THE IMPACT OF PROJECT BASED LEARNING ON STUDENT ENGAGEMENT AND MOTIVATION

by

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ABSTRACT

The purpose of this study was to determine the effect that a project based instructional method would have on student achievement and attitude towards science. Students were given a pre-unit survey regarding attitude and confidence in science as well as a pre-test to gauge content knowledge. During the study, the treatment group received instruction based heavily around projects, with students constructing model atoms and alternate periodic tables. The non-treatment group received instruction in a traditional format of lecture and class discussion. Throughout the study, both groups of students were given Claim, Evidence, Reasoning prompts to evaluate their understanding of concepts relating to atoms and the periodic table. Students were given the same survey and pre-test questions at the end of the unit to determine if project based learning had an effect. Students in the non-treatment group showed a greater improvement in confidence and post-test scores whereas students in the treatment group improved more in their critical thinking and reasoning skills.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

I work at Centralia High School, located in southern Illinois, approximately an hour east of St. Louis. The city of Centralia has a population of 12,182 and is surrounded by small towns and farmland (U.S. Census Bureau QuickFacts: Centralia City, Illinois). According to the Illinois Report Card via the Illinois State Board of Education (2021), Centralia High School has 874 students enrolled for the 2021-2022 school year. We are a majority low-income school, with 62% of students eligible for free and reduced lunch. In addition, the student population is made up of approximately 23.9% minority students (CENTRALIA HSD 200 District Snapshot. *Illinois Report Card,* Illinois State Board of Education, 2021).

The class I chose to use for my capstone research project is Title I General Science, which is essentially the lowest level of science we offer at the school. Students who are enrolled in this class have the lowest 15% of 8^{th} grade testing scores. They are below grade level in both math and English, testing closer to a 5^{th} – 7^{th} grade range. The students vary wildly in motivation, from students who want to do well but are just behind academically, to students who are only in school, so they are not considered truant.

These students have always tended to ask why they need to know the content being covered in class and how is it relevant to their lives. If they find the material irrelevant, they are less likely to be engaged and more likely to miss assignments and perform poorly on assessments. Because of this, these students could be engaged more, and therefore learn more, by giving them a greater degree of control of the content they will study.

Project based learning places the decision making and learning in the hands of the student, with the teacher acting more as a facilitator. Students choose topics to study, within set guidelines, and decide how to go about completing their project. They arrive to class each day knowing what tasks need to be accomplished and the reasoning for said tasks. They are able to link what is happening in the classroom with their lives out outside of school.

With each unit covered, a new list of possible projects was then introduced and students chose a specific topic to focus on. This gave students a chance to work with a larger number of their peers and to modify and improve their research techniques throughout the semester. For example, during the unit on forces and motion, students who were interested in football could choose to do research on football helmets and work on designing a helmet that will minimize impact. During the ecology unit, students could choose to investigate some of the invasive species in the area and develop plans to minimize their impact on the local ecosystem. Students could choose projects off the possible project lists or they could propose an idea their group came up with on their own.

Focus Question

My experiences working with unmotivated students who are looking for a purpose in their education has led to the formation of the following focus question, What impact does project based learning have on student attitude and academic performance?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Project-Based Learning

According to the Buck Institute of Education, project-based learning (PBL) is a teaching method that tasks students with investigating an authentic question, problem, or challenge in order to gain scientific knowledge and skills. PBL looks to create powerful learning experiences for students by connecting the science content with the student's real life outside the classroom (Kingston, 2018).

PBL shifts the learning process from a teacher-centered classroom to one in which students actively inquire and engage in projects that can take place both inside and outside of the classroom (Laverick, 2018). Students are not asked to learn content with little to no real life context. The methods implemented in PBL allow students to utilize problem solving skills, collaboration, and inquiry to not only gain content knowledge but also work towards solutions to real life problems (Bradford, 2005).

The project method of instruction offers some distinct advantages over traditional instruction. Instead of typical day to day lessons and assignments, PBL allows for continual work on part of the student towards a larger goal. Research has shown that PBL teaching methods increase student knowledge as well as promote students' professional skills and attitudes (Capraro et al., 2013). These projects can give students opportunities to interact with adults and organizations outside of the school by helping them develop valuable skills that can't be taught in a traditional classroom. It also can help students develop possible career interests as they work closely with professionals in the field they are investigating (Kingston, 2018).

Student Motivation and Engagement

Finding new ways to engage and motivate students is a challenge that each teacher faces throughout their career. Students want to know how the content being delivered is relevant to their lives. The "why do I need to know this?" is a constant question not only in science classrooms, but in education in general. Research has shown that using PBL and allowing students to choose real world topics that interest them has increased their engagement with the material in addition to improving their attitude and confidence towards science (Basche et al., 2016). One study found that when teachers implemented a project-based curriculum and worked alongside local experts, students became more comfortable with scientific practices and were 20% more engaged in the material being studied than they had been while working in a more traditional classroom (Juuti et al., 2021).

Teacher's Role in a PBL Classroom

With the nature of project-based learning being student-centered instruction, the teacher's role is different from that of a traditional classroom. In PBL instruction, the teacher is there to facilitate, guide, monitor, and mentor the students as they actively investigate the assigned topic. Teachers have to move away from the standardized, Madeline Hunter style lesson plan that focuses heavily on delivering content and move towards encouraging questioning, evidence gathering, and critical thinking in a much more open-ended format. Topics that students investigate should link the content required by state standards with issues that are relevant to the lives of students and their communities (Colley, 2008).

This style of planning will require extensive preparatory work on the part of the teacher. Although students are tasked with identifying the project they intend to study, the teacher is responsible for making students aware of the project expectations and responsibilities as well as explaining how students will be assessed. This could include helping students identify possible areas of study, narrow down the scope of their investigation, and plan how to best implement their project. Throughout the process, the teacher closely monitors and supervises group dynamics and progress (Colley, 2018).

CHAPTER THREE

METHODOLOGY

Demographics

The purpose of this study was to determine if using a project-based learning format instead of the traditional instructional method of lecture and discussion impacted student performance and attitude. Specifically, my focus asked how using project-based instruction would impact student engagement and academic performance in class. To investigate this question, two groups of ninth grade general science students were studied. One group was taught a unit on the periodic table using a project-based format, while the other was given more traditional instruction using a lecture and discussion format. Both groups were given a pre-test to gauge knowledge before the unit began and then a test with identical questions at the end of the unit to assess growth. Both groups were also given a survey to collect qualitative data on attitudes towards science, science instruction, and school projects. This same survey was repeated at the end of the unit. Throughout the study, students in both groups were assessed using claim, evidence, reasoning (CER) papers well as muddiest point and one-minute papers.

I teach two sections of ninth grade general science at Centralia High School. The sections are the same size with 15 students and have very similar in demographics. In the first section, four students have individualized education plans (IEPS) compared to three students in the second section. Both sections are comprised of nine males and six females. The first section had class immediately before lunch while the second group came to class immediately after lunch.

Treatment

To test the effectiveness of project-based learning, the two sections received different forms of instruction in February 2023. The unit on the periodic table is part of our third quarter curriculum giving students a basic understanding of chemistry. The first section was taught about the periodic table using a more traditional instructional style of lectures with notetaking, in-class discussion, and independent work based around our class science textbook. Each topic followed a similar format of teacher-led instruction followed by independent practice or small group work. The second group was taught about the periodic table while working through a project titled Mendeleev Museum created by the PBL Science Spot (*the science spot*). Instead of a heavy emphasis on teacher led instruction, the students worked through topics regarding the periodic table while developing artifacts for their museum. The learning process was predominantly student led. Both groups took the same pre-test to gauge knowledge going into the unit and a post-test to measure growth. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Data Collection and Analysis Strategies

To collect data on the effectiveness of project-based learning, students were given the Periodic Table Pre and Post Test to determine academic growth regarding the periodic table (Appendix B). The pre-test consisted of ten fill-in-the blank questions regarding the periodic table and its properties. Students were instructed to answer as many questions as possible, but because we had not yet learned the material, it was acceptable to leave spaces blank. At the end of the unit, the students in both groups were given the same 10 fill in the blank questions as a post test. The pretest scores were compared to the post test scores for all students in both groups and an average percentage growth was calculated for each group.

Data from the CER assessments were also collected throughout the unit and reviewed for common mistakes amongst both groups. Students were given four different prompts during the unit and were asked to make a claim, provide evidence, and then explain their reasoning for each. The CER prompts focused on understanding valence electrons and how location on the periodic table could help one predict an atom's properties. This data was analyzed using a scoring rubric and then comparing the numbers of students who answered correctly with correct reasoning, correctly with incorrect reasoning, and incorrectly for each group (Appendix C).

Students were also given the Periodic Table Quiz that required them to use a periodic table to find the number of protons, neutrons, electrons, and valence electrons for five elements. The scores for the treatment and non-treatment group were compared and the quizzes were reviewed for common mistakes (Appendix D).

Data on student attitude towards science was collected through the use of the Student Attitude Survey given before and after the unit to both groups (Appendix E). The survey asked students to respond to a variety of questions regarding science class with strongly agree, agree, neither, disagree, or strongly disagree. Students were also asked to rank instructional strategies from the most helpful (1) to the least helpful (5). The data from the student surveys was analyzed by looking for changes in attitude from the beginning of the unit to the end.

Table 1. Data Triangulation Matrix

Research Question:	Data Source 1	Data Source 2	Data Source 3
How does using project-based instruction impact student attitude and academic performance in science class?	Periodic Table Pre/Post Test	In-class Assessments -CERs -Periodic Table Quiz	Student Attitude Survey

CHAPTER FOUR

DATA ANALYSIS

Results

The results from the Periodic Table Unit Pre- and Post- Tests indicated that students in the non-treatment group who were taught using a more traditional, direct instruction method showed a larger average gain than students in the treatment group who learned through project based instruction. The treatment group showed an average normalized gain of 0.58 (*n*=12) with an average mean and median post-test score of 60%. According to Hake (1998), a normalized of 0.3 or lower is considered low gain while a gain of 0.7 or greater is considered a high gain (Table 2). Two students in the treatment group showed high gain values while one showed a low gain value at 0.3.

The non-treatment group showed an average normalized gain of 0.73 (*n*=11) with an average post-test mean score of 67% and a median score of 80% (Figure 1). Eight students in the non-treatment group showed high gain values with the remaining three students showing medium gains values (Figure 2). All students in the non-treatment group had an average gain of 0.5 or higher with only two students scoring below 70% on the post-test (Figure 3)

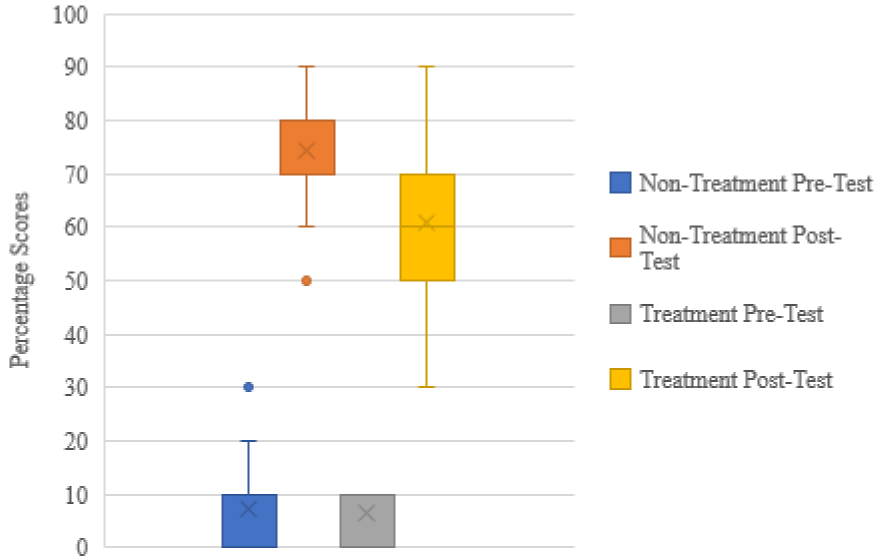


Figure 1. Scores on the Periodic Table Pre- and Post- Test for treatment, (*n*=12), and non-treatment groups, (*n*=11).

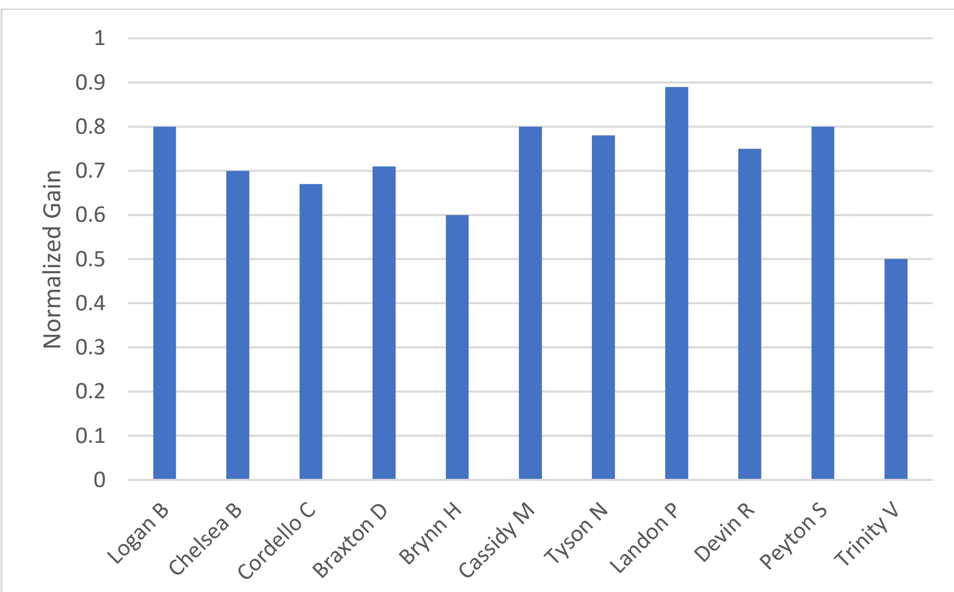


Figure 2. Normalized gains for individual students in the non-treatment group. A normalized of 0.3 or lower is considered low gain while a gain of 0.7 or greater is considered a high gain (Hake 1998).

Table 2. Pre- and post- test normalized gain values.

Teaching Method	Unit	*n*	Normalized Gain
Treatment – Project Based Instruction	Periodic Table	12	0.58
Non-Treatment – Direct Instruction		11	0.73

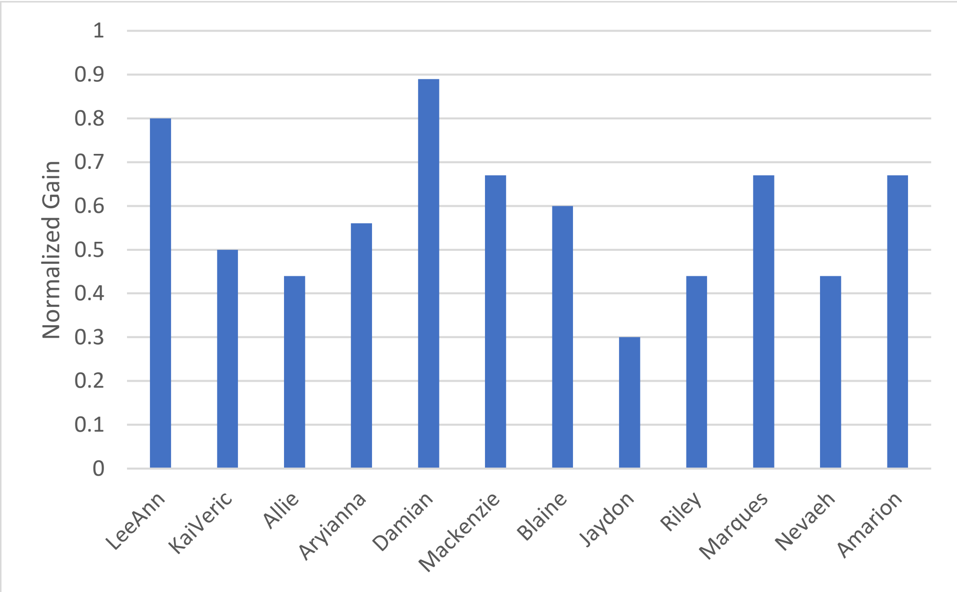


Figure 3. Normalized gains for individuals in the treatment group. A normalized of 0.3 or lower is considered low gain while a gain of 0.7 or greater is considered a high gain (Hake 1998).

On the Periodic Table Pre- and Post- tests, several questions focused specifically on using the periodic table to find the number of protons, electrons, and neutrons for an atom. All students in both the treatment and non-treatment group incorrectly answered these questions on the pre-test, showing that all students began the unit with no prior knowledge on how to read the periodic table. Both groups showed significant improvement on the post-test. The treatment group had eleven students correctly answer all three questions with the remaining student answering two of the three questions correctly (*n*=12). The non-treatment group showed similar improvements, with nine students correctly answering all three questions correctly, one answering two of three correctly, and one answering one question correctly (*n*=11).

The Periodic Table Test had one question focusing specifically on understanding element location on the periodic table. No students answered the question correctly on the pre-test. The results on the post- test showed significant differences in growth, with only one student from the treatment group (*n*=12) answering correctly compared to nine of the students in the non-treatment group (*n*=11). This suggest that although both groups showed significant gains in using the Periodic Table to find the number of protons, electrons, and neutrons of an atom, the treatment group did not improve on understanding atom location on the Periodic Table (Figure 4).

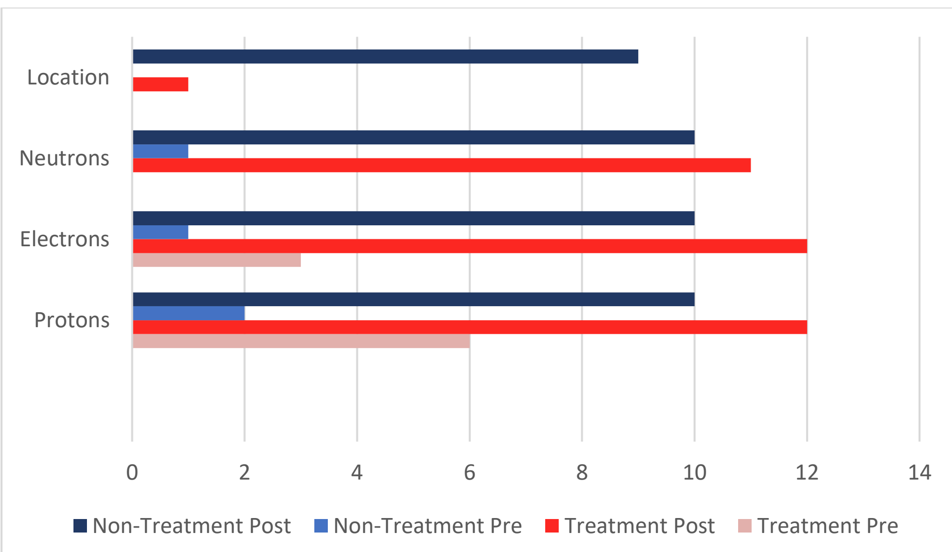


Figure 4. Number of students responding correctly to Periodic Table Pre- and Post- test questions regarding using the periodic table to find parts of an atom. Note: Protons = finding the number of protons; Electrons = finding the number of electrons; Neutrons = finding the number of neutrons; and Location = determining the location of an element on the table. Treatment group, *n*=12. Non-Treatment group, *n*=11.

Mid-way through the unit, students were given the Periodic Table Quiz that consisted of 22 questions to assess student progress on using the Periodic Table to determine protons, electrons, neutrons, and valence electrons. The treatment group had a mean score of 91% on the quiz, with 57% of students earning an A, 29% of students earning a B, 7% a C, and 7% a D (*n*=14). The non-treatment group had a mean score of 83% on the quiz, with 54% of students earning an A, 15% earning B's, C's and F's respectively (*n*=13). The non-treatment students who earned lower grades had been absent for multiple class periods leading up to the quiz (Figure 5).

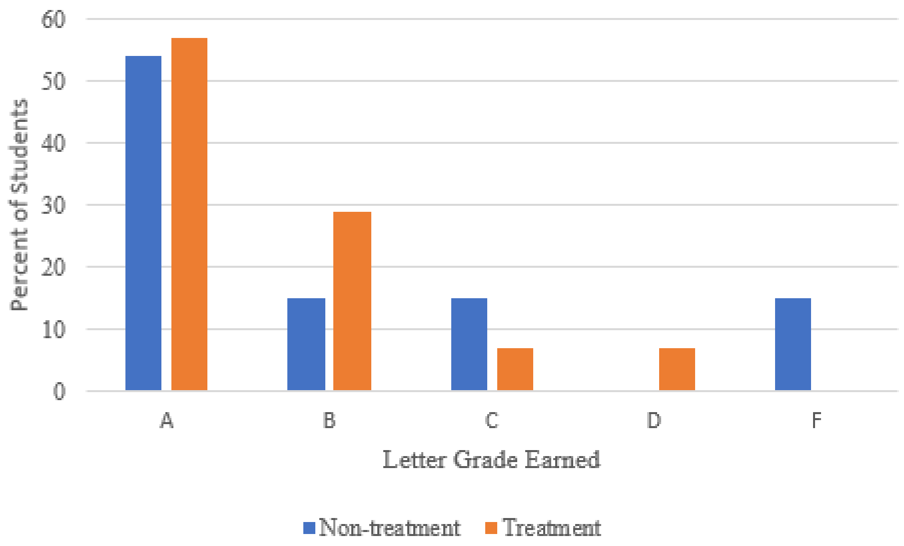


Figure 5. Results of the Periodic Table Quiz. Treatment group, *n*=12. Non-Treatment group, (*n*=11).

Students in both groups also completed a series of Claim, Evidence, Reasoning (CER) prompts throughout the unit. The first CER prompt focused on Bohr models and using the number and arrangement of valence electrons to identify an atom. For this prompt, the treatment group had three students correctly answer the question and valid evidence and reasoning. One student stated "B is the answer because they are in the same row and there is seven on the outside." Another three students answered correctly but had inaccurate reasoning. One of the students in the group wrote, "The correct answer is B because it is closer to Bromine on the Periodic Table." The remaining seven students incorrectly responded to the prompt (*n*=13) (Figure 6). All of the students who responded incorrectly used the same reasoning to come to their conclusion – counting the total number of electrons instead of looking at the number of valence electrons and energy levels. For example, a student stated "Bromine has 35 atoms and letter A has 20 so it has to be similar to Bromine" (Figure 7). The non-treatment group had nine students correctly respond with valid reasoning to the prompt (*n*=13). A student answering correctly stated "B would be more similar because it has the same number of VE." As with the treatment group, the students that responded incorrectly used the same incorrect reasoning to justify their answer.

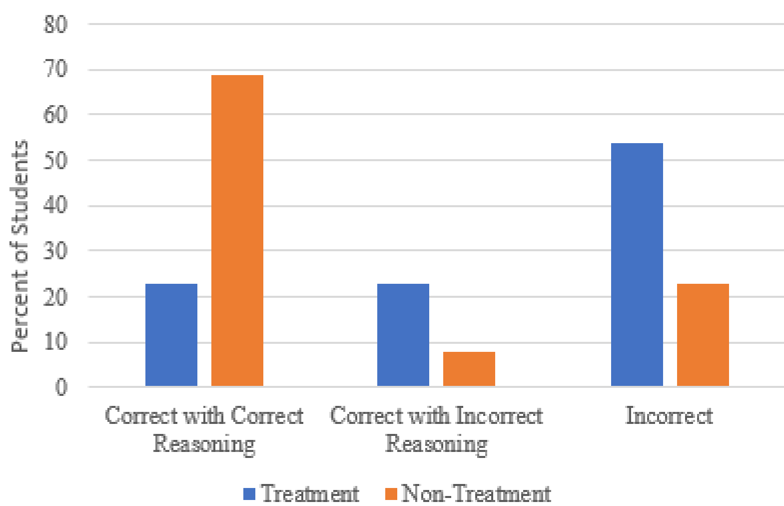


Figure 6. Responses to CER prompt 1 pertaining to Bohr Models and valence electrons.

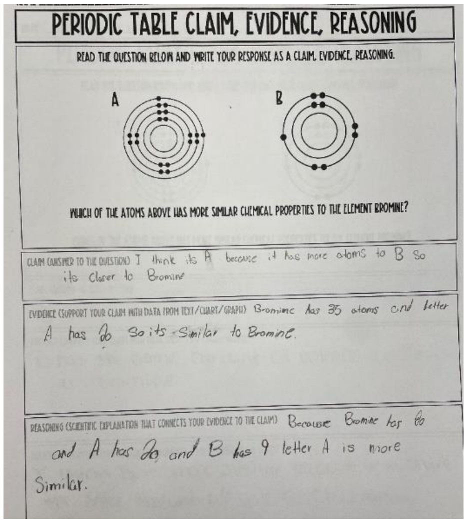


Figure 7. Example of the incorrect response and reasoning for the first CER prompt.

The second and third CER prompt related to using the location of elements on the Periodic Table to predict properties. On the second prompt, the treatment group 10 students (*n*=13) of student respond correctly with valid reasoning and the non-treatment group had 7 students respond correctly with valid reasoning (*n*=11) (Figure 8). One student wrote "X and Z are in the same column, which makes them in the same group. Groups have the same number of valence electrons so they have the same properties." Students had begun to realize the importance of groups and valence electrons configuration to an atoms properties (Figure 9). The students in the non-treatment group that answered incorrectly did so because they did not follow the prompts instructions. One student stated "Y has to be Argon because I just went to where the letters were on the Periodic Table" (Figure 10). Both groups showed improvement between prompts two and three. On the third prompt, 100% of the treatment group and 82% of the non-treatment group responded correctly with valid reasoning (Figure 11). Students demonstrated that they understood the significance of group and period number in electron configuration. A student stated "D would be the element because it is in group 17 and period 5, meaning it would have 7 valence electrons and 5 energy levels" (Figure 12).

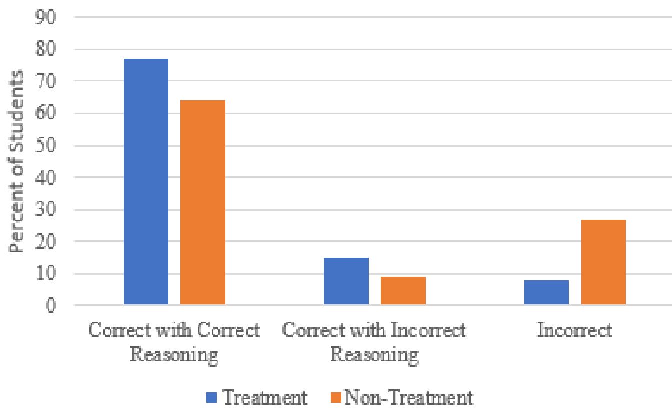


Figure 8. Responses to CER Prompt 2 asking students to find similar elements based of locations on the periodic table.

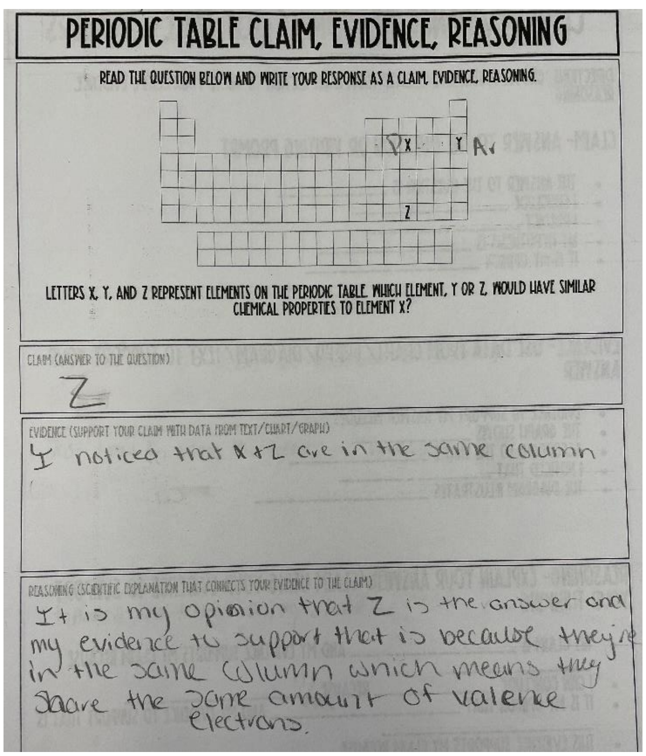
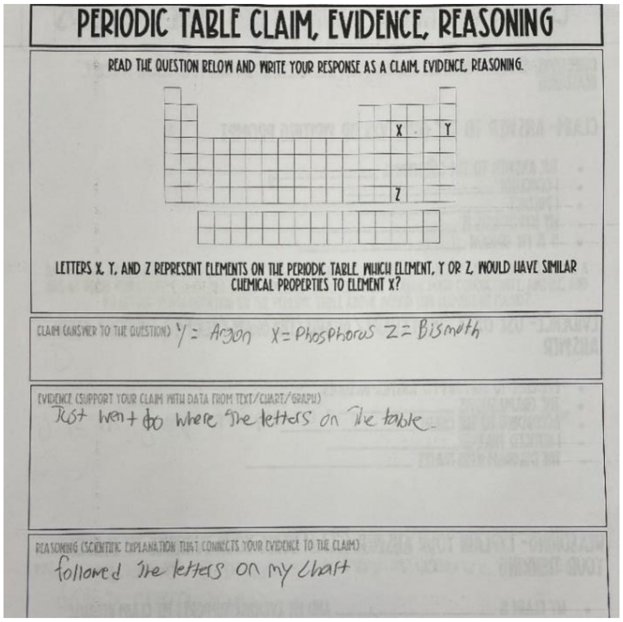


Figure 9. Example of student response to CER Prompt 2 demonstrating knowledge of the importance of group number to atoms properties.


PERIODIC TABLE CLAIM, EVIDENCE, REASONING

READ THE QUESTION BELOW AND WRITE YOUR RESPONSE AS A CLAIM, EVIDENCE, REASONING.

X Y Z

LETTERS X, Y, AND Z REPRESENT ELEMENTS ON THE PERIODIC TABLE. WHICH ELEMENT, Y OR Z, WOULD HAVE SIMILAR CHEMICAL PROPERTIES TO ELEMENT X?

CLAIM (ANSWER TO THE QUESTION) Y = Argon X = Phosphorus Z = Bismuth

EVIDENCE (SUPPORT YOUR CLAIM WITH DATA FROM TEXT/CHART/GRAPH)
Just went to where the letters on the table

REASONING (SCIENTIFIC EXPLANATION THAT CONNECTS YOUR EVIDENCE TO THE CLAIM)
followed the letters on my chart

Figure 10. Example of student response to CER Prompt 2 showing a failure to follow prompt instructions.

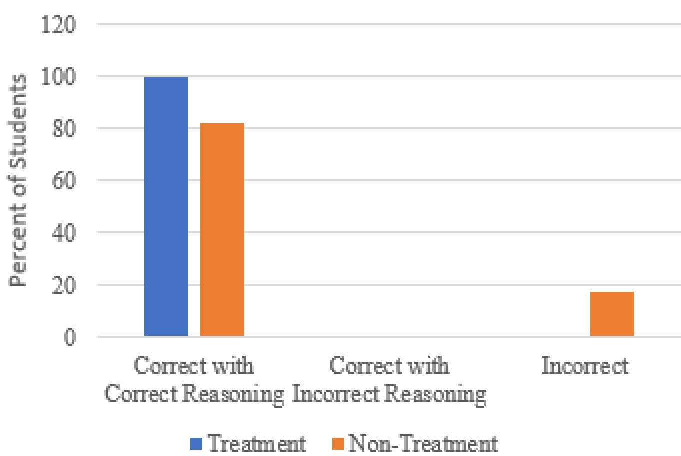
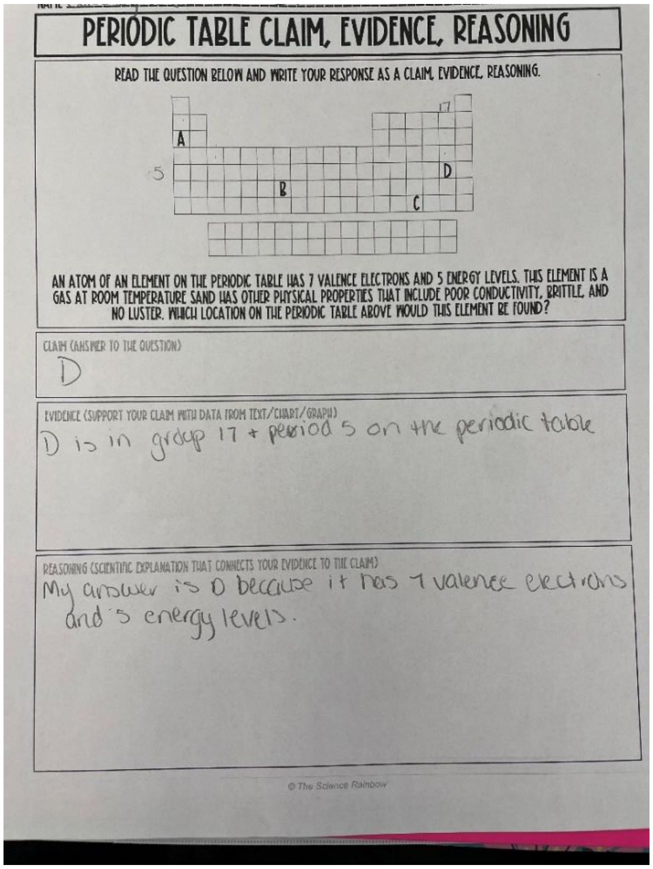


Figure 11. Responses to CER Prompt 3 asking students to identify an atoms location on the Periodic Table based of listed characteristics.



PERIODIC TABLE CLAIM, EVIDENCE, REASONING

READ THE QUESTION BELOW AND WRITE YOUR RESPONSE AS A CLAIM, EVIDENCE, REASONING.

AN ATOM OF AN ELEMENT ON THE PERIODIC TABLE HAS 7 VALENCE ELECTRONS AND 5 ENERGY LEVELS. THIS ELEMENT IS A GAS AT ROOM TEMPERATURE SAND HAS OTHER PHYSICAL PROPERTIES THAT INCLUDE POOR CONDUCTIVITY, BRITTLE, AND NO LUSTER. WHICH LOCATION ON THE PERIODIC TABLE ABOVE WOULD THIS ELEMENT BE FOUND?

CLAIM (ANSWER TO THE QUESTION)

D

EVIDENCE (SUPPORT YOUR CLAIM WITH DATA FROM TEXT/CHART/GRAPH)

D is in group 17 + period 5 on the periodic table

REASONING (SCIENTIFIC EXPLANATION THAT CONNECTS YOUR EVIDENCE TO THE CLAIM)

My answer is D because it has 7 valence electrons and 5 energy levels.

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Figure 12. Example of student response to CER Prompt 3 demonstrating a solid understanding of the importance of group and period number.

The Pre- and Post- Student Attitude Survey showed that the non-treatment group had an increase in overall confidence in the science ability throughout the unit, from 27.3% of students strongly agreeing on the pre-test that they could earn the grade they want in science to 55% strongly agreeing on the post-test. Students stated that “taking notes and practicing the math” and “going over it about 100 times” helped them understand and feel confident with the material. The treatment group also showed an improvement in confidence, though not as drastic as the non-treatment group. In the pre-unit survey, only 16.6% of students were confident in their ability to earn the grade they desired. After the unit, 27% strongly agreed – an increase of

10.4%. Students stated that ‘doing projects and multiple different assignments’ helped them to understand the material and feel confident when taking the post-test.

Student enjoyment in science was gauged by asking students how much they enjoy coming to science class and how much they enjoy completing science related projects. The non-treatment group saw an increase from 63% agreeing or strongly agreeing to the statement ‘I enjoy coming to science class’ to 82% at the end of the unit (*n*=11). The treatment group saw a decrease from pre- to post- unit, with enjoyment declining from 83% to 63% (*n*=11) (Figure 13). This could possibly be due to the increased amount of discipline issues that had to be dealt and with due to students being out of their normal, assigned seats.

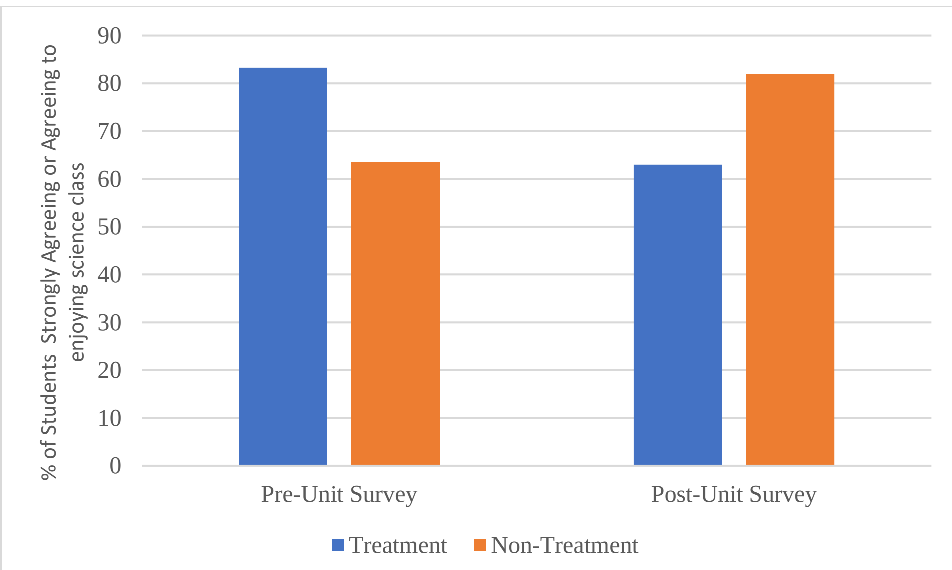

Figure 13. Student responses to ‘I enjoy coming to science class’ on the Pre-Unit and Post-Unit Survey.

CHAPTER FIVE

CLAIM, EVIDENCE, AND REASONING

Claims From the Study

The goal of this project was to determine if student academic performance and attitude toward science would improve if students worked through a unit via project-based learning compared to teacher-led direct instruction. Research was conducted over a single unit on the Periodic Table, with one class serving as the treatment group and one as the non-treatment. Unfortunately, due to behavior issues, it was not possible conduct research on a second unit, switching the treatment and non-treatment classes. The group of students that served at the non-treatment group for the project did not do well if a regular, structured routine was not followed. These students struggled to stay on task if out of their seat and I saw an increase in discipline issues whenever small projects were attempted. It was not in the best interest of these students to attempt project based learning. From this study, the following claims can be made:

1) Project-based learning does not significantly improve student performance from pre- to post-unit assessments for this group.

2) Project-based learning did improve students critical thinking and reasoning abilities for this group.

3) Project-based learning did not lead to an increased level of enjoyment or confidence in science class.

The data gathered from pre- and post- tests, quizzes, CER prompts, and surveys showed that there was not a significant difference in academic performance between project-based instruction and direct instruction. Although the non-treatment group had a higher average normalized gain from pre- to post- test, the treatment group performed better on the mid-unit quiz and the CER prompts. The projects that the treatment groups completed throughout the unit focused primarily on atom structure and the organization of the Periodic Table. To help students understand atom structure, they had to build a Bohr model of an element of their choosing using materials found in the classroom (Figure 14). To help students understand the overall organization of the Periodic Table, they had to develop an alternative Periodic Table using a topic they felt very knowledgeable about (Figure 15). They had to organize the items from their topic in a way that would match how the Periodic Table is organized.

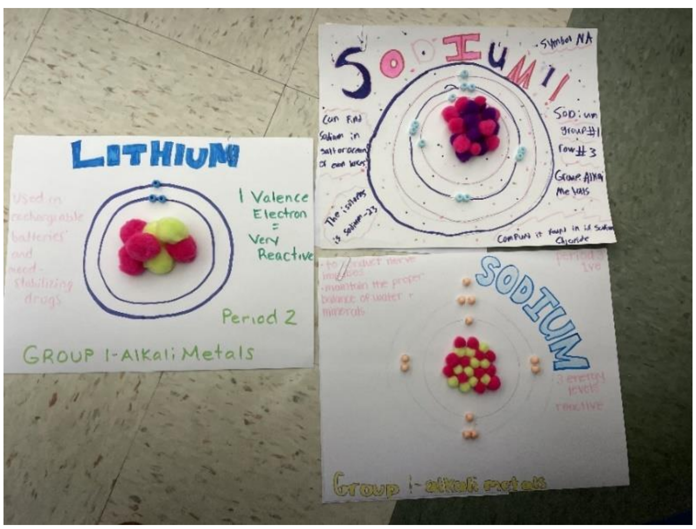

Figure 14. Student examples of Bohr Models made to demonstrate understanding of atomic structure.

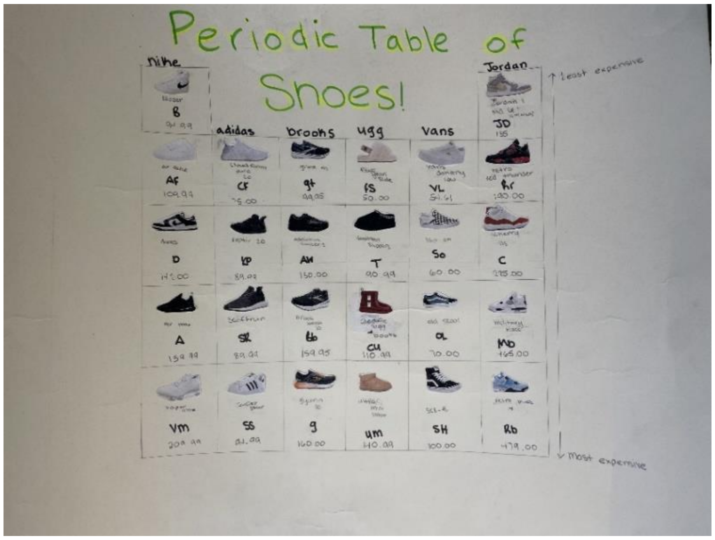

Figure 15. Student example of an alternative Periodic Table created to demonstrate understanding of table organization.

Both of these topics were covered heavily on the quiz and CER prompts. The treatment group students struggled on questions relating to terminology and properties of metals and nonmetals, both topics that did not play a major role in their project. While the non-treatment students performed well on the post-test, they did not do as well on the CER prompts. These prompts required students to apply the knowledge practiced in class to a new problem. The non-treatment students had become very comfortable with the repetition of the teacher-led lessons and had trouble translating that knowledge to a new problem. This shows a positive correlation between student-led, project-based learning and better critical thinking.

In terms of student attitude toward science, the non-treatment group showed a greater increase in confidence and enjoyment than the treatment group. The non-treatment group practiced skills daily and the increased repetition is what I believe led to an increase in confidence. By day five of repeating the same task, students felt confident answering questions in class and the material began to feel easy. This confidence directly impacted their enjoyment in class. The treatment group showed an increase in confidence, but decrease in enjoyment. Although the students reported enjoying hands-on activities and projects, the overall percentage of students that enjoyed coming to class decreased. This is most likely due to the fact that project based learning lessons are primarily student-led and many students in the class struggled to stay on task, leading to an increase in disciplinary issues. More data from a larger group of students is needed to draw a definitive conclusion between project-based learning and student attitude toward science.

Value of the Study and Consideration for Future Research

Teaching methods have had to shift dramatically over the last few years. Teachers have had to adapt to teaching entirely online to a school setting that now seems to place a heavy emphasis on the use of technology in the classroom. And while there are many positives that have come from the shift towards technology use in a 1-to-1 classroom, I have seen a decline in scientific thinking and the value of hands-on activities and work. Students want quick solutions – those a google search away - and have lost some of the wonder that should come with science. Because of this, I wanted to create a student-led, project based unit that allowed students to research topics and apply their understanding to a new problem or situation. My goal was to create a hands-on science classroom that encouraged critical thinking and improved students' attitudes towards the science in general through the use of project-based learning.

The shift from a teacher-led classroom to a student-led, project based classroom helped students not only understand key concepts, but be able to apply that knowledge to a new situation. Although this seemed to make students somewhat uncomfortable, with most having grown quite accustomed to being able to find answers without much thought, and show a slight decline in their class enjoyment, their critical thinking skills improved by the end of the unit. Those that worked through a teacher-led format were confident and enjoyed class, but struggled when it came time to apply their knowledge.

After reflecting on the results of my study, I believe there is much to be gained from further research. I would like to gather data from a much larger group where both groups can receive the treatment since this was not possible with my group of students this year. I would also like to compare the results of a project-based unit on students from honors level classes with those in title, low level classes. My honors level students are grade-focused and will memorize facts to do well on assessments, but it is not always clear if they can apply their knowledge to new situations. Being able to compare the effect of the treatment on groups that vary in academic achievement and attitude towards science and school in general would allow be me to more clearly identify the effect the project-based unit had on students. I believe both groups could benefit from a mix of teacher-led instruction and project based learning. The insight that could be gained from this research could help to identify the best method for producing critically thinking science students.

Impact of Action Research on the Author

This action research made me realize that there is not a one-method fits all way to teach science to high school students. With the transition to NGSS and inquiry-based learning, I think I felt the push to create a classroom environment that was student-led and hands-on; a classroom where I was merely the facilitator and the students were the primary driving force behind their own learning. What I have realized through this research is that this may not work for all students. Although projects are fun, and science should be exciting and fun, they don't always lead to the desired outcomes. Many students need a base of knowledge in a content area before they have the confidence to take the next step. Teacher-led instruction may be required to give them this confidence before they start an independent, project-style task.

I have also realized that students need to practice the skill of critical thinking and it is not something I as a teacher should expect students to be able to do without instruction and repetition. This feels especially true after the COVID years of remote learning where all answers could be found via an internet search or were shared in group chats amongst students. Developing assessments that not only test content knowledge but also application will be a goal of mine moving forward.

Finally, the action research process reminded me that we can always be growing and developing as educators. It is easy to get complacent and remain stuck in what is comfortable, but gathering and analyzing data shows that as the world and students change, our methods of instruction need to change as well.

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APPENDICES

APPENDIX A

MONTANA STATE UNIVERISITY'S INSTITUTION REVIEW BOARD COMPLIANCE

Hello Johnson, Katrina,

Your protocol was reviewed by the IRB and has been approved.

PI: Johnson, Katrina

Approval Date: 1/6/2023

Title: THE IMPACT OF PROJECT BASED LEARNING ON STUDENT ENGAGEMENT AND MOTIVATION

Protocol #: 2023-542-EXEMPT

Review Type: Exempt Review

Expiration Date: 1/6/2028

APPENDIX B

PRE/POST ASSESSMENT

Periodic Table Pre-Test

1. Mendeleev discovered that periodic patterns appeared when he arranged the elements in order of increasing ___________________.

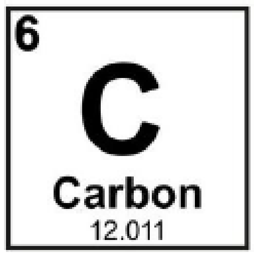
2. The property of an element that indicates the number of protons in its atoms is the ___________________ ___________________.

3. A column of elements in the periodic table is called a group, or ___________________.

4. The electrons in an atom that are involved in forming chemical bonds are called ___________________.

5. Elements in Group 1 have ___________________ valence electron(s).

Use the image below to answer questions 6-8.

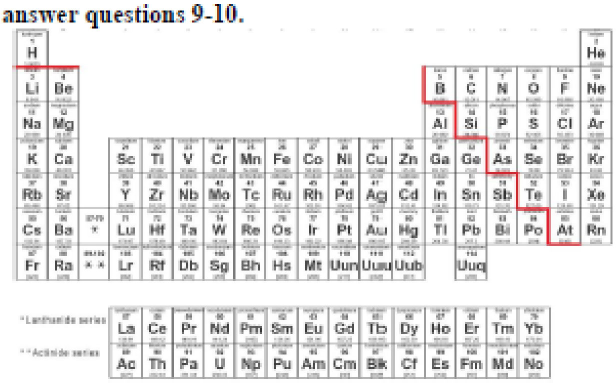


6. How many protons does one atom of carbon have? ____________

7. How many total electrons does one atom of carbon have? _________

8. How many neutrons does one atom of carbon have? ____________

Use the image below to answer questions 9-10.



9. Carbon is in group _____________ and period ______________.

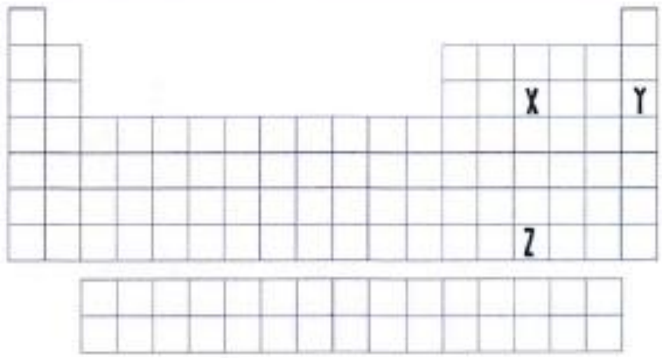
10. Carbon is a(n) _______________________. I know this because it is to the right of the stair step line.

APPENDIX C

CLAIM, EVIDENCE, REASONING ASSESSMENTS

PERIODIC TABLE CLAIM, EVIDENCE, REASONING

READ THE QUESTION BELOW AND WRITE YOUR RESPONSE AS A CLAIM, EVIDENCE, REASONING.



LETTERS X, Y, AND Z REPRESENT ELEMENTS ON THE PERIODIC TABLE. WHICH ELEMENT, Y OR Z, WOULD HAVE SIMILAR CHEMICAL PROPERTIES TO ELEMENT X?

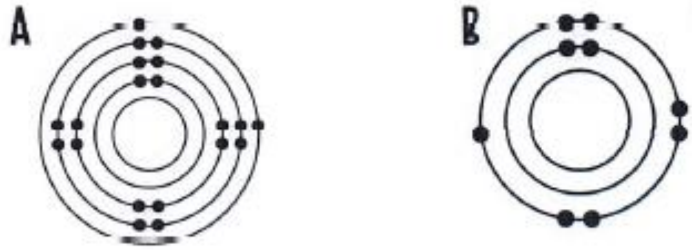
CLAIM (ANSWER TO THE QUESTION)

EVIDENCE (SUPPORT YOUR CLAIM WITH DATA FROM TEXT/CHART/GRAPH)

REASONING (SCIENTIFIC EXPLANATION THAT CONNECTS YOUR EVIDENCE TO THE CLAIM)

PERIODIC TABLE CLAIM, EVIDENCE, REASONING

READ THE QUESTION BELOW AND WRITE YOUR RESPONSE AS A CLAIM, EVIDENCE, REASONING.



WHICH OF THE ATOMS ABOVE HAS MORE SIMILAR CHEMICAL PROPERTIES TO THE ELEMENT BROMINE?

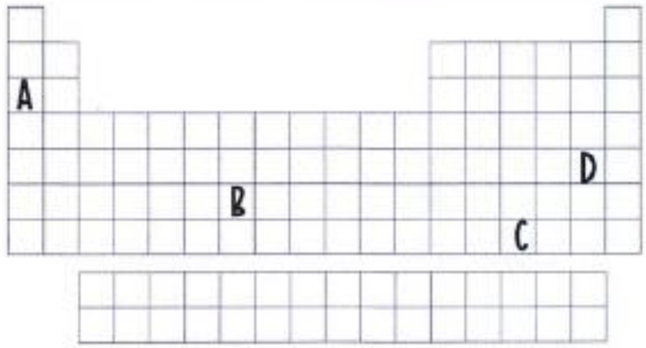
CLAIM (ANSWER TO THE QUESTION)

EVIDENCE (SUPPORT YOUR CLAIM WITH DATA FROM TEXT/CHART/GRAPH)

REASONING (SCIENTIFIC EXPLANATION THAT CONNECTS YOUR EVIDENCE TO THE CLAIM)

PERIODIC TABLE CLAIM, EVIDENCE, REASONING

READ THE QUESTION BELOW AND WRITE YOUR RESPONSE AS A CLAIM, EVIDENCE, REASONING.



AN ATOM OF AN ELEMENT ON THE PERIODIC TABLE HAS 7 VALENCE ELECTRONS AND 5 ENERGY LEVELS. THIS ELEMENT IS A GAS AT ROOM TEMPERATURE SAND HAS OTHER PHYSICAL PROPERTIES THAT INCLUDE POOR CONDUCTIVITY, BRITTLE, AND NO LUSTER. WHICH LOCATION ON THE PERIODIC TABLE ABOVE WOULD THIS ELEMENT BE FOUND?

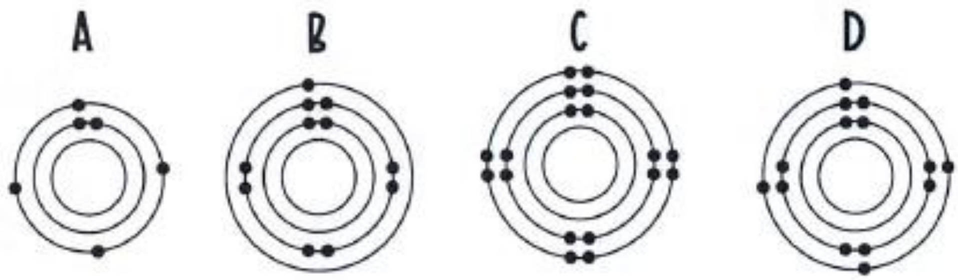
CLAIM (ANSWER TO THE QUESTION)

EVIDENCE (SUPPORT YOUR CLAIM WITH DATA FROM TEXT/CHART/GRAPH)

REASONING (SCIENTIFIC EXPLANATION THAT CONNECTS YOUR EVIDENCE TO THE CLAIM)

PERIODIC TABLE CLAIM, EVIDENCE, REASONING

READ THE QUESTION BELOW AND WRITE YOUR RESPONSE AS A CLAIM, EVIDENCE, REASONING.



THE ATOMS ABOVE REPRESENT CERTAIN ELEMENTS ON THE PERIODIC TABLE. WHICH TWO ATOMS WOULD BE FOUND IN THE SAME GROUP ON THE PERIODIC TABLE?

CLAIM (ANSWER TO THE QUESTION)

EVIDENCE (SUPPORT YOUR CLAIM WITH DATA FROM TEXT/CHART/GRAPH)

REASONING (SCIENTIFIC EXPLANATION THAT CONNECTS YOUR EVIDENCE TO THE CLAIM)

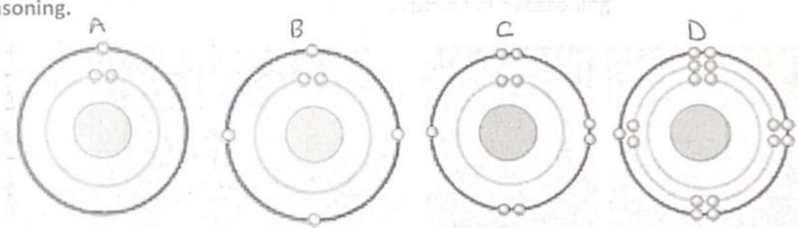
APPENDIX D

THE PERIODIC TABLE QUIZ

Periodic Table Quiz

	Protons	Electrons	Neutrons	Valence Electrons
Aluminum				
Chlorine				
	20			
		54		
			6	4

Compare the four Bohr Models below. **Which two atoms would be found in the same group on the periodic table.** Explain your reasoning.



Letters __________ and ____________ because ____.

APPENDIX E

STUDENT ATTITUDE SURVEY

1. How much do you agree or disagree with the following statements.

Mark only one oval per row.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I enjoy coming to science class.	⬭	⬭	⬭	⬭	⬭
I enjoy watching science related shows on TV/Youtube.	⬭	⬭	⬭	⬭	⬭
I am confident that I can earn the grade I want in science class.	⬭	⬭	⬭	⬭	⬭
I enjoy completing projects related to the science topic we are covering.	⬭	⬭	⬭	⬭	⬭
I enjoy taking notes in class and discussing science topics.	⬭	⬭	⬭	⬭	⬭
Hands on activities and projects help me understand the material.	⬭	⬭	⬭	⬭	⬭
Hands on activities and projects make science class more enjoyable.	⬭	⬭	⬭	⬭	⬭