactive Science Notebook Survey, five students from each class were randomly selected to take part in the post-treatment interview, which used the Interview Questions (Appendix F). The students were different than the students who took part in the pre-treatment survey. These interviews were conducted using the same structure as the pre-treatment interviews. The students were interviewed in two groups of five students during our RTI period. After transcription, the students deleted the recording of the interview. The post-treatment interviews were analyzed for themes and used to support other data (Table 1).

Table 1
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3	Data Source 4
<i>Primary Question</i>				
How will integration of interactive science notebooks affect student achievement in my secondary chemistry classroom?	Content Pre- and Post-tests	Student Work Samples Analyzed with Rubrics	Teacher Journal	Interactive Science Notebooks Pre- and Post-Treatment Survey
<i>Secondary Questions</i>				
Will the use of interactive science notebooks be more effective than allowing students to determine their own form of record keeping?	Content Pre- and Post-Tests	Interactive Science Notebooks Pre- and Post-Treatment Survey	Interviews	Teacher Journal
What are student opinions regarding interactive science notebooks, and do those opinions change as a result of their integration into my classroom?	Interactive Science Notebooks Pre- and Post-Treatment Survey	Interviews	Teacher Journal	Student Work Samples Analyzed with Rubrics

DATA AND ANALYSIS

The results of the Periodic Trends Pre- and Post-Tests (Appendix C), which used multiple choice, fill-in-the-blank, and short answer questions to assess the content knowledge of the students, had an average normalized gain of 0.69 ($N=41$) (Figure 1). According to Hake (1998), this is considered to be a *medium* normalized gain since it falls between 0.31 and 0.70. The results of the Chemical names and Formulas Pre- and Post-Tests (Appendix D), which used the same variety of questions as the Periodic Trends Pre- and Post-Tests, had an average normalized gain of 0.81, a *high* gain (Figure

2). The teacher journal has evidence to support the high normalized gain. Many students would state during these lessons that they remembered this concept from physical science, where many of the same ideas are taught using simpler compounds than those that are typically seen in chemistry lessons.

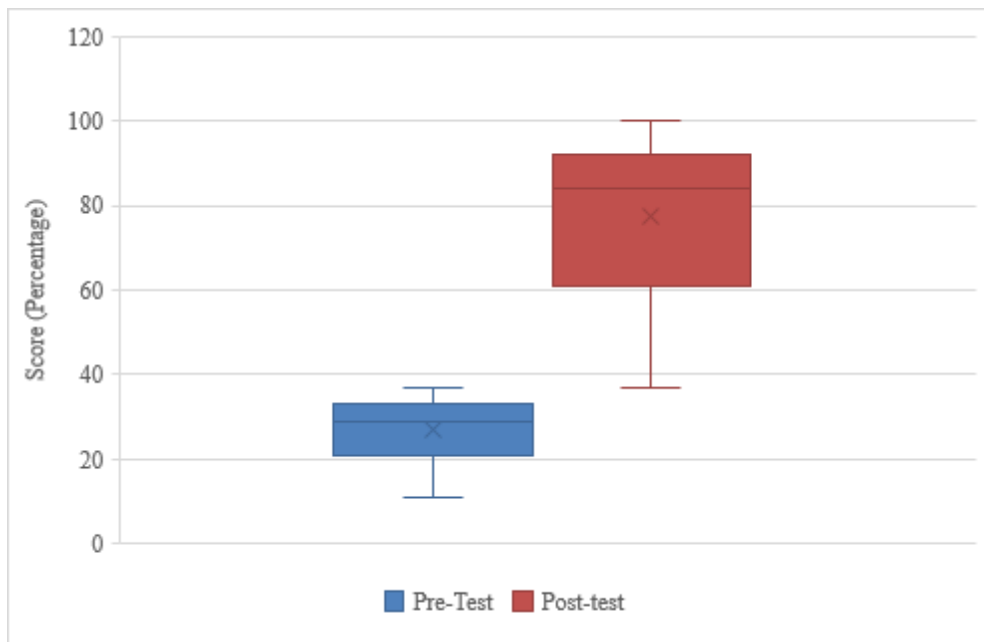


Figure 1. Periodic trends pre- and post-test score distributions, ($N=41$).

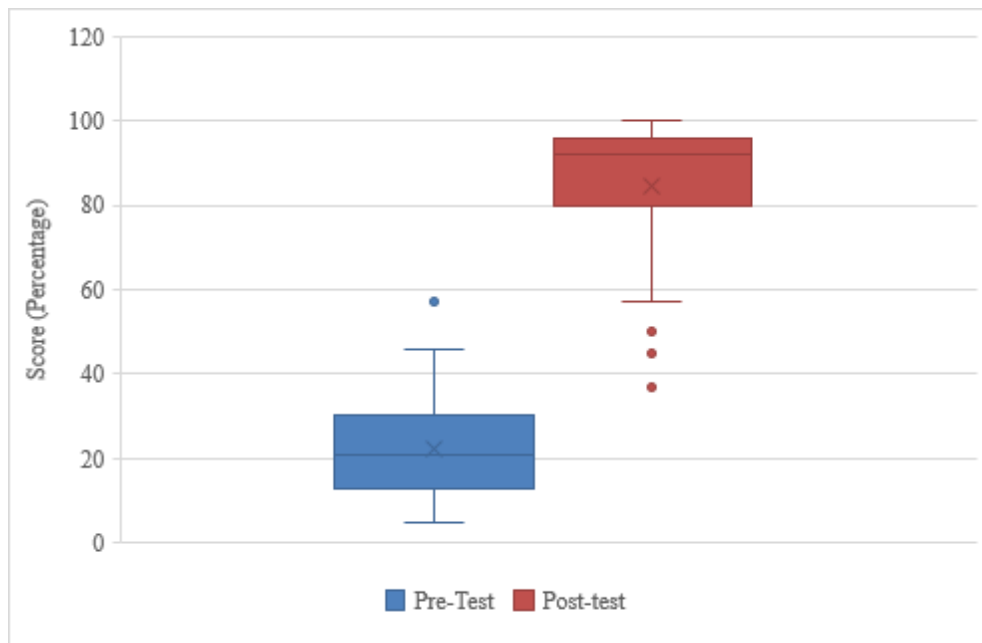


Figure 2. Chemical names and formulas pre- and post-test score distributions, ($N=41$).

When students were asked how they organized their materials during the two pre-treatment units, there were a variety of responses. One student stated, “I have all of my notes in a notebook. Then I have all of my loose papers in a folder.” Another student added, “In a one -subject notebook with a pocket at the front of the notebook. I put my worksheets in the pocket and my notes in order by chapter with any other stuff for that chapter following the notes.” A third student added, “I have all of my papers and notes in my textbook.” A fourth student added, “Everything has gotten so out of order I end up just using the next open page in whatever notebook I have with me.” The teacher journal entries for these two units support the interview results. There were a lot of lost assignments during these two units. In addition, when students would be asked to refer back to their notes because the answer to their question is there, many students would reply that they did not know where their notes were.

All treatment unit tests used the same variety of questions as mentioned for the Periodic Trends Test. For the Chemical Quantities Pre- and Post-Tests (Appendix H), the normalized gain was 0.73, which falls into the *high* category (Hake, 1998) (Figure 3). This was all new material to all students. The teacher journal notes that this test did take the students two class periods to complete, while all other tests took a single class period. This was expected given previous experience with this test. The Chemical Reactions Pre- and Post-Tests (Appendix I) had a normalized gain of 0.72, which again falls into the *high* category (Hake, 1998). This set of data had outliers on both the pre- and post-tests, with the post-test having one more outlier than the pre-test (Figure 4). In the teacher journal, there was a note during Chemical Reactions that there was a two-week influenza outbreak at school that resulted in low attendance for most of the unit. For the final treatment unit, the Stoichiometry Pre- and Post-Tests (Appendix J), the normalized gain was 0.74, which is also in the high category (Hake, 1998). However, this unit also had the most outliers and was the only unit to have outliers on both sides of a distribution, which can be seen on the pre-test distribution (Figure 5). According to the teacher journal, there were more issues with student focus in this unit than with any other unit. There was a 5-day weekend due to the Mardi Gras holiday in the middle of this unit and the lack of focus was centered around this. At the beginning and end of the unit, focus was high as it normally is. As a result of these test results, the use of the ISNs was effective when compared to allowing students to determine their own record keeping due to the consistency of normalized gains during the treatment units when compared to inconsistency of normalized gains during the pre-treatment units.

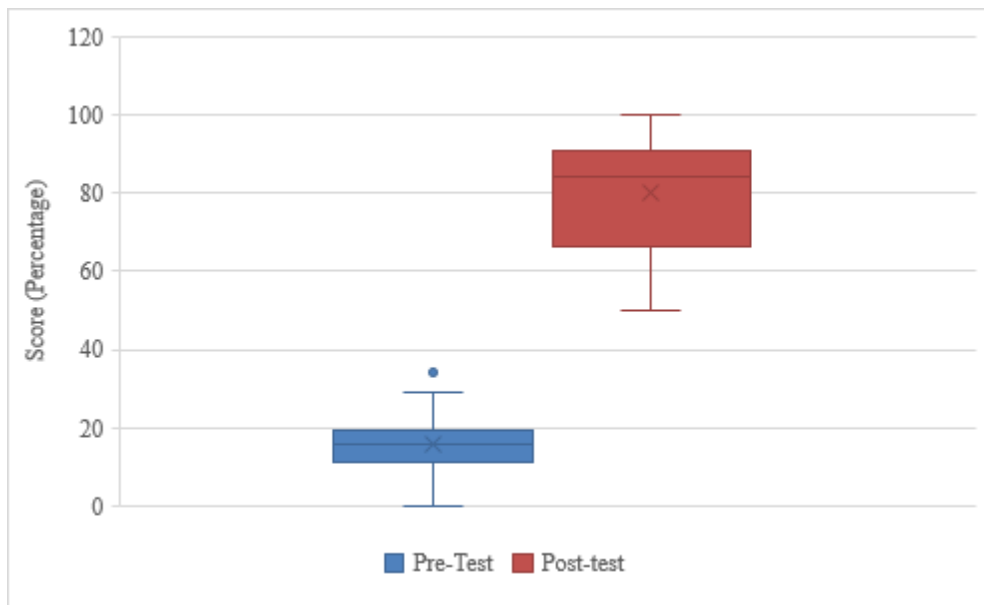


Figure 3. Chemical quantities pre- and post-test score distributions ($N=41$).

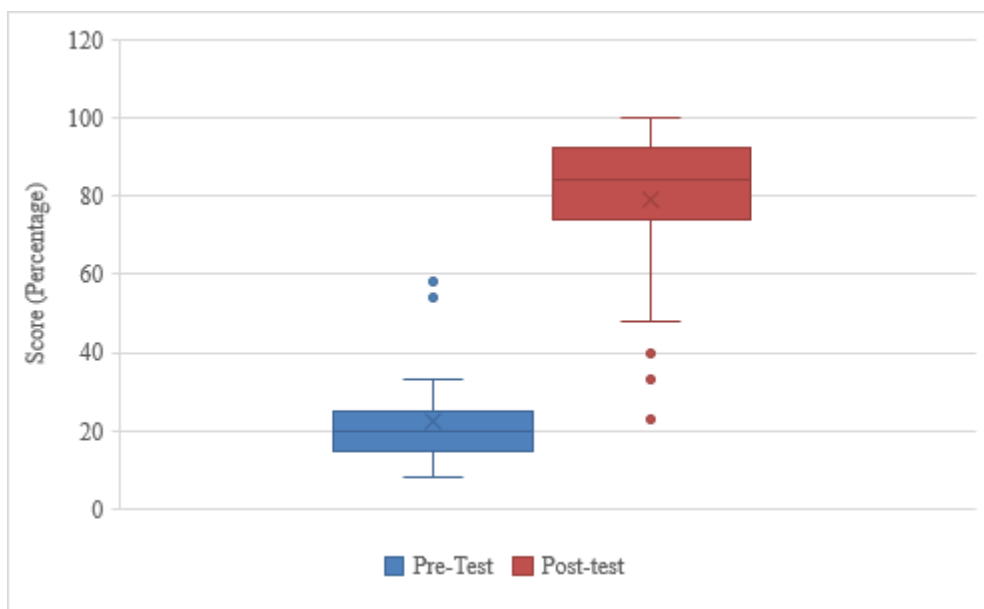


Figure 4. Chemical reactions pre- and post-test score distributions ($N=41$).

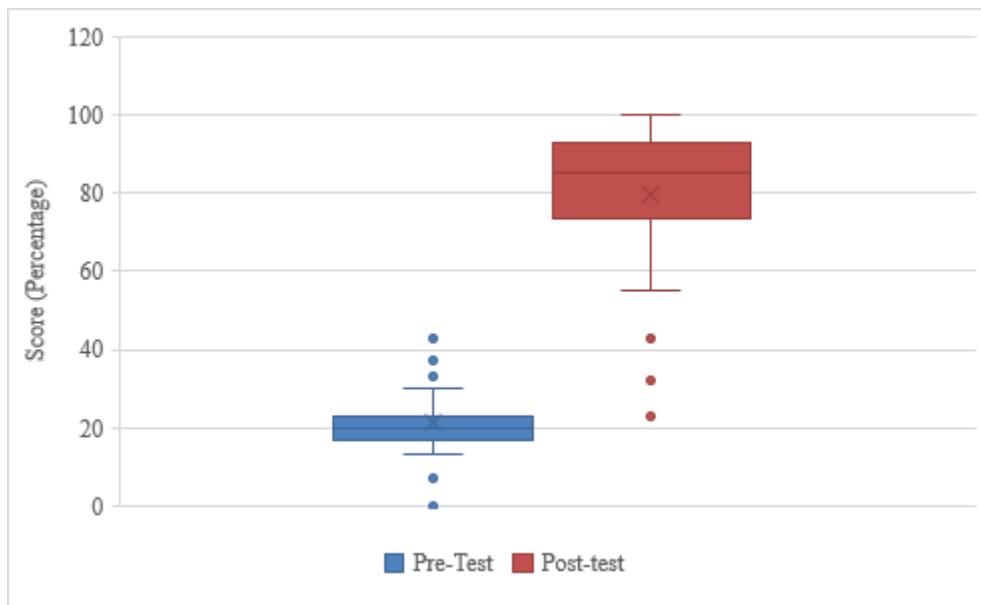


Figure 5. Stoichiometry pre- and post-test score distributions ($N=41$).

The results of the Interactive Science Notebook surveys were not as clear as the Pre- and Post-Test scores for both the pre-treatment and treatment. The Wilcoxon Signed Rank Test was used to analyze the difference in paired Likert Data from the surveys. For the first set of questions regarding students' comfort levels with science in general, the question "I feel like I am good at science" showed a statistically significant difference with a p-value of 0.04 (Figure 6). The other question in this set, "I enjoy science class" did not show a statistically significant difference with a p-value of 0.14.

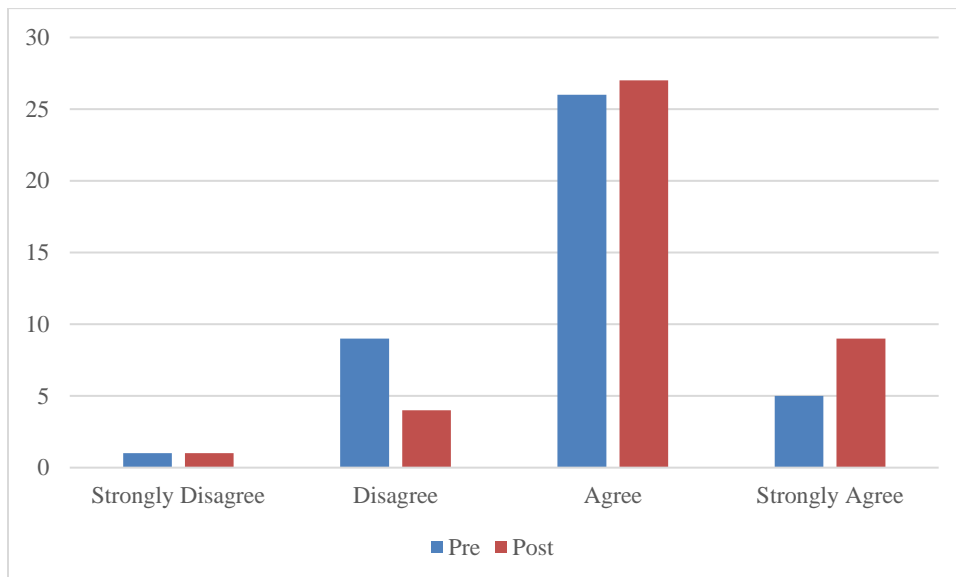


Figure 6. Survey question, “I feel like I am good at science,” (N=41).

The second group of Interactive Science Notebook survey questions revolved around the ISNs and techniques used in them. Only two of the questions, which related to the ISN itself, showed a statistically significant difference with p-values of 0.000004 and 0.00005 (Figures 7-8). When students were asked during the pre-treatment interview about previous experience with interactive science notebooks, the response was negative. One student stated, “It wasn’t that organized and it was hard to keep up with. Another student added, “I don’t like them because there was nowhere to put loose papers and the papers that get glued or taped get torn up.” Responses in the post-treatment interview reflected the difference shown statistically, with the overall response becoming positive. A student said, “The interactive notebooks helped me keep things organized.” Another student added, “It was really good and simple, easier to keep track of everything.” In addition to this, notes in the teacher journal helped to support these results. During a lab that required a processing time, a conversation started among the students about the

notebooks in both class periods. The students said that they preferred this approach to the ISN as “It felt like you planned things ahead. In the other class, it felt like it was made up as we went along.” When students who planned to take physics the following school year were asked if they would be interested in using ISNs in physics, they students replied that they would like that. They stated that from what they understood, physics was a math-heavy course and they said the ISNs “made chemistry math like stoichiometry a lot easier.” The remaining four questions, which related to techniques commonly used in the ISNs, did not show a statistically significant difference with p-values of 0.83, 0.36, 0.07, and 0.47.

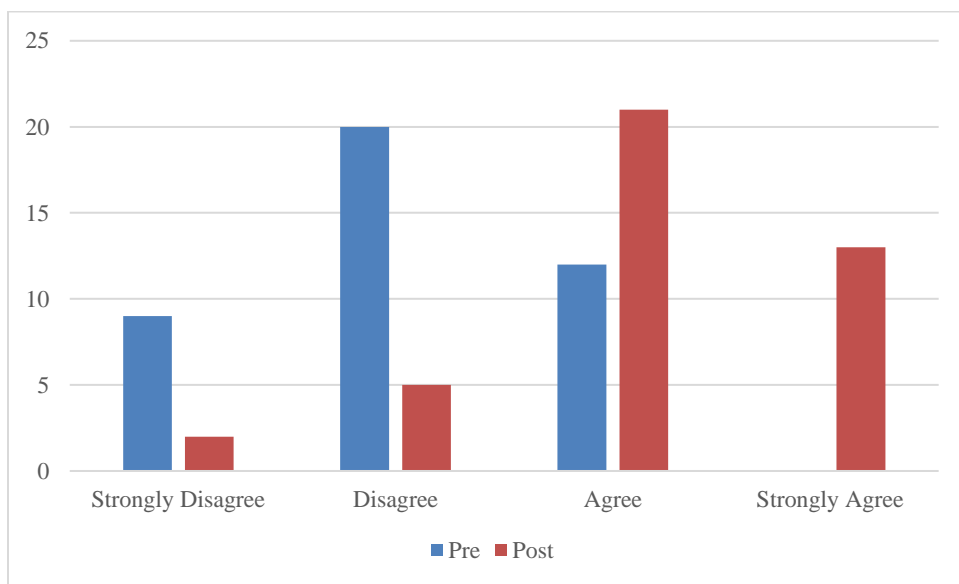


Figure 7. Survey question, “I like using interactive science notebooks,” ($N=41$).

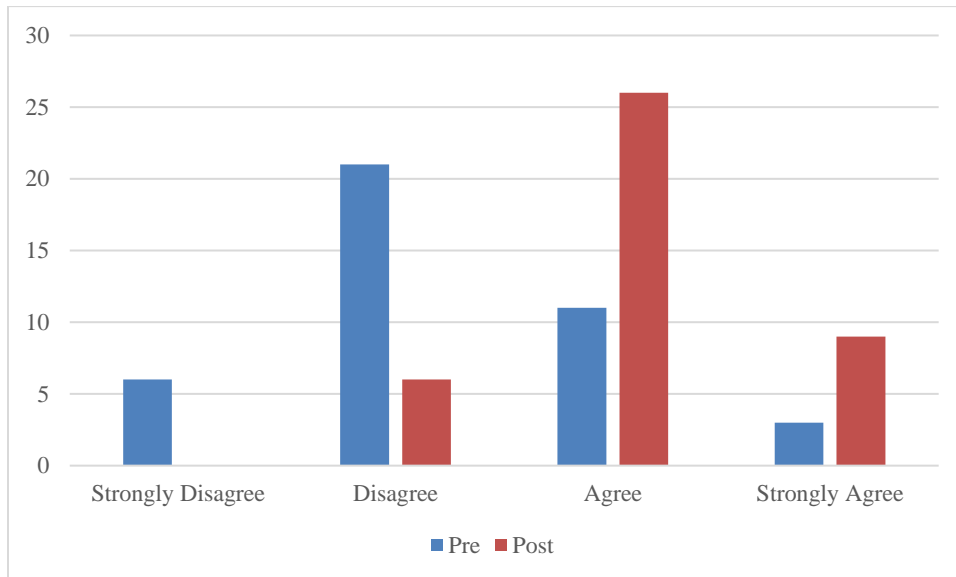


Figure 8. Survey question, “I feel that I learn better using interactive science notebooks,” (N=41).

The final set of six survey questions dealt with organization of class materials. For three of those questions, the p-values showed statistically significant differences as their values were 0.02, 0.03, and 0.01 (Figures 9-11). Though there are statistically significant differences, the questions themselves are complete opposites. This discord is reflected in student interview responses. Prior to the treatment, one student stated, “I would rather choose my own method because I know where I put things and I’m organized.” Another student disagreed, stating, “I would rather interactive notebooks if they would be organized, where we know where our notes and classwork is, especially our practice problems.” After the treatment, there was still disagreement in interview responses. One student stated, “I would rather the interactive science notebooks method for organizing because I like organizing my notes the way the teacher wants them. My own methods are crazy.” Another student added, “I like that the interactive notebooks has things organized day by day. It makes it easy if I need to look back.” A classmate disagreed with these

students, stating, “I like choosing my own method because I get to choose how I write notes and where I put my papers.” During the lab conversation mentioned previously, a couple of students had started using the same organization method in math class, placing their notes on the right side and their homework or practice on the left side. According to them, their grades were going up since using this approach and they felt much better about math class. Many students planned to continue this approach themselves after the completion of the treatment, and they did so. Others planned to return to the approach they had used previously, either because they preferred it or because the ISNs were “a lot of work.” For the other three questions, the p-values did not show statistically significant differences as their values were 0.84, 0.07, and 0.09.

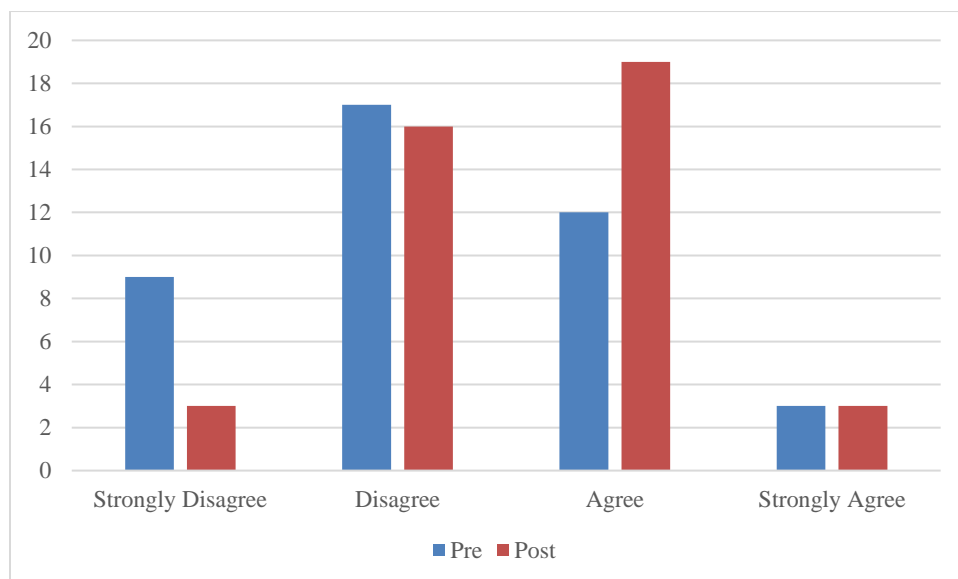


Figure 9. Survey question, “I want to be told how to organize my class materials,” (N=41).

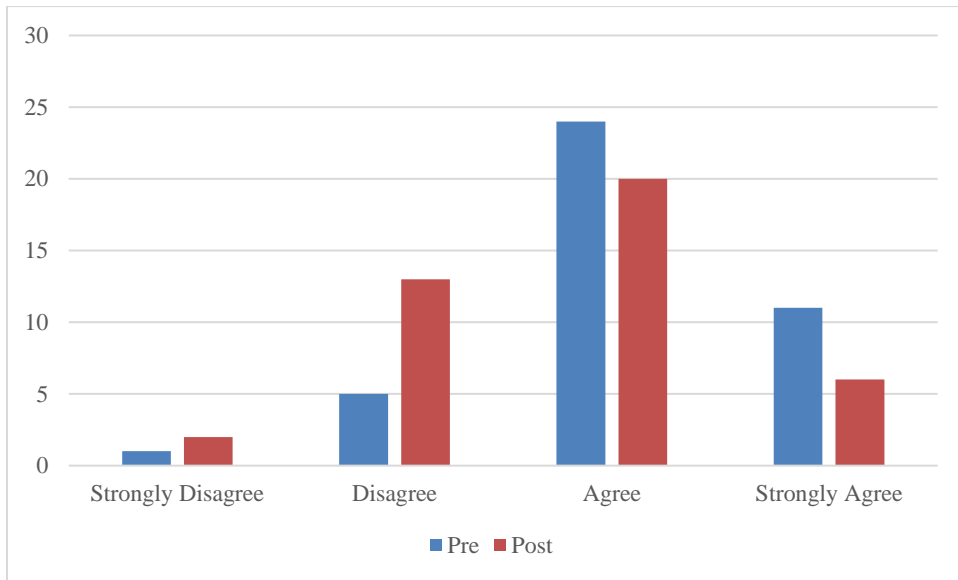


Figure 10. Survey question, “I like choosing my own way of taking notes,” (N=41).

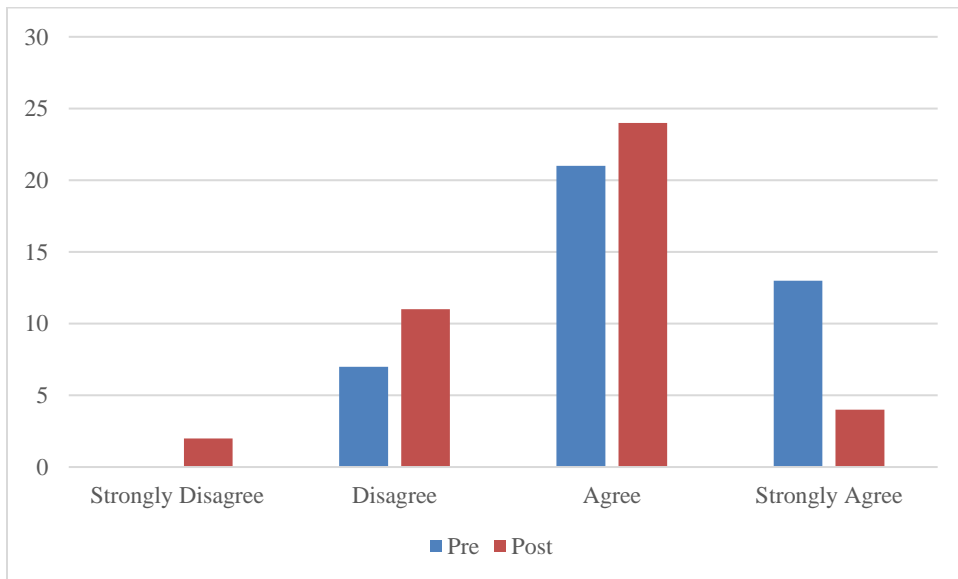


Figure 11. Survey question, “I feel that I learn better when I choose how to organize my class materials,” (N=41).

The ISNs were assessed once a week using the Rubric for Interactive Science Notebook Assessment (Appendix G). The scores remained consistently high throughout the seven weeks that the notebooks were used and assessed, with a few exceptions

(Figure 12). The students attributed this to having a copy of the rubric taped to the inside cover of their notebooks. There is a note in the teacher journal at the end of the first week of notebook use that a student stated in class that having the rubric “makes it easy to know what is expected of my notebook.” Another student quickly added, “I might have liked the notebooks better before if it would have been clear on what I should have on each page.” During the post-treatment interview, one student volunteered when they were asked if they had anything else to share. This student said, “I really liked the rubric. I knew exactly what each page should look like. It made it easier to stay organized.” The classmates in the interview with this student agreed.

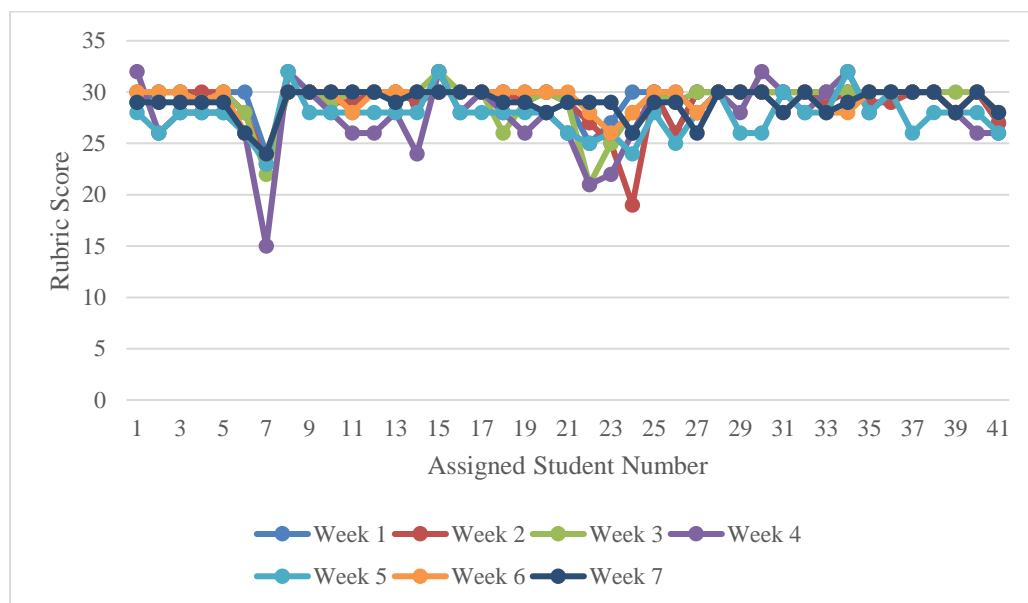


Figure 12. Weekly ISN scores using rubric for interactive science notebook assessment, (N=41).

The results of the survey, interview, and rubrics show that the overall viewpoint of the students with regards to the notebooks changed from negative to positive.

However, there were individual students who were exemptions to this statement. The

students did not prefer any particular technique used with the notebooks. Also, as a group, the students were conflicted as to whether they preferred the ISNs or their own form of record keeping.

INTERPRETATION AND CONCLUSIONS

The first of my research subquestions asked, “will the use of interactive science notebooks be more effective than allowing students to determine their own form of record keeping?” While growth was not seen in the normalized gains of the pre- and post-tests, there was an increased consistency in the treatment units when compared to the pre-treatment units. For the two pre-treatment units, the normalized gains were 0.69 and 0.81. These gains, although impressive, are not very consistent as they are not near each other in magnitude. For the treatment units, the normalized gains were 0.73, 0.72, and 0.74. The major difference during the treatment units is that the normalized gains are consistent. Also, while these scores are higher than one of the pre-treatment units, they are also lower than one of the pre-treatment units. Looking at the data from this perspective implies that there was not a positive effect on student achievement when comparing the use of ISNs to allowing students to determine their own form of record keeping. But the consistency in the treatment units could also be interpreted as effective because this implies that the learning was consistent across all the treatment units in comparison to the uneven learning seen in the pre-treatment units.

These findings will have an effect on my teaching practice. I would personally prefer my students to learn consistently rather than learning some topics better than others. It is evident from these normalized gains the ISNs are the better option for

consistent learning across multiple topics. This is encouraging when deciding whether or not to continue the use of the ISNs in my classroom. There will need to be a full year of evidence rather than just three units, but the evidence is there to warrant a longer-term investigation into the effectiveness of the ISNs on student achievement. With any science, some topics are more difficult than others. The true test will be if an ISN can help with these especially difficult topics. Also, it needs to be seen if the consistencies seen here can be transferred to other sciences such as physics.

The second of my research subquestions asked, “what are student opinions regarding interactive science notebooks, and do those opinions change as a result of their integration into my classroom?” The students clearly did not like the ISNs prior to the treatment. The evidence from the interview was also very telling. Of the 10 students interviewed, none of the students liked the ISNs prior to treatment. Their biggest complaint was a lack of organization in the ISNs with their prior experiences. After the treatment, opinions changed for a majority of students, as seen in Figure 7. The evidence from the interviews also supported this. Of the 10 students interviewed, 9 of the students liked the ISNs. Although the overall opinion of the ISNs changed, there was no change in opinion of the various techniques common to ISNs, such as drawings and use of color. Also, when it came to the topic of organization, the students were conflicted. Some students in the interview liked the ISN because it made clear exactly how to organize the materials, especially with having the rubric right there in the notebooks. Evidence from my teacher journal also supports this, as different students stated on several occasions that they liked the rubric for this very reason. There were a few students who disagreed

with this viewpoint, as they felt they kept their materials sufficiently organized and did not need anyone to tell them how to organize their materials. But, the overall student view of the notebooks was negative at the start of the treatment, changing to positive as a result of the treatment.

As with the first subquestion, a change was evident from before the treatment to after that is large enough to merit a permanent change in my teaching practices. This change in student opinions from being highly negative to positive about the notebooks is encouraging. The students enjoyed using the notebooks. When students enjoy what they are doing in class, they learn better. This is encouraging when it comes to the continued use of the notebooks. Since ending the treatment units, we have returned to my prior method of teaching which was ready to go for the remainder of the year. The time constraints of teaching four subjects and completing this project made that an unfortunate necessity. The students have asked several times if we are going to return to using the notebooks before the end of the year. This is also encouraging to continuing the use of the ISNs in future school years. However, it will need to be seen if this change is sustainable through an entire school year before making the ultimate decision to make a more permanent transition to the ISNs.

When compared to previous research, my findings agree with the researchers' findings. At the start of the process, the literature stated that it was important to show how the notebook would be assessed from the start. This was done using the Rubric for Interactive Science Notebook Assessment (Appendix G). The students stated that having the rubric was a huge help for them, both in the post-treatment interviews and during

everyday conversations that were recorded in the teacher journal. The research said that if students clearly understood what was expected of their ISNs from the beginning, high scores on ISN assessments would correlate with high performance assessment scores. This correlation exists in my data. Also, according to the research, the increased organization that the ISNs provided should have led to students having a positive perception of the ISNs. As seen in the survey results, post-treatment interviews, and comments recorded in the teacher journal, The students' view of the ISNs changed from negative to positive. This ability to quickly locate what they need can allow students to feel more confident in their abilities in the science classroom. As seen in Figure 6, there was a slight upward shift in students feeling that they are "good at science." The research presents the idea of the ISN being a good long-term record, one that can potentially stretch over multiple years. Even though the notebooks were only used for about 10 weeks, the students liked being able to look back at material that was already covered. I liked it as well because I spend less time reviewing old material with students who had lost their notes and more time with students who need help with the current topic.

All of these observations and events lead back to the original focus question for my research, "How will integration of interactive science notebooks affect student achievement in my secondary chemistry classroom?" The integration had a different effect than what was expected. I expected to see mild growth normalized gains after the first unit, which was used for adjustment to the new method. I did not expect to see highly consistent normalized gains across all three units of treatment. I had not expected to see the students come into the treatment with such negative viewpoints on ISNs, but

once they did I hoped to change a couple of students' minds. I did not expect to see the complete shift in thinking that was seen in most of the students. They greatly enjoyed the ISN, wanted to continue it when the treatment phase ended, and in some cases transferred the organization skills to another subject successfully. The integration of interactive science notebooks had a positive effect on student achievement in my secondary chemistry classroom.

VALUE

The action research process had a major impact on my classroom. By using daily reflections and adjustments made in my teacher journal, each chemistry lesson became a little more tailored to what the students felt worked best or the next move that I felt was best based on the previous few days. If students needed more practice, they got more practice, even if that was not what I had originally planned. Lessons became less about following the lesson plan and more about adjusting to what the students needed. Adjusting mid-lesson admittedly was something that I had struggled with as far back as my student teaching at another school.

Another huge benefit was the ability of students to all have the same notes in the same location. I often vary from the textbook when I teach skills because the textbook uses an awkward methodology that takes longer. Previously, this presented problems because students' notes were not organized enough for them to find where I had previously taught a skill. Looking in the book didn't always help them because I had taught the skill differently. Now, when a student needed help on something I previously taught, I could simply tell them what lesson to look back at. For most students, this was

all they needed. It allowed me to dedicate more time to the students who were truly struggling with understanding a concept, which meant these students were more likely to complete their work rather than giving up as they tended to do prior to the ISNs.

For the next school year, I plan to continue the use of the ISNs in my chemistry course. The consistency in test results across the three treatment units when compared to the inconsistency in the two pre-treatment units was too significant to ignore. It will be a great year to begin a full redesign of the course as we are going to begin integrating our new science standards for the state of Louisiana into our classrooms, with full integration to come the year after next. This will be the first new set of standards since the 1997 introduction of the Grade Level Expectations. These standards are based on the Next Generation Science Standards. I feel that the ISNs will work well with the new standards that I have seen. For chemistry, I do not plan to make any immediate changes to the setup that was followed. As the year progresses, I will make any changes that I feel are necessary.

In the next school year, I also plan to integrate the ISNs into my physics course. Many of the chemistry students that were a part of this project and loved the notebooks plan to take physics in the next school year. Physics lends itself well to the setup for the ISNs that we used in chemistry. However, a couple of the guidelines that we followed in chemistry will be relaxed in physics. I will allow the students to choose which side of the notebook is for input activities and which side is for output activities. I feel that it is a decision that they are responsible and experienced enough to make for themselves. The right-side input and left-side output followed the research I completed prior to beginning

the project, made sense to me and seemed easy for my example notebook, but I am left-handed. My left-handed students agreed with me. My right-handed students disagreed. With left-handed individuals, you can still see the notes on the right side of the page while you work with the notebook open. For right-handed individuals, they had to stop working and pick up their arm to see the notes on the right side of their notebook. If their notes were on the left, they would not experience this problem. I plan to modify the Rubric for Interactive Science Notebook Assessment (Appendix G) so that students can state at the beginning of the year which side of the notebook will be dedicated to input activities and which side will be dedicated to output activities. Otherwise, I do not foresee any issues with the integration of the notebooks into physics.

For my other two subjects, Biology II and physical science, the ISNs will not be integrated during the next school year. My Biology II course is a college-preparation course. Nearly all the students who have taken or plan to take the course will be attending McNeese State University, which is the same university that I attended for my bachelor's degree. There is no use of anything like the ISNs at this university. The professors employ a more traditional lecture system. As a result, I want these students to be prepared for that type of setting, so I will continue to use my current lecture-based system for them. For my physical science, I was originally planning to use the ISNs with them in the next school year and had even started working on some of the modifications that I wanted to make for them to use the ISNs. These modifications included a simplified rubric and a glue-in table of contents rather than having them create their own table of contents as the older students do. But around the conclusion of the project, I was

informed that eighth-grade students will no longer be allowed to skip ahead to high school science. Due to the new Louisiana standards, this eliminates physical science temporarily from the courses that I teach. The files and plans that I started working on have been securely stored until such a time that I may need them again.

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APPENDICES

APPENDIX A
INSTITUTIONAL REVIEW BOARD APPROVAL



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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 c/o Microbiology & Immunology
 Montana State University
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 Telephone: 406-994-6783
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Administrator:
 Cheryl Johnson
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MEMORANDUM

TO: Alison Dupuis and John Graves
FROM: Mark Quinn *Mark Quinn CJ*
DATE: November 16, 2016
SUBJECT: "Effectiveness of Interactive Science Notebooks on Student Achievement versus a Traditional Classroom Model" [AD111616-EX]

The above research, described in your submission of November 15, 2016, 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:

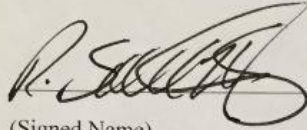
- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula,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

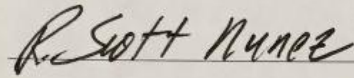
APPENDIX B
EXEMPTION REGARDING INFORMED CONSENT

Exemption Regarding Informed Consent

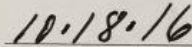
I, Scott Nunez, Principal of Bell City High School, verify that the classroom research conducted by Alison Dupuis is in accordance with established or commonly accepted educational settings involving normal educational practices. To maintain the established culture of our school and not cause disruption to our school climate, I have granted an exemption to Alison Dupuis regarding informed consent.



(Signed Name)



(Printed Name)



(Date)

APPENDIX C

PERIODIC TRENDS PRE- AND POST-TEST

Periodic Trends

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- Which of the following is formed by gaining electrons?
 - Ions
 - Anions
 - Cations
 - Dogions
- The nucleus of an atom is _____ charged.
 - positively
 - negatively
 - variably
 - none of these
- Which of the following is formed by losing electrons?
 - Ions
 - Anions
 - Cations
 - Dogions
- According to the Aufbau Principle, electrons enter the _____ energy level first.
 - highest
 - middle
 - no
 - lowest
- According to _____ Rule, when electrons occupy orbitals of equal energy, they don't pair up until they have to.
 - Bohr's
 - Rutherford's
 - Hund's
 - Pauli's
- _____ have an effect on group trends.
 - Neutrons
 - Energy levels
 - Nuclear charges
 - Orbitals
- _____ have an effect on period trends.
 - Neutrons
 - Energy levels
 - Nuclear charges
 - Orbitals
- Atomic size _____ as you move down a group.
 - increases
 - stays the same
 - decreases
 - doesn't follow a pattern
- Atomic size _____ as you move across a period.
 - increases
 - stays the same
 - decreases
 - doesn't follow a pattern
- Ionization energy _____ as you move across a period.
 - increases
 - stays the same
 - decreases
 - doesn't follow a pattern
- Ionization energy _____ as you move down a group.
 - increases
 - stays the same
 - decreases
 - doesn't follow a pattern

12. Ionic size _____ as you move across a period.
 a. increases
 b. stays the same
 c. decreases
 d. doesn't follow a pattern
13. Ionic size _____ as you move down a group.
 a. increases
 b. stays the same
 c. decreases
 d. doesn't follow a pattern
14. Electronegativity _____ as you move across a period.
 a. increases
 b. stays the same
 c. decreases
 d. doesn't follow a pattern
15. Electronegativity _____ as you move down a group.
 a. increases
 b. stays the same
 c. decreases
 d. doesn't follow a pattern

Completion

Complete each statement.

16. Metallic elements form _____ ions.
17. Nonmetallic elements form _____ ions.
18. Atoms behave in ways to try and achieve a _____ configuration.
19. The area around the nucleus where electrons are most likely to be found is called the _____.
20. The vertical columns in the periodic table are called _____.
21. The horizontal rows in the periodic table are called _____.
22. The radius of an atom _____ be measured directly.

Short Answer

23. Complete the Following chart:

	# of Orbitals	Maximum Electrons	Starts at energy level
s	1		1
	3	6	
d	5		
		14	4

24. What can the Quantum Mechanical Model tell us?
25. What does the Periodic law state?

Ionization Energies			
Symbol	First	Second	Third
H	1312		
He	2731	5247	
Li	520	7297	11810
Be	900	1757	14840
B	800	2430	3569
C	1086	2352	4619
N	1402	2857	4577
O	1314	3391	5301
F	1681	3375	6045
Ne	2080	3963	6276

26. What is the second ionization energy for neon?
27. What is the first ionization energy for boron?
28. Why does hydrogen lack second and third ionization energies?

Problem

29. Write the electron configuration for oxygen.
30. Write the electron configuration for magnesium.
31. Write the electron configuration for argon.

APPENDIX D

CHEMICAL NAMES AND FORMULAS PRE- AND POST-TEST

Chapter 6: Chemical Names and Formulas

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- The correct name for the N^{3-} ion is the:
 - nitride ion
 - nitrate ion
 - nitric ion
 - nitrite ion
- Elements of Group 4A:
 - do not commonly form ions
 - generally form positive ions
 - generally form anions
 - generally form negative ions
- Which element when combined with chlorine would most likely form an ionic compound?
 - lithium
 - bromine
 - phosphorus
 - carbon
- The cation Fe^{3+} is formed when:
 - an atom of zinc loses two electrons
 - an atom of iron loses two electrons
 - an atom of iron gains three electrons
 - an atom of iron loses three electrons
- The metals in Groups 1A, 2A, and 3A:
 - all form ions with a 1+ charge
 - form ions with a charge found by subtracting the group number from 8
 - lose electrons when they form ions
 - gain electrons when they form ions
- When naming an ion of a transition metal that has more than one common ionic charge, the numerical value of the charge is indicated by a:
 - suffix
 - prefix
 - roman numeral following the name
 - superscript after the name
- In naming a binary molecular compound, the number of atoms of each element present in the molecule is indicated by:
 - prefixes
 - suffixes
 - superscripts
 - roman numerals
- A chemical formula includes the symbols of the elements in the compound and subscripts that indicate
 - atomic mass of each element.
 - number of atoms or ions of each element that are combined in the compound.
 - formula mass.
 - charges on the elements or ions.

Short Answer

- Why was it necessary for chemists to develop a system for naming chemical compounds?
- What three things should a chemical compound's name tell you?

Problem

11. Write the formulas for the following diatomic molecules:

- A. Fluorine
- B. Oxygen
- C. Hydrogen
- D. Bromine

12. Write the formulas for the compounds formed from these pairs of ions:

- A. Ba^{2+} , Cl^-
- B. sodium sulfide
- C. Al^{3+} , O^{2-}
- D. calcium bromide

13. Name the following binary ionic compounds:

- A. Li_3N
- B. K_2S
- C. CuCl_2
- D. MnO_2

14. Write formulas for the following ternary ionic compounds.

- A. potassium cyanide
- B. sodium silicate
- C. ammonium chloride
- D. sodium hydroxide

15. Name the following ternary ionic compounds:

- A. NaCN
- B. LiNO_3
- C. K_2CO_3
- D. $\text{Cu}(\text{OH})_2$

16. Write the formula for the following molecular compounds

- A. nitrogen tribromide
- B. dichlorine monoxide
- C. carbon tetrafluoride
- D. dinitrogen tetrafluoride

17. Name the following molecular compounds

- A. PCl_5
- B. XeF_2
- C. P_4O_6
- D. NO_2

APPENDIX E

INTERACTIVE SCIENCE NOTEBOOK SURVEY

Instructions: Please answer the following questions. Your participation in this survey is voluntary, you may stop at any time, and participation will not affect your grade in this class.

1. I feel like I am good at science.

Strongly Disagree Disagree Agree Strongly Agree

2. I like using interactive science notebooks.

Strongly Disagree Disagree Agree Strongly Agree

3. I want to be told how to organize my class materials.

Strongly Disagree Disagree Agree Strongly Agree

4. I feel that having color in my notes is distracting.

Strongly Disagree Disagree Agree Strongly Agree

5. I feel that I learn better using interactive science notebooks.

Strongly Disagree Disagree Agree Strongly Agree

6. I am good at keeping my class materials organized.

Strongly Disagree Disagree Agree Strongly Agree

7. I like choosing my own way of taking notes.

Strongly Disagree Disagree Agree Strongly Agree

8. I enjoy science class.

Strongly Disagree Disagree Agree Strongly Agree

9. I feel that drawing pictures doesn't help me learn.

Strongly Disagree Disagree Agree Strongly Agree

10. I like being able to easily look back at material that we've already covered.

Strongly Disagree Disagree Agree Strongly Agree

11. I feel that I learn better when I choose how to organize my class materials.

Strongly Disagree Disagree Agree Strongly Agree

12. I want to choose how to organize my class materials

Strongly Disagree Disagree Agree Strongly Agree

13. I like drawing pictures to learn or review material.

Strongly Disagree Disagree Agree Strongly Agree

14. I feel that I learn better when my notes have color.

Strongly Disagree Disagree Agree Strongly Agree

APPENDIX F
INTERVIEW QUESTIONS

Pre-Treatment Interview Questions:

1. What is your previous experience with interactive science notebooks?
2. How does that experience make you feel about the interactive science notebooks?
3. Would you rather interactive science notebooks or choosing your own method of organizing class materials? Why or why not?
4. How do you currently organize your class materials?
5. Would you say that you are good at keeping your class materials organized? Why or why not?
6. Is there anything else that you would like me to know about this topic at this time?

Post-Treatment Interview Questions:

1. What was your experience with the interactive science notebooks like?
2. How does that experience make you feel about the interactive science notebooks?
3. Would you rather interactive science notebooks or choosing your own method of organizing class materials? Why or why not?
4. Do you plan to change how you organize your class materials now that we've completed the interactive science notebooks?
5. Would you say that you are good at keeping your class materials organized? Why or why not?
6. Do you feel that you learned the class information better with the interactive science notebooks? Why or why not?
7. Is there anything else that you would like me to know about this topic at this time?

APPENDIX G

RUBRIC FOR INTERACTIVE SCIENCE NOTEBOOK ASSESSMENT

Right Side – Input Activities				
Category	4	3	2	1
Necessary information	All necessary information included	Most necessary information included	Some necessary information included	Minimal necessary information included
Organization and the Basics	Work is extremely organized; pages are numbered and dates are included; work is very neat and clearly legible	Work is adequately organized; pages are numbered and dates are included; work is mostly neat and legible	Work is somewhat organized; some pages are numbered and some dates are included; work is somewhat neat and legible	Work is poorly organized; pages are not numbered and dates are not included; work is not neat and legible
Left Side – Output Activities				
Category	8	6	4	2
Completion of Activity	Activity is complete above and beyond the requirements given to students. Evidence of understanding is clearly demonstrated	Activity is complete at the requirements. Evidence of understanding is demonstrated	Activity is nearly complete at then requirements. Evidence of understanding is somewhat demonstrated	Activity is partially complete. Evidence of understanding is not demonstrated.
Creativity (if applicable)	Creativity exceptionally demonstrated. Color used throughout to enhance the work.	Creativity adequately demonstrated. Some color used throughout to enhance the work.	Some creativity demonstrated. Little color used throughout to enhance the work.	Little creativity demonstrated. No color used throughout to enhance the work
Organization and the Basics	Work is extremely organized; pages are numbered and dates are included; work is very neat and clearly legible	Work is adequately organized; pages are numbered and dates are included; work is mostly neat and legible	Work is somewhat organized; some pages are numbered and some dates are included; work is somewhat neat and legible	Work is poorly organized; pages are not numbered and dates are not included; work is not neat and legible

APPENDIX H
CHEMICAL QUANTITIES PRE- AND POST-TEST

Chemistry Chapter 7 Test

Matching

Match each item with the correct statement below.

- a. molar volume
 - b. molar mass
 - c. atomic mass
1. the volume occupied by a mole of any gas at STP
 2. the mass of a mole of any element or compound
 3. the number of grams of an element that is numerically equal to the atomic mass of the element in amu

Match each item with the correct statement below.

- a. representative particle
 - b. mole
 - c. Avogadro's number
 - d. percent composition
 - e. standard temperature and pressure
 - f. empirical formula
4. the smallest whole number ratio of the atoms in a compound
 5. the number of representative particles of a substance present in 1 mole of that substance
 6. the SI unit used to measure amount of substance
 7. 0°C and 1 atm
 8. an atom, an ion, or a molecule, depending upon the way a substance commonly exists
 9. the percent by mass of each element in a compound

Multiple Choice

Identify the choice that best completes the statement or answers the question.

10. The lowest whole-number ratio of the elements in a compound is called the _____.
 - a. representative formula
 - b. empirical formula
 - c. binary formula
 - d. molecular formula
11. What SI unit is used to measure the number of representative particles in a substance?
 - a. ampere
 - b. kilogram
 - c. mole
 - d. kelvin
12. Which of the following compounds have the same empirical formula?
 - a. C_6H_{12} and C_6H_{14}

- b. C_4H_{10} and $C_{10}H_4$
 - c. C_7H_{14} and $C_{10}H_{20}$
 - d. CO_2 and SO_2
13. The volume of one mole of a substance is 22.4 L at STP for all ____.
- a. gases
 - b. solids
 - c. compounds
 - d. liquids
14. If the density of a noble gas is 3.741 g/L at STP, that gas is ____.
- a. He
 - b. Xe
 - c. Kr
 - d. Ne
15. The molar mass of a gas can be determined from which of the following?
- a. the volume of a mole of the gas
 - b. Avogadro's number
 - c. the density of the gas at STP
 - d. the volume of a the gas at STP
16. Which of the following gases at STP would have the greatest volume?
- a. 4.00 mole of He
 - b. 1.00 mole of O_2
 - c. 0.200 mole of SO_3
 - d. 5.00 mole of H_2
17. The molar mass of a substance can be calculated from its density alone, if that substance is a(n) ____.
- a. element
 - b. solid
 - c. liquid
 - d. gas at STP
18. What information is needed to calculate the percent composition of a compound?
- a. the formula of the compound and the atomic mass of its elements
 - b. the weight of the sample to be analyzed and its density
 - c. the formula of the compound and its density
 - d. the weight of the sample to be analyzed and its molar volume
19. A 22.4-L sample of which of the following substances, at STP, would contain 6.02×10^{23} representative particles?
- a. cesium iodide
 - b. oxygen
 - c. gold
 - d. sulfur
20. Which expression represents the percent by mass of nitrogen in NH_4NO_3 ?

- a. $14 \text{ g N}/80 \text{ g NH}_4\text{NO}_3 \times 100\%$
 - b. $28 \text{ g N}/80 \text{ g NH}_4\text{NO}_3 \times 100\%$
 - c. $80 \text{ g NH}_4\text{NO}_3/28 \text{ g N} \times 100\%$
 - d. $80 \text{ g NH}_4\text{NO}_3/14 \text{ g N} \times 100\%$
21. The mass of a mole of NaCl is the
- a. molecular mass.
 - b. atomic mass.
 - c. compound mass.
 - d. molar mass.
22. Which of the following is an empirical formula?
- a. $\text{C}_2\text{N}_2\text{H}_8$
 - b. Sb_4S_6
 - c. $\text{Be}_2(\text{Cr}_2\text{O}_7)_2$
 - d. $\text{C}_3\text{H}_8\text{O}$

Short Answer

23. Avogadro's number of representative particles is equal to one _____.
24. The molar volume of a gas at STP occupies _____.
25. How many moles of silver atoms are in 2.2×10^{20} atoms of silver?
26. How many atoms are in 0.091 mol of titanium?
27. How many molecules are in 3.20 mol CO_2 ?
28. What is the molar mass of AlF_3 ?
29. What is the mass in grams of 7.20 mol C_8H_{18} ?
30. What is the number of moles of beryllium atoms in 42 g of Be?
31. How many moles of CaBr_2 are in 4.0 grams of CaBr_2 ?
32. What is the volume, in liters, of 0.100 mol of C_3H_8 gas at STP?
33. What is the number of moles in 620 L of He gas at STP?
34. What is the density at STP of the gas sulfur hexafluoride, SF_6 ?
35. If the density of an unknown gas Z is 3.25 g/L at STP, what is the molar mass of gas Z?

36. If 120.4 grams of Hg combines completely with 48.0 grams of Br to form a compound, what is the percent composition of Hg in the compound?
37. What is the percent composition of NiO, if a sample of NiO with a mass of 44.4 g contains 35.1 g Ni and 9.3 g O?
38. What is the percent composition of carbon, in octane, C_8H_{18} ?

APPENDIX I

CHEMICAL REACTIONS PRE- AND POST-TEST

Chemistry: Chapter 8 Test**Multiple Choice**

Identify the choice that best completes the statement or answers the question.

- In the equation $2\text{Al}(s) + 3\text{Fe}(\text{NO}_3)_2(aq) \rightarrow 3\text{Fe}(s) + 2\text{Al}(\text{NO}_3)_3(aq)$, iron has been replaced by
 - nitrogen.
 - water.
 - nitrate.
 - aluminum.
- In a double-replacement reaction, the
 - products are always molecular.
 - reactants are two ionic compounds.
 - products are a new element and a new compound.
 - reactants are two elements.
- A chemical equation is balanced when the
 - coefficients of the reactants equal the coefficients of the products.
 - subscripts of the reactants equal the subscripts of the products.
 - same number of each kind of atom appears in the reactants and in the products.
 - products and reactants are the same chemicals.
- In the activity series of metals, which metal(s) will displace hydrogen from an acid?
 - any metal
 - only metals below hydrogen
 - only metals from Li to Na
 - only metals above hydrogen
- When a binary compound decomposes, what is produced?
 - two elements
 - an oxide
 - a tertiary compound
 - an acid
- The reaction represented by the equation $\text{Cl}_2(g) + 2\text{KBr}(aq) \rightarrow 2\text{KCl}(aq) + \text{Br}_2(l)$ is a(n) _____ reaction.
 - combustion reaction.
 - single-displacement reaction.
 - decomposition reaction.
 - synthesis reaction.
- The replacement of bromine by chlorine in a salt is an example of a single-displacement reaction by
 - halogens.
 - water.
 - sodium.
 - electrolysis.
- To balance a chemical equation, it may be necessary to adjust the
 - formulas of the products.
 - subscripts.
 - number of products.
 - coefficients.
- A catalyst is
 - the product of a combustion reaction.
 - a solid product of a reaction.
 - not used up in a reaction.
 - one of the reactants in single-replacement reactions.

10. An element in the activity series can replace any element
- above it on the list.
 - below it on the list.
 - in its group.
 - in the periodic table.
11. When a solid produced by a chemical reaction separates from the solution it is called
- the mass of the product.
 - a molecule.
 - a precipitate.
 - a reactant.
12. In what kind of reaction does a single compound produce two or more simpler substances?
- synthesis reaction
 - decomposition reaction
 - ionic reaction
 - single-displacement reaction
13. The reaction represented by the equation $2\text{HgO}(s) \rightarrow 2\text{Hg}(l) + \text{O}_2(g)$ is a(n) _____ reaction.
- single-displacement reaction.
 - combustion reaction.
 - decomposition reaction.
 - synthesis reaction.
14. In a combustion reaction, one of the reactants is
- hydrogen.
 - a metal.
 - oxygen.
 - nitrogen.
15. The reaction represented by the equation $2\text{Mg}(s) + \text{O}_2(g) \rightarrow 2\text{MgO}(s)$ is a _____ reaction.
- decomposition reaction.
 - double-displacement reaction.
 - single-displacement reaction.
 - synthesis reaction.
16. The reaction represented by the equation $\text{Mg}(s) + 2\text{HCl}(aq) \rightarrow \text{H}_2(g) + \text{MgCl}_2(aq)$ is a _____ reaction.
- composition reaction.
 - double-displacement reaction.
 - decomposition reaction.
 - single-displacement reaction.
17. What does the symbol Δ above the arrow in a chemical equation mean?
- Electricity is need in the reaction.
 - A precipitate will form during the reaction.
 - Heat is supplied to the reaction.
 - A catalyst is needed in the reaction.
18. What can be predicted by using an activity series?
- the melting points of elements
 - the electronegativity values of elements
 - the amount of energy released by a chemical reaction
 - whether a certain chemical reaction will occur
19. A net ionic equation
- shows dissolved ionic compounds as dissociated free ions.
 - is not necessarily balanced with respect to mass or charge.
 - shows the spectator ions.
 - shows only those particles involved in the reaction.

20. This symbol (\rightleftharpoons) indicates that ____.
- the reaction is reversible
 - heat must be applied
 - an incomplete combustion reaction has occurred
 - a gas is formed by the reaction
21. In every balanced chemical equation, each side of the equation has the same number of ____.
- molecules
 - coefficients
 - atoms of each element
 - moles
22. The reaction represented by the equation $2\text{KClO}_3(s) \rightarrow 2\text{KCl}(s) + 3\text{O}_2(g)$ is a(n) _____ reaction.
- ionic reaction.
 - combustion reaction.
 - synthesis reaction.
 - decomposition reaction.
23. In order for the reaction $2\text{Al} + 6\text{HCl} \rightarrow 2\text{AlCl}_3 + 3\text{H}_2$ to occur, which of the following must be true?
- Al must be above Cl on the activity series.
 - Heat must be supplied for the reaction.
 - A precipitate must be formed.
 - Al must be above H on the activity series.
24. Which of the following combinations of symbol and explanation of symbol is correct when used in a chemical equation?
- (aq), dissolved in water
 - (g), grams
 - (s), solid product
 - (l), liters
25. In writing a chemical equation that produces hydrogen gas, the correct representation of hydrogen gas is
- H.
 - OH.
 - H₂.
 - 2H.
26. In what kind of reaction do two or more substances combine to form a new compound?
- decomposition reaction
 - synthesis reaction
 - ionic reaction
 - double-displacement reaction
27. In an equation, the symbol for a substance in water solution is followed by
- (l).
 - (aq).
 - (g).
 - (s).
28. The products of a combustion reaction include
- water, carbon dioxide, and carbon monoxide.
 - hydrogen, water, and carbon dioxide.
 - hydrogen and carbon monoxide.
 - hydrogen and water.

29. In the chemical equation $\text{H}_2\text{O}_2(aq) \rightarrow \text{H}_2\text{O}(l) + \text{O}_2(g)$, the O_2 is a ____.
- reactant
 - catalyst
 - product
 - solid
30. If chlorine gas is produced by halogen replacement, the other halogen in the reaction must be
- astatine.
 - bromine.
 - iodine.
 - fluorine.
31. The reaction represented by the equation $\text{Pb}(\text{NO}_3)_2(aq) + 2\text{KI}(aq) \rightarrow \text{PbI}_2(s) + 2\text{KNO}_3(aq)$ is a _____ reaction.
- combustion reaction.
 - decomposition reaction.
 - synthesis reaction.
 - double-displacement reaction.

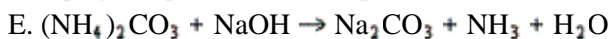
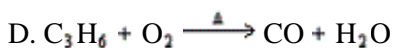
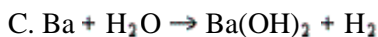
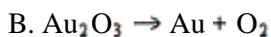
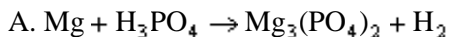
Completion

Complete each statement.

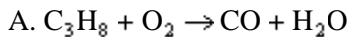
32. In the chemical reaction represented by the equation $2\text{Cr}(s) + 3\text{O}_2(g) \rightarrow 2\text{CrO}_3(s)$, two chromium atoms combine with _____ oxygen atoms.
33. In the chemical equation $2\text{AlCl}_3(aq) + 3\text{Pb}(\text{NO}_3)_2(aq) \rightarrow 3\text{PbCl}_2(s) + 2\text{Al}(\text{NO}_3)_3(aq)$, the state of PbCl_2 is a(n) _____.

Short Answer

34. Balance each of the following equations.



35. Balance the each of the following equations. Indicate whether combustion is complete or incomplete.



APPENDIX J

STOICHIOMETRY PRE- AND POST-TEST

Chemistry Chapter 9 Test (60 points)

Multiple Choice (2 points each)

Identify the choice that best completes the statement or answers the question.

- Which of the following is NOT a reason why actual yield is less than theoretical yield?
 - competing side reactions
 - loss of product during purification
 - impure reactants present
 - conservation of mass
- Metallic copper is formed when aluminum reacts with copper(II) sulfate. How many grams of metallic copper can be obtained when 54.0 g of Al react with 319 g of CuSO_4 ?
 $\text{Al} + 3\text{CuSO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 + 3\text{Cu}$
 - 21.2 g
 - 162 g
 - 127 g
 - 381 g
- In a chemical reaction, the mass of the products
 - is less than the mass of the reactants.
 - is greater than the mass of the reactants.
 - is equal to the mass of the reactants.
 - has no relationship to the mass of the reactants.
- A balanced chemical equation allows one to determine the
 - mechanism involved in the reaction.
 - electron configuration of all elements in the reaction.
 - energy released in the reaction.
 - mole ratio of any two substances in the reaction.
- In the reaction $2\text{CO}(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g)$, what is the ratio of moles of oxygen used to moles of CO_2 produced?
 - 2:2
 - 1:1
 - 2:1
 - 1:2
- Which type of stoichiometric calculation does not require the use of the molar mass?
 - mass-particle problems
 - mass-mass problems
 - mass-volume problems
 - volume-volume problems
- At STP, how many liters of oxygen are required to react completely with 3.6 liters of hydrogen to form water?
 $2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(g)$
 - 3.6 L
 - 2.4 L
 - 1.8 L
 - 2.0 L
- What is the first step in most stoichiometry problems?
 - convert given quantities to masses
 - add the coefficients of the reagents
 - convert given quantities to moles
 - convert given quantities to volumes
- In a particular reaction between copper metal and silver nitrate, 12.7 g Cu produced 38.1 g Ag. What is the percent yield of silver in this reaction?
 $\text{Cu} + 2\text{AgNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{Ag}$
 - 176%
 - 88.2%

b. qualitative analysis

d. stoichiometry

19. In the reaction represented by the equation $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$, what is the mole ratio of nitrogen to ammonia?

a. 2:3

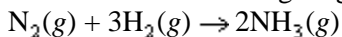
c. 1:1

b. 1:3

d. 1:2

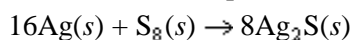
Problem/Short Answer (4 points each)

20. What is the limiting reagent when 150.0 g of nitrogen react with 32.1 g of hydrogen?



21. Assuming no errors were made in measuring the yield, can the percent yield of a chemical reaction be greater than 100%?

22. When a mixture of sulfur and metallic silver is heated, silver sulfide is produced. What mass of silver sulfide is produced from a mixture of 3.0 g Ag and 3.0 g S_8 ?



Matching (2 points each)

Match each item with the correct statement below.

a. actual yield

e. limiting reagent

b. percent yield

f. mass

c. theoretical yield

g. number of molecules

d. excess reagent

h. volume

23. the reactant that determines the amount of product that can be formed in a reaction

24. the reactant that is not completely used up in a reaction

25. the ratio of the actual yield to the theoretical yield

26. the maximum amount of product that could be formed from given amounts of reactants

27. the amount of product formed when a reaction is carried out in the laboratory