Station Learning: Does it Clarify Misconceptions on Climate Change and Increase Academic Achievement through Motivation in Science Education?

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Abstract

To clarify students’ misconceptions, hands-on learning stations were used to introduce current issues that students may experience due to climate change. Since climate change is highly controversial, it is very important for students to eliminate misconceptions because they will be creating future policies and management practices to solve for climate change. The three issues this study addressed were how misconceptions about climate change may be clarified using learning stations, will this classroom activity motivate students, and will learning stations increase academic achievement. This experiment was a one-group pretest-posttest design. This study used a single-factor completely randomized design. The quantitative data was analyzed using a one-tailed t-test with a 95% confidence interval. This experiment included qualitative data, including interviews, journal entries, and a questionnaire. Misconceptions were identified through semi-structured interviews. After the treatment, coding was used to determine if students’ conceptions have changed. The motivation questionnaire was coded in five different categories, expressing how station learning motivated or unmotivated student learning. Students showed a clear conceptual change after the station learning treatment. The group experienced a significantly greater post-test, than to the pre-test. Intrinsic motivation, self-efficacy, and self-determination was achieved through student socialization and helping another through the treatment. These findings suggest that science should be conducted through a social and collaborated interaction to raise motivation, thus clarifying students’ misconceptions and achievements.

**Key words:** Climate change, motivation, misconceptions, intrinsic, self-efficacy, self-determination, academic achievement, station learning
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Chapter 1 Introduction

Problem/Background

All students bring misconceptions to the classroom. Unfortunately, many of these misconceptions encompass scientific views such as climate change or evolution (Meadows & Wiesenmayer, 1999). Misconceptions about climate change are generally encountered in science classes or the media (Lomardi & Sinatra, 2012). Many researches have successfully alleviated this problem from multiple teaching strategies, including hands-on learning, computer simulations, and modeling (Tobin & Dawson, 1992; Shepardson, Niyogi, Choi, & Charusombat, 2009; Schaal & Bogner, 2005; Cavalli-Sforza, Weiner, & Lesgold, 1999; McNeil et al., 2010). In this article, station learning was used to determine if students’ misconceptions on climate change are clarified by this teaching method.

According to the Intergovernmental Panel on Climate Change (IPCC), global warming is an alteration to Earth, which is human facilitated (IPCC, 2007). The IPCC has confirmed that human activities involving fossil fuel consumption are the source of greenhouse gases (i.e. methane, carbon dioxide, and nitrous oxides) responsible for the increasing global temperatures. Increasing temperatures may alter the Earth’s environmental systems, weather patterns, and oceanic current patterns. These alterations can affect human health as well as other biotic organisms such as native flora and fauna. Since students may experience climate change, it is important for them to learn more about it.

Paleorecords have shown events where the Earth’s climates have changed from an ice age to increased global temperatures. Fluctuation in temperatures also occurred during the last glacial period, where mean annual global temperatures rose by 5 degrees Celsius within a few
decades (Nicholls, Gruza, Joauzel, Karl, & Ogallo, 1996). During these alterations of climate change, plant fossil records indicate the capability for fast migration between ecosystems. Fossil records indicate that these fast migrations have occurred within a few decades (Pitelka, 1997). However, the last glacial period occurred during the Holocene (11,700 years ago), where humans didn’t fragment landscapes as they do today. Habitat destruction and fragmentation, is increasing the rate of extinct species and endangered species on Earth. Together with global climate change, this can impact species extinction and strand plants without migration (Schemske et al., 1994).

Since 1978, satellite data has shown that the Arctic sea ice has shrunk by 2.1-3.3% per decade. Mountain glaciers and snow cover in high mountain ecosystems have declined in both hemispheres on Earth. From long-term studies, scientists are confident that climate change will lead towards an increase of intense flooding, heat waves, cyclones, and droughts for both developed and undeveloped countries (IPCC, 2007a). Ice melting from glaciers and the polar ice caps may change oceanic current and alter weather patterns. Biodiversity hot spots such as the coral reefs may corrode away due to carbonic acids forming in the ocean. (IPCC, 2007a)

According to Shepardson et al. (2009), many children do not think climate change will have a major impact on people or society. Students at the age of 11 to 12 have an understanding of greenhouse effect in the role of global warming, but misunderstand how to alleviate global warming. Students identified improving environmental issues as means to reduce climate change (Taber & Taylor, 2009). It’s crucial for students to eliminate misconceptions on climate change because they will be creating or voting on new policies and management practices for solving the problems of climate change. If science education is creating citizens for future management and
policies, then it’s important to identify student misconceptions about climate change (Osborne & Freyberg, 1985) and practical solutions for solving climate change.

**Theoretical Framework**

In order for students’ misconceptions to clarify, students must be taught through the constructivist perspective. Piaget (1970) defined constructivism as a person’s ability to connect new knowledge with prior knowledge, which was based on personal experiences. Since students already hold misconceptions, teachers must use teaching strategies that resolve students’ cognitive disequilibrium’s, or student schemes that are not accurate. From this approach, students are left with a “cognitive conflict,” where the students must reevaluate their existing schemes or experiences with a new concept.

An approach to solve cognitive disequilibrium is through Bandura’s social cognitive theory (Bandura, 2006). Albert Bandura’s social cognitive theory was designed to explain how people acquire competence, attitude, styles of behaviors, and how they motivate their level of functioning (Bandura, 2006) in science learning through three motivating components-intrinsic, self-efficacy, and self-determination motivation (Sanfeliz & Stalzer, 2003). Intrinsic motivation is defined as a student’s interest or curiosity for learning science. Self-efficacy is defined as a student’s belief that they can achieve well in science. Self-determination is the student’s belief that they have the confidence or control to learn science (Bryan, Glynn, & Kittleson, 2011).

According to Gonzales et al., (2004), American students continue to perform poorly in science when compared to other nations, so it’s important to find what motivates students to learn science. In order for students to achieve motivation, students must be taught through their learning style (Cluck & Hess, 2003). Howard Gardner’s intelligence theory describes seven
ways students learn, including linguistic, logical, musical, kinesthetic, visual, interpersonal, and intrapersonal (Cluck & Hess, 2003). If station learning can offer students an opportunity to learn through their learning style, then motivation can be reached and cognitive disequilibrium can be solved.

Purpose/Rationale

The purpose of this study is to determine if station learning is an adequate teaching strategy for clarifying misconceptions on climate change. Supporting evidence suggests that learning at workstations can offer many learning styles, such as visual (pictures), kinesthetic (hands-on activities), and intrapersonal (cooperative groups) (Jarrett, 2010; Schaal & Bogner, 2005). Taber and Taylor (2009) found that hands-on activities and visual aids increased student knowledge on climate change. Learning stations have been found to increase students’ intrinsic motivation, self-efficacy, and self-determination through cooperative group learning by watching their peers succeed and increasing competence (Gerstner and Bogner, 2010; Jenson et al., 2011; Schaal & Bogner, 2005). If this teaching strategy, station learning, increases motivation, knowledge, and supports many learning styles, then perhaps it’ll offer enough support to help students work through their cognitive disequilibrium’s and clarify their misconceptions on climate change.

Research Question

In previous studies, station learning has shown to increase motivation, knowledge, and support many learning styles (Gerstner & Bogner, 2010; Jarrett, 2010; Schaal & Bogner, 2005; Taber & Taylor, 2009). In this study, station learning was experimented at a vocational school to determine if student misconceptions on climate change were resolved. To clarify their
misconceptions, hands-on learning stations were used to introduce current issues that students may experience due to climate change. For students to care and understand the importance of knowing the issues addressing climate change they must be motivated. Once motivated, students will raise curiosity of climate change through intrinsic motivation and will become academically successful through self-efficacy and self-determination. The three issues this study addresses are how misconceptions about climate change may be clarified using learning stations, will this classroom activity motivate students, and will learning stations increase academic achievement.
Chapter 2 Literature Review

Introduction

The following chapter focuses on the background literature that has identified ways to improve science education, helping clarify misconceptions. Many studies have shown common student misconceptions about climate change and the different teaching strategies used to teach students about climate change. In order clarify these misconceptions, studies have focused on different theories on student motivation and how motivation is a major enforcer for student success in the classroom. For students to reach success, previous studies have shown how teaching strategies, such as station learning, provided multiple learning styles to motivate students to learn and become successful.

Misconceptions

Many students often bring misconceptions (mistaken thoughts or ideas) about global climate change to science classrooms due to previous encounters in science classes or the media (Lomardi & Sinatra, 2012.). Previous research has shown many student misconceptions on climate change. Lombardi and Sinatra (2012) has shown that students misconceptions on climate change include: (1) differences between weather and climate, (2) identifying stratospheric ozone depletion as a primary contributor to climate change, and (3) linking unrelated pollution effects (i.e. litter, toxic waste, and secondary pollutants) to explain climate change. Shepardson et al. (2009) involved students’ written words and drawings illustrating their understanding on climate change concepts. Shepardson et al. (2009) found that the majority of students thought greenhouse gases exist as a layer in the atmosphere. Fisher (1998) identified that the majority of students did not consider carbon dioxide (CO₂) or water vapor as a
greenhouse gas. Furthermore, students do not understand the difference between human activities that impact climate change (e.g. driving a car) and those that do not impact climate change (e.g. littering) (McNeill et al., 2010).

Due to media coverage on the Kyoto Protocol and documentary films such as An Inconvenient Truth, climate change interests have dramatically increased from 1997 to 2006 (Boykoff, 2007). Climate change has now been added to the National Science Education Standards (NRC, 1996), but has not yet been identified as a major science education standard in America (Sharma, 2011). Some states still lack mentioning climate change in their Benchmarks for Science Literacy and environmental science standards for grades 9-12 (Sharma, 2011). Since the children of today are going to be the leaders of the future, it is important to educate them about climate change and its threats. Regarding the misconceptions listed above, an international panel of scientific experts’ stated that (1) long term observations show a trend in climate change, specifically melting of snow and ice, (2) increases of atmospheric greenhouse gases are the result of climate change, and (3) anthropogenic activities such as carbon emissions are the contributor to increased atmospheric concentrations of greenhouse gases. (Intergovernmental Panel on Climate Change, 2008). If climate change is not solved then the Earth will encounter extreme weather events, threats to unique and threatened ecosystems, and impacts to vulnerable human populations.

There has been strong evidence that have correlated unique and threatened ecosystems, such as polar and high mountain ecosystems, to become extinct or threatened due to climate change. Since 1978, satellite data has shown that Arctic sea ice has shrunk by 2.1-3.3% per decade. Mountain glaciers and snow cover in high mountain ecosystems have declined in both hemispheres on Earth. A medium correlation has stated that an increase of global temperatures
by more than 1.5-2.5°C, may risk 20-30% of plants and animals towards extinction. From long-term studies, scientists are confident that climate change will lead towards an increase of intense flooding, heat waves, cyclones, and droughts for both developed and undeveloped countries (IPCC, 2007a). Ice melting from glaciers and the polar ice caps may change oceanic current and alter weather patterns. Biodiversity hot spots such as the coral reefs may corrode away due to carbonic acids forming in the ocean. (IPCC, 2007a) Elderly folk may become vulnerable to heat stroke (Kerr, 2007) and many ecosystems and infrastructure from both developed and undeveloped countries will be at risk (IPCC, 2007b). Less-developed nations, such as South Africa or South Asia, that are already struggle with water stress, endemic hunger, and food insecurity will be greatly impacted by species extinction and weather changes (IPCC, 2007b).

For these vary reasons, science education should be re-envisioned for the climate change era. New standards should addressing issues, such as the carbon cycle and the role of fossil fuels, the relationship between fossil fuels and humans, and finally societal and agricultural impacts of climate change, due to food and water shortages (Shepardson et al., 2009). Science education needs to be reformatted to integrate social studies, as well as other disciplinarians, to interrogate for complex relationships between humans and the natural world. Many of the greenhouse gases are anthropogenic produced due to economics within countries. Science can claim cause and effect relationships due to climate change and how to live in a sustainable manner, but it cannot control human behavior towards climate change mitigation (Sharma, 2011).

Many teaching strategies have been used to help clarify student misconceptions on climate change. McNeil et al. (2010) used modeling, videos, direct instruction, brainstorming, and computer simulations (Cavalli-Sforza et al., 1999) to help students comprehend concepts of
climate change. According to McNeil et al. (2010) and Cavalli-Sforza et al. (1999) these teaching strategies proved to be effective. Between the pre and post-test, there was a significant increase in student understanding of what climate change is, its causes, and the consequences. Schaal and Bogner (2005) has shown that station learning with cooperating learning, hands-on, inquiry based learning, and student autonomy, may positively affect students’ motivation. Gerstner and Bogner (2010) showed that hands-on experiences, which can take place in station learning, in an interactive science programme have higher interests scores towards student’s intrinsic motivation than traditional lessons. Taber and Taylor (2009) found that an intervention teaching strategy, with hands-on and small group learning was effective for teaching climate change. This strategy showed a significant increase in the number of correct answers in the posttest than in the pretest. In order to clarify misconceptions and increase academic success, station learning will require a combination of hands-on, small group, cooperating learning, and inquiry based learning.

Even though there have been teaching strategies that have mitigated students’ misconceptions, students must feel dissatisfied, through constructivism, with their existing concepts before they can restructure those concepts (Dreyfus, Jungwrith, & Eliovitch, 1990). Piaget defined constructivism as how human are able to connect new information with past knowledge that was based on personal experiences (Piaget, 1970). When a learner constructs their own knowledge based on personal experiences, one can evolve these schemes to more complex experiences, known as adaptation in constructivism. Adaptations are a part of the equilibration, or accurately connect new information to existing experiences, process of connecting and evolving experiences. True learning begins when students are resolved of their disequilibrium’s, or student schemes that are not accurate. Students will then be introduced to a
“cognitive conflict,” where the students must reevaluate their existing schemes or experiences with a new concept (Meadows and Wiesenmayer, 1999).

Students will not change their prior concept because it is simply taught to them. The cognitive conflict requires teachers to provide and present more correct and satisfying data to the student than their previous concept (Meadows and Wiesenmayer, 1999). Highly resistant misconceptions require more targeted learning activities and periods longer than one year to produce a conceptual change. Although, Hewson (1981), stated that even a persuasive teacher may not change a student’s misconception, a reason why motivation is so important in education.

Motivation

Intrinsic

In order to correct misconceptions, students must employ their cognitive disequilibrium and resolve their concepts through cognitive conflicts. Teachers are required to supply students with this information through various teaching strategies, such as station learning. Before students become engaged, clarifying misconceptions requires a lot of thought and therefore students must be motivated. Motivation can be defined as any process that promotes humans to change in behavior (Sevinc, Ozmen, & Yigit, 2011). Behaviors can be identified as promoting both new learning and building on previous knowledge, skills, and behaviors (Barlia, 1999). According to Sevinc et al. (2011), learning is achieved through behavioral changes and to acquire a behavioral change requires motivation.

To explain human learning and motivation more thoroughly, we can investigate how human learn through constructivism, multiple intelligence theory, and the social cognitive theory. As stated earlier, Piaget defined constructivism as how human are able to connect new
information with past knowledge that was based on personal experiences. Students will obtain cognitive conflicts and need to correct their cognitive disequilibrium. One approach to solve cognitive disequilibrium is Bandura’s social cognitive theory (Bandura, 2006). The social cognitive theory was designed to explain how people acquire competence, attitude, styles of behaviors, and how they motivate their level of functioning (Bandura, 2006) in science learning through three motivating components-intrinsic motivation, self-efficacy, and self-determination (Sanfeliz & Stalzer, 2003). Intrinsic motivation can be defined as a student’s interest or curiosity for learning science for its own sake, self-efficacy is the student’s belief that they can achieve well in science, and self-determination is the students control over learning science education (Bryan et al., 2011). According to Bryan et al. (2011) “motivation in science learning can be achieved through an internal state that arouses, directs, and sustains science-learning behavior” (p.1050). To achieve this motivation, students need to be taught through Howard Gardner’s multiple intelligence theory. This theory describes the different ways in which students learn; these styles include linguistic, logical, musical, kinesthetic, visual, interpersonal, and intrapersonal. Cluck and Hess (2003) stated that the use of multiple intelligences and cooperative learning groups, showed an increased motivation in class work and participation. If learning stations are designed to fulfill students’ specific learning styles, it may motivate them to learn and allows them to correct any cognitive disequilibrium.

According to Gerstner and Bogner (2010), hands-on station learning significantly increased student learning when compared to pretest to posttest. The hands-on station learning was intrinsically motivating for the students and performed well on tests. The students found hands-on station learning beneficial when compared to regular textbook lessons. Although, students did find that teacher-instructed experiments were as interesting as student-directed
experiments. Clinkenbeard (2012) stated that student’s intrinsic motivation occurs when lessons meet student’s intellectual levels. When a task is too difficult it leads to anxiety and often abandonment of the assignment. When a task is too easy then the student becomes bored. Class discussions and integrating technology to scientific concepts, such as computer, are teaching approaches that have been used to stimulate intrinsic motivation. According to Vavilis and Vavilis (2004), students felt that meaningful discussions greatly enhanced learning because they can justify or possibly defend the concepts they have learned. Relating scientific concepts in society has shown to intrinsically motivate reluctant learners because they can relate the lesson in their present lives (Clinkenbeard, 2012).

**Self-efficacy**

Self-efficacy is defined as a student’s belief that they can achieve well in science class. Bryan et al. (2010) study focused on whether or not there is a connection between student motivation and enrollment in an advanced placement (AP) science course. The other focus of the study encompassed previous and present student achievement as a motivator in the AP science course. According to Britiner (2008), Mamlok-Naaman (2011), and Sevinc et al. (2011), student self-efficacy is related to their academic achievement and (Bryan et al. 2010) played an important role in achieving motivation in an AP science classes. Students that are metacognitively aware of their motivations are more adapted to regulate their behaviors in science courses (Bryan et al., 2010).

According to Bandura (1994), self-efficacy motivation is only useful if students use their skills, have support, and are engaged to learn. The self-efficacy theory states four different modes that students’ sense during self-efficacy- mastery experience, vicarious experience, social
persuasion, and physiological reactions (Bandura, 1994). Throughout the mastery experience, students undergo a transition towards confidence, accomplishment, and success when faced with challenges. Jenson, Petri, Day, and Truman (2011) also found that mastery experiences were promoted due to a learning environment accepted by the students.

Students who become successful based on increased self-confidence due to peer success are known as vicarious self-efficacy (Bandura, 1994). Students with disabilities have reported that group science projects increase their self-efficacy because they can discuss concepts within the group and seeing other team members succeed increases student self-confidence. Although, vicarious experiences can reflect negatively on students if not implemented correctly. Vicarious experiences decreased students confidence when they believe assignments were judged based on their disabilities, such as performing lab work (Jenson et al., 2011).

Social Persuasion encompasses the support students have from their parents, friends, and teachers boosting self-confidence. These types of students rely on family, friends, and teachers to help them increase their self-efficacy (Bandura, 1994). Students that relied on teacher and peer support in the classroom valued from positive feedback and constructive criticism on lab reports and assignments as a way to boost self-efficacy (Jenson et al., 2011). This also relates to vicarious experiences because feedback and constructive criticism should be directed towards the students’ abilities.

Physiological reactions can diminish students’ self-confidence. Physiological reactions contain stresses, tension, and depressed moods which can lower academic success (Bandura, 1994). Stresses that dampened self-efficacy were tests and abstract theories in science courses. High-stakes tests and abstract theories created stress and anxiety within students taking the tests,
making it difficult for the students to remember what they studied or learned (Jenson et al., 2011).

**Self-Determination**

According to Deci and Ryan (1985), self-determination theory is based on student autonomy; the students must feel that they have control in their lives. With this control comes the confidence necessary to succeed in education (Lavigne, Vallerand, & Miquelon, 2007). The self-determination theory has three different parts, which focuses on goal-oriented behaviors in order to be successful (Sevinc et al., 2011). The first part of self-determination theory encompasses intrinsic motivation, which is doing an activity for the satisfaction or pleasure. The second part of self-determination is extrinsic motivation, which focuses on external rewards, for instance, high grades, graduating, or avoiding punishment (Watters & Ginns, 2000). The third part of self-determination theory is amotivational syndrome, meaning a student’s behavior didn’t lead towards the desired outcome (Cokley, Bernard, Cunningham, & Motoike, 2001). Students that are unmotivated believe that their behaviors are out of their control (Vallerand et al., 1992). A study by Vallerand, Fortier, & Guay (1997) has shown students’ who are self-determinedly motivated pursue with their education and those who are not risk dropping out.

A study by Lavigne et al. (2007) has shown that teachers who support student autonomy increased students’ autonomy, leading them towards academic competence. Gerstner and Bogner, 2010 found that competence was established through hands-on activities, which lead towards self-determination motivation. Self-determination was preserved and developed by providing students with positive feedback relating to student efforts, rather than their abilities (Deci & Ryan, 1985). This is also similar to the social persuasion from the self-efficacy theory
The social persuasion perspective of the self-efficacy theory states that students who rely on teacher and peer support in the classroom value from positive feedback and constructive criticism on lab reports and assignments (Jenson et al., 2002). According to Bryan et al. (2011), all three motivational components (intrinsic, self-efficacy, and self-determination motivation) were related to another based on academic achievement in science.

**Station Learning**

**Clarifying Misconceptions with Station Learning**

Station learning can be defined as allocated areas in the classroom that have featured objects (e.g., microscopes, computers, literature, etc.) which require hands-on activities where individuals or small groups rotate to different areas and investigate a topic. These specific areas (or stations) are not designed to be in any specific order, but encompasses the topic on hand. Stations must follow specific themes, allowing the students to further investigate the topic. Hands-on activities should use scientific equipment and promote scientific inquiry. Each station should not involve an in-depth investigation, but should be performed within 10-15 minutes to promote scientific inquiry and spark interest in the subject (Jarrett, 2010).

Since station learning involves hands-on activities and students working in small groups, students misconceptions about scientific topics may be clarified. According to McNeill and Vaughn (2012) and Shepardson et al. (2009), students struggled to develop and apply models on specific climate change concepts such as the greenhouse effect. These abstract models could be better understood if students can observe real models representing the greenhouse effect at a learning station. At the station, students can investigate the model, along with supporting
literature to clarify misconceptions. McNeill and Vaughn (2012) found that students can elaborate on these thoughts and ideas by brainstorming within their small groups, which may convince students to alter their misconceptions of science.

**Station Learning effects on Motivation**

Sevinc et al. (2011) stated that it is important to know students’ motivation levels and what affects student motivation in science. Schaal and Bogner (2005) stated that station learning involves cooperating learning, hands-on, inquiry based learning, and student autonomy which may positively affect students’ motivation. Gerstner and Bogner (2010) showed that hands-on experiences in an interactive science programme have higher interests scores towards student’s intrinsic motivation than with a traditional textbook lesson. Student centered activities such as hands-on experiences, increase intrinsic motivation and can be related to the self-determination theory due to the students feeling competent in their study (Gerstner & Bogner, 2010).

Cooperative learning stations allow students to work with others and accomplish goals in which makes them feel successful, fulfilling self-efficacy motivation. Cooperative grouping increase student self-efficacy by visually seeing their group members succeeding and believing that if one student can succeed, I can too. Students found that accomplishing goals within a group effort was personally rewarding, which boosted their self-efficacy (Jenson et al., 2011). For students to achieve academic success or continue in science as a career, these three motivational components must be fulfilled in order to pursue successful scientists (Bryan et al., 2011).
Chapter 3 Methods

Introduction

Students from Tri-County Career Center in Nelsonville, OH. performed learning stations, as a teaching strategy, which encompassed the teachings on climate change. This process began with teacher and student interviews to discover three students’ misconceptions on climate change. After the interviews, pre-tests about climate change were given to the students, serving as a diagnostic assessment. In this lesson, there were five different learning stations that displayed different aspects of climate change. Each student completed their learning station activity sheets, providing an assessment determining if station learning clarified students’ misconceptions. A post-test was given to determine if students have learned more about concepts of climate change. After these activities were completed, students completed a motivational questionnaire that determined if station learning increased students intrinsic, self-efficacy, and self-determination motivation towards science learning.

Experimental Design

Quantitative

This experiment was a one-group pretest-posttest design. This study used a single-factor completely randomized design. The test group was from students at Tri-County Career Center, the treatment is the use of station learning, and the results were determined using a pre-treatment and post-treatment test. The data was analyzed using a one-tailed t-test with a confidence interval of 95% using SPSS for Windows Release 16.0.1 (November 15, 2007).

Qualitative
This experiment included three interviews, journal entries, and a questionnaire. The experimental design was a one group pretest-posttest. The interviews were performed in a semi-structured format to identify students’ misconceptions. After the treatment, the interviewees’ misconceptions were compared to the station learning worksheet to determine if students’ conceptions have changed, which was determined by the coding in Appendix E. Samples from the student interviews were used to model how those students’ conceptions have changed after they have experienced the learning stations. The journal entries entailed the interviewees’ behaviors or reactions throughout the treatment. There were three entries per day for three days. The motivation questionnaire was coded in five different categories, expressing how station learning motivated or unmotivated student learning. Each category of motivation (intrinsic, self-efficacy, and self-determination) was collaborated separately to determine if students’ felt that station learning was motivating.

Participants

The teachings and learning descriptions in this paper happened in an 11th grade environmental science at Tri-County Career Center in Nelsonville, OH. The students transferred to this school because they were visual and kinesthetic learners and Tri-County’s classes were founded by hands-on experiences. Most of the students that transfer to Tri-County were not studious and the majority of students have failed the Ohio Graduation Test (OGT). The total participants in this study included 49 students (21 girls, 28 boys), some students obtained disabilities, but they did not show any difficulty in academic achievement. Any other type of instruction, such as direct instruction, tended to frustrate or confuse most of the students, resulting in behavioral problems. The students at Tri-County were predominately White
descents and lived in a rural setting. The majority of the students came from the same socioeconomic background and receive free or reduced breakfast and lunch.

The three students that were selected for interviews are Betty, Amanda, and Joe (all students were given pseudonyms).

Betty was from a wealthy family in a rural environment. Her career goal was to become a nurse. She had left her “home school,” Trimble High School, to take courses in the nursing program at the local career center, Tri-County Career Center. She was a very bright, social, and motivated when it comes to school work.

Amanda was from a middle class family in a rural environment. Her career goal was to become a nurse. She had left her “home school,” Logan High School, to take courses in the nursing program at the local career center, Tri-County Career Center. She performed fairly well on assignments when done individually, but became very talkative when it came to group activities.

Joe was from a lower class family in rural environment. He wanted to become a mechanic in his future career. He had left his “home school,” Trimble High School, to take courses in the mechanics program at the local career center, Tri-County Career Center. In Joe’s previous classes, he had performed below average. Joe wanted to perform well in school, but he had a hard time focusing on the assignment and tended to become talkative. Joe had been diagnosed with attention deficit hyperactivity disorder (ADHD) and had an individualized education program (IEP).

Methods:

Interviews
Student interviews allowed the teacher to identify student thought processes and misconceptions about climate change. There were three students interviewed in this project. The students varied in academic performance and learning styles because it was important to get an array of perspective to identify students’ misconceptions on climate change. A semi-structured interview was performed; permitting follow-up questions to probe for a clearer and deeper understanding (Appendix A). If the students’ answers to the question had no logic, students were asked to clarify or to elaborate on their answer. Answers were not be video or vocally recorded and were be collected through writing. For privacy reasons and to lower distractions, the students were interviewed in the back office inside the classroom. Interviews lasted from one to three class periods because some of the students needed more processing time to answer the questions.

Pre-test

The pre-test was designed to determine students’ background knowledge on climate change (Appendix B). These questions were constructed based on participants’ misconceptions of climate change in the interview. The pre-tests were paper based and tested during classroom time. The students were given extended time to complete the assessment, if necessary. Any accommodations or modifications the students needed during the test were granted to student. The pre-test covered an array of topics about climate change and questions that focused on the more common misconceptions participants had about climate change in the interview. The test results defined what topics of climate change should be taught in the classroom.

Learning stations
In this study there were five different learning stations that students had to perform. The students formed groups at their initial station and rotated through each station. These worksheets (Appendix D) were completed during classroom time with assistance from the instructor. At each station, there were documents describing theories, laws, and data sets associated with the phenomena being explored.

The first station involved the theory behind the “greenhouse effect.” At this station, there were documents, which students were required to read through, explaining the different types of greenhouse gases and the processes of the greenhouse effect. Beside the documents was a miniature greenhouse that modeled this phenomenon. The miniature greenhouse was heated with an exterior heat lamp which simulated the sun. Inside the greenhouse had elevated temperatures than the exterior and students had to identify this phenomenon. The students had to explain how the greenhouse simulated greenhouse gases in the atmosphere.

The next station contained three different density Styrofoam balls, modeling the Earth. The different types of Styrofoam acted as different concentration levels of greenhouse gases in the atmosphere. In the middle of the Styrofoam balls was a heat source and thermometer inserted from the side that gauged temperatures. The students had a handout at this station defining how different greenhouse gas concentrations affected the temperatures on Earth. The student explained why each Earth model had different temperatures, describing the concentration levels.

Station three covered how plants survived under increasing temperatures. This station involved growing plants in the classroom. One tray of plants was exposed to the classroom environment and the other tray was placed in a miniature greenhouse. Both trays were located
under grow lights, but the trays located inside the greenhouse were under a heat lamp. This station helped students observe and investigate what happens to plants under extreme heat conditions and how plants may have to migrate to different biomes due to climate change.

Station four included sea shells and coral specimens, which simulated the effects of these organisms if oceans become more acidic. This station included a directory explaining how increased levels of atmospheric CO$_2$ create carbonic acid in the ocean. The sea shells and coral specimens were place in carbonic acid, showing increases of carbonic acid decreased pH levels in the “ocean” and destroyed the coral reef and other calcium carbonated shelled organisms.

Station five included how scientists have used satellite imagery to monitor melting of glaciers and polar ice caps. Students investigated how the melting of polar ice caps and glaciers on Greenland can alter oceanic currents and change weather patterns, due to increased greenhouse gases. This lead students to learn more about the differences between climate and weather.

*Journal Entries*

The journal entries were created to record the interviewees’ reaction or behaviors throughout the treatment, based on observations. The journal entries were record electronically (i.e. laptop) after the class period was completed. There was an entry every day for each interviewee for three days.

*Post test*

The post-test was designed to determine if the students understood or comprehended the subject matter. The post-test were paper based and tested during classroom time. If necessary,
the students were given extended time to complete the assessment. Any accommodations or modifications the students needed during the test were granted to student. The post-test covered the same array of topics from the pre-test that focused on climate change and questions that focused on the more common misconceptions about climate change.

\textit{Motivation}

To determine students’ level of motivation through station learning, a questionnaire was handed to the students after the post test (Appendix F). The questionnaire had three different sections that ask questions to determine students’ intrinsic, self-efficacy, and self-determination motivation. The questions from the questionnaire were derived from the Science Motivation Questionnaire (Glynn & Koballa 2006; Glynn, Taasoobshirazi, & Brickman, 2009). These questionnaires were paper-based and taken during classroom time. The students were given extended time to complete the questionnaire, if necessary. Any accommodations or modifications the students needed during the test were granted to student.

\textbf{Data Collection:}

The data was collected through a series of interviews, tests, worksheets from the station learning exercise, journal entries, and a questionnaire. Interviews were conducted though one-on-one conversations in a private room setting. Since the interviews were constructed in a semi-structured format, follow-up questions allowed the interviewer probe for a deeper understanding. Based on student misconceptions, questions on pre-test and station learning worksheets covered the students’ misconceptions.

The pre-test and post-test contained a series of true and false, multiple choice, and short answer questions, which was taken during regular class time. During the tests, any
accommodations or modifications were made for students who have IEPs. Most of the accommodations for these students typically involved reading the test questions, time and a half to complete the test, or providing them a quiet room to take the test. Modifications made for the tests involved shorting the test length.

The station learning activity worksheets included short answer questions that build to more complex questions (Appendix D). Student had documents found near the stations that helped guide them through the activity and questions. Students had an opportunity to start at any station and rotate to other stations with group members. Each station required at least 15-20 minutes of time before students would rotate. The maximum time allotted to finish the station learning was three school days. If a student started at station one, they would answer questions based on the phenomenon known as the “greenhouse effect.” The students analyzed a document containing a figure displaying the greenhouse effect and explained why the temperature is hotter in the model.

Station two provided a more in depth explanation on how greenhouse gases trap heat. The documents provided at this station entail the different types of greenhouse gases, greenhouse gas sources, and clean energy sources. Greenhouse gases were numerically listed based on their ability to absorb heat. The documents at this station included graphs that illustrated how increased CO₂ concentrations in the atmosphere correlated to increased temperatures. The Styrofoam balls, modeling the Earth’s atmosphere, demonstrated different concentrations of greenhouse gases in the atmosphere. Students read thermometer temperatures and explained why temperature variations existed between models. Students related how the higher concentrations of greenhouse gases will increase the greenhouse effect, thus increasing temperatures. The documents at this station included graphs that illustrated how increased CO₂
concentrations in the atmosphere correlate to increased temperatures. The Styrofoam balls also allowed students to observe that greenhouse gases do not exist in a layer, but throughout the atmosphere.

Station three included how ten plants (20 total) survived in a heated environment compared to the controlled classroom environment. Half the plants were placed in a greenhouse model and under a heated lamp. This station modeled the physiological changes plants will undergo through heated environments due to stress. Students recorded the changes and compared them to the controlled classroom environment. The physiological changes simulated how plants may have to migrate to different biomes due to climate change. Students had to answer questions that involved how plants may not be able to migrate quickly enough due to human fragmentation or time restrictions. Follow-up questions were based on plant migration included plant, animal, and habitat extinctions.

Station four encompassed how oceans may become more acidic due to the increases of atmospheric concentrations. The station displayed pictures describing the carbon cycle between the ocean and atmosphere. The documents briefly described how this cycle will increase oceanic acidity levels. Students weighed shells or coral specimens and place them in Coca Cola, simulating carbonic acid. The following day, students removed the specimens and recorded the new weight. From these results, students analyzed what may happen to future calcium carbonated organisms and coral organisms, such as the coral reef, if atmospheric CO₂ continues to rise.

Station five used diagrams of Greenland’s glaciers and the Earth’s polar ice caps from the 1970s to present time. The documents at this station included graphs that illustrated how
increased CO₂ concentrations in the atmosphere correlated to increased temperatures. Students used this information to describe how melting of the ice caps correlated to the increasing of temperatures. The second stage in this station included how the melting of ice caps and Greenland’s glacier can change oceanic patterns and weather patterns. Another diagram is used to show how cool melt water can change the oceanic current. The document in this section explained how changing oceanic currents can change weather patterns in coastal regions and eventually climate. Since climate and weather is introduced in this section, students had to answer, what is the difference between weather and climate? Students had to answered questions that asked how changing oceanic currents would alter climate.

Journal entries were taken each day for each interviewee through the three allotted days. The instructor observed the interviewees while they experienced the treatment. Any behavioral changes that the interviewees experienced were recorded, such as socialization or involvement in the treatment. The entries were recorded after the classes were in session, maximizing assistance.

The motivation questionnaires were handed to the students in paper format after the post-test. The questionnaire consisted of three different sections that asked questions that determined students’ intrinsic motivation, self-efficacy, and self-determination. The students selected; never, rarely, sometime, usually, or always, depending on how they experienced that question.

**Data Analysis:**

**Quantitative**

This experiment was a one-group pretest-posttest design. This study used a single-factor completely randomized design. The test group was from students at Tri-County Career Center, the treatment was the use of station learning, and the results were determined using the averages
from the pre-treatment and post-treatment test scores. The data was analyzed using a one-tailed t-test with a confidence interval of 95% using SPSS for Windows Release 16.0.1 (November 15, 2007). Pre and post-test questions were coded and individual questions received different amounts of points based on difficulty (Appendix C). The average of the pre-test score was compared to the average of the post-test scores, determining the effect of learning stations on academic achievement. Under the same experimental design, the proportion of students’ pre and post-test grades (i.e. F, D, C, B, and A) were used to determine how station learning influenced a change in grade distribution. In both sections, grades were based on a scale from 0 to 100 points, where A = 90-100%, B = 80-89%, C = 70-79%, D = 60-69%, and F = 0-59%.

Qualitative

All the data from the interviews, treatment, journal entries, and questionnaire were qualitatively analyzed to determine if station learning was successful in clarifying students’ misconceptions of climate change. A series of questions were asked at each learning station, highlighting the important concepts at each station (Appendix D). The questions at each station were coded for the accuracy of the students’ responses (Appendix E). Based on the code, the interviewees’ misconceptions were compared to the station learning worksheet to determine if students’ conceptions have changed. Samples from the student interviews were used to model how interviewed students’ conceptions changed after they have experienced the learning stations. Journal entries explained the different experiences each interviewee had throughout the treatment. These experiences provided evidence for student motivation, academic achievement, and clarifying misconceptions. The motivation questionnaire was coded in five different categories, expressing how station learning motivates student learning. Each category of
motivation (intrinsic, self-efficacy, and self-determination) was given an average to determine if students’ felt that station learning is motivating.

Summary

This chapter described how the experiment was designed and analyzed. This study used a one-group pretest-posttest design and single-factor completely randomized design, where station learning was the treatment. Quantitative data was analyzed using a one-tailed t-test with confidence intervals of 95%. Averages from the pre-test score were compared to the averages of the post-test scores, determining the effect of learning stations on academic achievement. Under the same experimental design, the proportion of students’ pre and post-test grades (i.e. F, D, C, B, and A) were used to determine how station learning influenced a change in grade distribution. Qualitative data included the interviews, observations, and motivational questionnaire. Responses from the interview were used to identify interviewee’s misconceptions on climates change. After the treatment, interviewees’ answers from the treatment worksheet were compared to the responses from the interview, declaring any changes in interviewees’ conceptions. Journal entries were taken to record interviewees’ behaviors or reactions throughout the treatment. The motivational questionnaire was handed to each student, expressing how station learning motivated or unmotivated student learning. Each category of motivation (intrinsic, self-efficacy, and self-determination) was collaborated separately to determine if students’ felt that station learning was motivating.
Chapter 4 Results

The following chapter was determined how station learning has changed students’ misconceptions, increased academic achievement, and increased motivation. The first section will show how student misconceptions have changed when compared to the interview and the treatment worksheet, based on coding. Following misconceptions, entails the observations of the interviewed students during the treatment. The second section focused on students’ pre and post-test scores and whether or not their grades have changed. The final section detected whether or not students found station learning motivating.

Misconceptions

Throughout the interview process, the students were mature and took the interview seriously. Since most of the students have been introduced to concepts of climate change in their 8th grade science class, the majority of the questions were answered correctly, when compared to the coding in Appendix E. The questions that the students answered correctly in the interview were 1, 6, 7, 9, 12, and 13. The questions that were answered correctly were not analyzed due to their accuracy. The remaining questions from the interview, shown in Appendix A, were answered incorrectly when compared to Appendix E. The questions will show the students’ initial misconception (Before Treatment) followed by how their conceptions after the treatment (After Treatment). These questions may not have all three of the students’ responses due to the accuracy of the individuals’ response.

**Question 2:** What is climate change?

**Before Treatment:**

*Joe:* “The seasons, spring to summer to fall to winter.”
Betty: “The daily change in temperature, how hot or cold it is.”

After Treatment:

Joe: “Gases hold in energy and keep warming Earth.”

Betty: “Greenhouse gases the more heat is trapped, increasing temperature.”

The misconceptions before the treatment have altered when compared to the conceptions after the treatment. The students’ answers to this question follow the code for questions number two in both stations one and two (Appendix E).

**Question 3**: Can you explain or draw the greenhouse effect?

Before Treatment:

*Amanda*: “The heat and pollution making it hotter.”

*Joe*: “CO₂ puts holes in the ozone layer, and retains heat on Earth.”

*Betty*: “Greenhouse where people have plants, to protect the plants.”

After Treatment:

*Amanda*: “The natural process that traps heat.”

*Joe*: “Gases holds in energy to keep warming the Earth.”

*Betty*: “Natural process that traps heat near the surface of Earth.”
The coding found in station one’s question two in Appendix E, found that students’ misconceptions on explaining the greenhouse effect changed after the treatment.

**Question 4:** Name all the greenhouse gases that you know?

**Before Treatment:**

*Amanda:* “\( CO_2 \)"

*Joe:* “carbon dioxide (\( CO_2 \)), carbon monoxide (CO), and sulfur dioxide (\( SO_2 \))

*Betty:* “carbon dioxide (\( CO_2 \)), carbon monoxide (CO), sulfur dioxide (\( SO_2 \)), and nitrogen oxides (\( NO_x \)).”

**After Treatment:**

*Joe:* “Carbon dioxide, methane, nitric oxides, water vapor, ozone, synthetic gases.”

*Amanda:* “Carbon dioxide, methane, nitric oxides, water vapor, ozone, synthetic gases.”

*Betty:* “Carbon dioxide, methane, nitric oxides, water vapor, ozone, synthetic gases.”

The coding of station two’s question one in Appendix E, found that students’ misconceptions of the greenhouse gases changed. The list of greenhouse gases shown in the after treatment is more accurate and complete.

**Question 5:** Do the greenhouse gases act the same as the greenhouse effect?
Before Treatment:

Joe: “No, greenhouse gases heat the Earth and the greenhouse effect are holes in the ozone layer that allows UV rays to enter Earth’s surface.”

After Treatment:

Joe: “Greenhouse gases hold in the heat and greenhouse effect keeps warming the Earth.” “More CO₂ makes temperatures go up.”

Joe’s misconception on the greenhouse gases’ contribution towards the greenhouse effect changed due to stations 1 and 2 (Appendix E). Joe’s misconception of greenhouse gases creating holes in the ozone layer to allow UV rays to enter Earth’s surface changed due to the treatment.

**Question 8**: How can increased greenhouse gases increase temperatures that lead towards climate change?

Before Treatment:

Amanda: “They are making a hole in the ozone layer, allow heat to enter.”

Joe: “Carbon dioxide (CO₂) and carbon monoxide (CO) and sulfur dioxide (SO₂) release heat when they are burnt and tear holes in the ozone layer, UV rays enter and heat the Earth.”

After Treatment:

Amanda: “Greenhouses gases (CO₂) traps heat and increase temperatures.”
Joe: “More CO₂ makes temperatures go up.” “That lower greenhouse gases don’t hold in heat as well.”

Amanda and Joe’s misconceptions were clarified due to questions two and six found in station two (Appendix E). They both previously thought that greenhouse gases created holes in the ozone layer, which allowed UV rays to enter the atmosphere, increasing the temperature. From these stations, the Joe and Amanda were able to connect how greenhouse gases effect temperature, thus an effect on climate.

**Question 10:** If plants are negatively affected, what will this do to animals and habitats?

*Before Treatment:*

**Amanda:** “Animals need plants to live and eat, they won’t have places to live or eat and will die.”

**Joe:** “Homes are destroyed for animals, they either go extinct or move.” Habitat is combined ecosystems and one ecosystem is done all plants and animals will die.”

**Betty:** “Animals need to eat, if not then they die. Habitats are where they live and no animals then nothing will be left.”

*After Treatment:*

**Amanda:** “Plants will have to migrate, ecosystem shift, and that will lead to new forest types. Wildlife will have to migrate but habitat fragmentation (small patches of habitat due to humans) may make it impossible for them to live.
Joe: “Plants will migrate to another area known as ecosystem shift and wildlife will follow.

Betty: “Plants will die off, wildlife/plants will have to migrate somewhere else (ecosystem shift), but humans may block them.

According to the coding for station three’s questions in Appendix E, the students’ conceptions before the treatment were not incorrect, just not complete. After the treatment, students’ conceptions were more complete and used terminology to explain the potential effects climate change brings to plants and animals.

**Question 11:** Can the carbon dioxide in the atmosphere create carbonic acids in the ocean?

**Before Treatment:**

*Amanda:* “Yes, \(CO_2\) gets in the atmosphere it can get in the clouds and create acid rain and rain in the oceans.”

*Joe:* “Yes, \(CO_2\) mixes with rain and acids are released in ocean.”

*Betty:* “Yes, factories releasing \(CO_2\) in waterways and then to the ocean.

**After Treatment:**

*Amanda:* “Algea die off.”

*Joe:* \(H_2O\) (water) + \(CO_2\) (carbon dioxide) = \(H_2CO_3\) (Carbonic Acid)

*Betty:* “Algae take carbon dioxide from atmosphere through photosynthesis, when it dies it sinks and creates carbonic acid.”
Amanda’s response before the treatment was correct but lacked the primary source of how carbon dioxide enters the ocean and creates carbonic acid. The answers after the treatment did not justify the coding found in station four, question one (Appendix E). The treatment did not clarify the misconceptions prior to the treatment. Joe and Betty were correct with their responses but missed key terminology that explained the reactions.

Observations

Betty worked well with the other students in her group. Throughout the three days, she didn’t socialize very often with her group members because she felt she could answer the questions on her own. When students needed help she offered, but she explained too fast where the other students could not follow. She asked questions promptly because she wanted to record the answer and finish the assignment. She wanted to understand the material, but simultaneously rushed through the stations to finish.

Amanda was social throughout the stations and worked hard with her group. Within her group, she discussed many of the topics found at the stations. The group worked hard to explain and finish the questions at each station. Amanda’s group didn’t have many questions, but when a question arose, they promptly recorded the information and applied it to the question. Throughout the three days, Amanda enjoyed station learning and socialized with her friends.

Joe worked hard on the assignment, but seemed to continually socialize about events not relevant to the stations. Joe was often off task, but his group helped him finish the assignment. He was curious about the stations for a day, but every day after he lost more interest. His group wanted to finish the assignment as quickly as possible, increasing their personal social time. After the first day, Joe’s group claimed to have finished the three day assignment, but multiple
errors were found and the group was instructed to revisit the stations. On day two, Joe’s group revisited the stations to correct their errors. During this time, they were social and spent more time at the stations. Their work improved during this time and many answers were corrected. On day three, Joe’s group was off task and didn’t want to finish their worksheet. During this time, Joe wasn’t engaged in the activity.

Pre and Post-Test

The group experienced a significantly greater mean post-test score (M=67.47, SE=1.64), than to the mean pre-test score (M=50.80, SE=2.08, t(48)= -8.61, p<.05) (See Figure 1, p.37, (All t-test analysis tables may be found in Table A1.1 and A1.2, pgs. 36-37).
Figure 1. Mean Score on Pre and Post-Test

Table A1.1. One-tailed t-test data analysis table of mean percentages for pre and post-test results

<table>
<thead>
<tr>
<th>Paired Samples Statistics</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PrePercent</td>
<td>.5080</td>
<td>49</td>
<td>.14572</td>
<td>.02082</td>
</tr>
<tr>
<td>PostPercent</td>
<td>.6747</td>
<td>49</td>
<td>.11509</td>
<td>.01644</td>
</tr>
</tbody>
</table>

*Note:* On average, students mean scores on pre-test (M=50.8, SE=2.1) is less than post-test mean scores (M=67.8, SE=1.6).
Table A1.2. One-tailed t-test data analysis table for pre and post-test results

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Sig. (1-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error Mean</td>
<td>95% Confidence Interval of the Difference</td>
<td>t</td>
<td>df</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pair 1</td>
<td>PrePercent</td>
<td>PostPercent</td>
<td>-0.16673</td>
<td>0.13564</td>
<td>0.01938</td>
<td>-0.20569</td>
<td>-0.12778</td>
</tr>
</tbody>
</table>

Note: Mean scores (percentage) were significantly different between the pre and post-tests, as indicated by the asterisks (*p< .05). The significant increase of post-test mean scores were found, M=67.47, SE=1.64, t(48)=-8.61, *p< .05.

The proportion of students that received an F on the post-test (M=20.41, SE=5.82) was significantly lower than the proportion of students that received an F on the pre-test (M=65.31, SE=6.87, t(48)=5.79, p<.05). The proportion of students that received a D on the pre-test (M=65.31, SE= 6.21) was not significantly different than the proportion of students that received a D on the post-test (M=38.78, SE=7.03, t(48)=-1.48, p>.05). A significant difference was found between the proportion of students that received a C on the post-test (M=22.45, SE=6.02), than on the pre-test (M=10.20, SE=4.37, t(48)=-1.77, p<.05). Since no student earned a B on the pre-test (M=0.00, SE=0.00), there was a significant increase in the post-test for the proportion of students that earned a B on the post-test (M=18.47, SE=5.59, t(48)=-3.29, p<.05). No student received an A on the pre-test or post-test during this study, therefore no significant value was calculated (Figure 2, p.39, (All t-test analysis tables may be found in Table B1.1 and B1.2. pgs. 39-40).
Figure 2. Proportion of Student Grades

![Graph showing the proportion of student grades across different grades (F, D, C, B, A) for pre- and post-tests. The grades are represented by bars with error bars indicating mean and standard deviation.](image)

Table B1.2. One-tailed t-test data analysis table for proportion of student grades

<table>
<thead>
<tr>
<th>Pair</th>
<th>Pre</th>
<th>Post</th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>F</td>
<td>.6531</td>
<td>49</td>
<td>.48093</td>
<td>.06870</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>F</td>
<td>.2041</td>
<td>49</td>
<td>.40721</td>
<td>.05817</td>
</tr>
<tr>
<td>2</td>
<td>D</td>
<td>D</td>
<td>.2449</td>
<td>49</td>
<td>.43448</td>
<td>.06207</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>D</td>
<td>.3878</td>
<td>49</td>
<td>.49229</td>
<td>.07033</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>C</td>
<td>.1020</td>
<td>49</td>
<td>.30584</td>
<td>.04369</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>C</td>
<td>.2245</td>
<td>49</td>
<td>.42157</td>
<td>.06022</td>
</tr>
<tr>
<td>4</td>
<td>B</td>
<td>B</td>
<td>.0000</td>
<td>49</td>
<td>.00000</td>
<td>.00000</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>B</td>
<td>.1837</td>
<td>49</td>
<td>.39123</td>
<td>.05589</td>
</tr>
</tbody>
</table>

Note: On average, proportion of student grades change for the post and pre-test grades F, C, and B from (M=65.3%, SE=6.9%) to (M=20.4%, SE=5.8%), (M=10.2, SE=4.4%) to (M=22.5%, SE=6.0%), and (M=0.0%, SE=0.0) to (M=18.4%, SE=5.6%), respectively.
Table B1.2. One-tailed t-test data analysis table for proportion of student grades

<table>
<thead>
<tr>
<th>Paired Samples Test</th>
<th>Paired Differences</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (1-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>Std. Error Mean</td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Pair 1</td>
<td>0.44898</td>
<td>0.54242</td>
<td>0.07749</td>
<td>0.29318</td>
<td>0.60478</td>
</tr>
<tr>
<td>Pair 2</td>
<td>-0.14286</td>
<td>0.677</td>
<td>0.09671</td>
<td>-0.33732</td>
<td>0.0516</td>
</tr>
<tr>
<td>Pair 3</td>
<td>-0.12245</td>
<td>0.48445</td>
<td>0.06921</td>
<td>-0.2616</td>
<td>0.0167</td>
</tr>
<tr>
<td>Pair 4</td>
<td>-0.18367</td>
<td>0.39123</td>
<td>0.05589</td>
<td>-0.29605</td>
<td>-0.0713</td>
</tr>
</tbody>
</table>

Note: Using a one-tailed t-test with a confidence interval of 95%, the proportion of student grades change significantly for the post and pre-test grades for F, C, and B, represented with the asterisk (* p< .05). The significant change for grades F, C, and B was (M=20.41, SE=5.82, t(48)=5.79, *p<.05), (M=22.45, SE=6.02, t(48)=-1.77, *p<.05), and (M=18.47, SE=5.59, t(48)=-3.29, *p<.05), respectively. The proportion of student grades change was not significant for the post and pre-test grades for D (M=38.78, SE=7.03, t(48)=-1.48, p>.05).

Motivation

Intrinsic

Based on the average of student responses, 5 (10%), 9 (18%), 19 (38%), 11 (22%), and 6 (12%) of the students felt that station learning was never, rarely, sometimes, usually, and always an intrinsic motivating teaching method for science, respectively. The highest average student response, 19 (38%), found station learning “sometimes” intrinsically motivating. The next highest average student response, 11 (22%), found station learning “usually” intrinsic motivating in science learning (Table C1., p. 41).
Table C1. Average of student responses on intrinsic motivation in science education

<table>
<thead>
<tr>
<th>Intrinsic motivation</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found learning science interesting</td>
<td>2 (4%)</td>
<td>9 (18%)</td>
<td>20 (41%)</td>
<td>12 (24%)</td>
<td>6 (12%)</td>
</tr>
<tr>
<td>I enjoy learning science</td>
<td>4 (8%)</td>
<td>8 (16%)</td>
<td>21 (43%)</td>
<td>14 (29%)</td>
<td>2 (4%)</td>
</tr>
<tr>
<td>I enjoy science that challenges me</td>
<td>9 (18%)</td>
<td>13 (27%)</td>
<td>18 (37%)</td>
<td>8 (16%)</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>I feel a sense of accomplishment when I understand science</td>
<td>4 (8%)</td>
<td>6 (12%)</td>
<td>14 (29%)</td>
<td>11 (22%)</td>
<td>14 (29%)</td>
</tr>
<tr>
<td>The science I learned is more valuable than the grade I received</td>
<td>6 (12%)</td>
<td>9 (18%)</td>
<td>20 (41%)</td>
<td>8 (16%)</td>
<td>6 (12%)</td>
</tr>
<tr>
<td><strong>Average of Student Responses:</strong></td>
<td><strong>5 (10%)</strong></td>
<td><strong>9 (18%)</strong></td>
<td><strong>19 (38%)</strong></td>
<td><strong>11 (22%)</strong></td>
<td><strong>6 (12%)</strong></td>
</tr>
</tbody>
</table>

**Self-Efficacy**

The students’ average responses were 4 (8%), 8 (16%), 17 (35%), 10 (20%), and 11 (22%) for station learning being never, rarely, sometimes, usually, and always a self-efficacy motivating teaching method for science, respectively. More than one-third of the students, 17 (35%), were “sometimes” motivated through self-efficacy by station learning. The second highest averaged student response towards self-efficacy motivation was “always” at 11 (22%) of the 49 students (Table D1, p.42).
Table D1. Average of student responses on self-efficacy motivation in science education

<table>
<thead>
<tr>
<th>Self-Efficacy</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I can master the knowledge and skills in this science course</td>
<td>5 (10%)</td>
<td>7 (14%)</td>
<td>20 (41%)</td>
<td>8 (16%)</td>
<td>9 (18%)</td>
</tr>
<tr>
<td>I believe I can earn an “A” in this science course</td>
<td>2 (4%)</td>
<td>9 (18%)</td>
<td>17 (35%)</td>
<td>10 (20%)</td>
<td>11 (22%)</td>
</tr>
<tr>
<td>I’m sure that I will do well on this science tests</td>
<td>4 (8%)</td>
<td>8 (16%)</td>
<td>18 (37%)</td>
<td>10 (20%)</td>
<td>9 (18%)</td>
</tr>
<tr>
<td>I’m expected do as well or better than my peers in this science course</td>
<td>5 (10%)</td>
<td>13 (27%)</td>
<td>13 (27%)</td>
<td>8 (16%)</td>
<td>10 (20%)</td>
</tr>
<tr>
<td>I am confident that I will be successful with the labs and projects in this science course</td>
<td>1 (2%)</td>
<td>5 (10%)</td>
<td>17 (35%)</td>
<td>14 (29%)</td>
<td>12 (24%)</td>
</tr>
<tr>
<td><strong>Average of Student Responses:</strong></td>
<td><strong>4 (8%)</strong></td>
<td><strong>8 (16%)</strong></td>
<td><strong>17 (35%)</strong></td>
<td><strong>10 (20%)</strong></td>
<td><strong>11 (22%)</strong></td>
</tr>
</tbody>
</table>

**Self-Determination**

Based on the average of student responses, 4 (6%), 12 (24%), 14 (28%), 14 (28%), and 7 (14%) of the students felt that station learning was never, rarely, sometimes, usually, and always a self-determining motivator for teaching science, respectively. On average, the two highest student responses for self-determining motivation were 14 (28%) and 14 (28%) for “sometimes” and “usually,” respectively. Of the 49 students responding to this questionnaire, 20 (41%), of the students rarely prepare for their labs and tests (Table E1., p.43).
Table E1. Average of student responses on self-determination motivation in science education

<table>
<thead>
<tr>
<th>Self-Determination</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I use strategies that ensure my success in this class</td>
<td>5 (10%)</td>
<td>6 (12%)</td>
<td>19 (39%)</td>
<td>15 (31%)</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>I work at learning science</td>
<td>2 (4%)</td>
<td>13 (27%)</td>
<td>14 (29%)</td>
<td>15 (31%)</td>
<td>5 (10%)</td>
</tr>
<tr>
<td>I prepare for my science labs and tests</td>
<td>3 (6%)</td>
<td>20 (41%)</td>
<td>12 (24%)</td>
<td>9 (18%)</td>
<td>5 (10%)</td>
</tr>
<tr>
<td>If I have trouble learning science, I try to figure it out</td>
<td>3 (6%)</td>
<td>8 (16%)</td>
<td>10 (20%)</td>
<td>15 (31%)</td>
<td>13 (27%)</td>
</tr>
<tr>
<td><strong>Average of Student Responses:</strong></td>
<td>4 (6%)</td>
<td>12 (24%)</td>
<td>14 (28%)</td>
<td>14 (28%)</td>
<td>7 (14%)</td>
</tr>
</tbody>
</table>
Chapter 5 Discussion, Future Recommendations, Conclusions

Misconceptions

Like many other studies, the three interviewed students’ misconceptions on climate change are very similar. Shepardson et al. (2009) has shown that many students do not consider $CO_2$ or $H_2O$ as a greenhouse gases. Furthermore, many students in previous studies have believed greenhouse gases are creating holes in the ozone layer, allowing more radiation to reach the Earth’s surface, thus increases in temperatures (Shepardson et al., 2009; McNeill and Vaughn, 2012). In this case, to clarify students’ misconceptions station learning was used as the treatment. Based on the observations recorded throughout the treatment, students were helping one another to understand the concepts at each station. Each station provided a hands-on activity and cooperative learning that helped the students comprehend the scientific concepts and provided visual aids to further assist the groups. The combination between group facilitation and visual aids provided these kinesthetic and visual learners an opportunity to comprehend the concepts and clarify their previous misconceptions, such as, “What is the greenhouse effect?” or “How can an increase of greenhouse gases increase temperatures that lead towards climate change?”

Although the data supports that station learning does clarify misconceptions, it can only be supported if the students have the proper background knowledge or interest to decipher the misconception. Interview question 11 (Appendix A) involved a very deep understanding in decomposition and chemical reactions. Based on the visuals describing how atmospheric carbon dioxide can become carbonic acids in the oceans, a student would have needed a background in chemistry and biology. In this case, the interviewed students didn’t answer the question correctly due to the lack of background knowledge to fully explain the process. The biological
and chemical processes are long and complicated, which requires many steps to comprehend. Visually seeing the long and complicated steps involved, may have negatively impacted students’ interest in explaining the processes.

**Academic Achievement**

In this study, station learning increased academic achievement in the classroom. From analyzing the pre and post-tests, the results found that the average post-test score increased significantly from the average pre-test score. The proportion of students’ grades significantly changed towards positive academic achievements. Based on the observations, station learning provided an opportunity for students to socialize about the concepts at each station. Socializing and visually comprehending new concepts at each station, allowed students to record accurate answers on their worksheets (Appendix E). Students witnessing their group members solving problems correctly and collaboratively may have increased their confidence to be successful in academics. Unfortunately, an A letter grade was never achieved on neither the pre nor post-test. Most of the students were not thought as studious, which impacted their academic achievements. According to the results, 41% of the students claimed that they didn’t prepare for the labs or test, which may result to the absence of an A letter grade.

**Motivation**

Students responded to a questionnaire on how station learning influenced intrinsic motivation, self-efficacy, and self-determination towards learning science. The majority of the students felt that station learning was sometimes an intrinsic, self-efficacy, and self-determining motivator in science education. According to the observations, Joe, Betty, and Amanda were engaged in station learning, but lost interest, wanted to complete the assignment solo, and helped
their group members, respectively. These observations would describe why the majority of the students felt that station learning was sometime motivating, they were engaged but had other feelings about station learning. The response: “sometimes,” also generates the idea that they were interested and, simultaneously, were not interested in station learning. The second highest response to intrinsic motivation, self-efficacy, and self-determination was usually, always, and usually, respectively. Since the second highest response showed motivation, the students were on more likely to be motivated by station learning, than not. Students found intrinsic motivation through visual and kinesthetic aids because it fulfilled their learning styles. As students socialized and witnessed their group members succeeding, self-efficacy was reached due to an increase of achievement. Student self-determination was achieved through confidence. Students were achieving their goals and answering questions correctly, raising confidence that they can succeed.

**Future Implications**

Motivation and academic achievement play an important role in science education. Teaching strategies such as, station learning, are needed to motivate students so they reach academic achievement. It is imperative that students have the background knowledge to achieve their goals, otherwise academic achievement and clarifying misconceptions may not be accomplished. In this case, students didn’t receive an A letter grade on the pre or post-tests. Without the proper background students will not be able to comprehend new material. Most of the students were not thought as studious, which may impact this observation, but it may be more complicated. The majority of these students may be suffering from test anxiety. If this is the reason, then students will indefinitely find it more difficult to reach academic achievement, regardless of motivation.
Another option could encompass student motivation. The results showed that students didn’t “always” find station learning as a motivating teaching strategy in science education. It seems impossible to find a teaching strategy that every student will enjoy due to personal opinions and preferences. If this is the case, then what are the teaching strategies that continually keeps students positively motivated? The effects of text anxiety and student motivation towards academic achievement need to be further researched.

Dreyfus et al. (1990) stated that students must feel dissatisfied with their preexisting concepts before reconstructing their new conceptions. Teachers have to continue using hands-on experiments because it may be possible that these new and exciting teaching strategies stimulate dissatisfaction in students’ misconceptions. Visual and cooperative learning could be enough stimulation for some students to want and learn more about science to clarify their misconceptions; more research is needed on this topic. Furthermore, this study has shown that station learning has altered misconceptions through written examples, but do the students believe them to be true? Since misconceptions are deeply believed thoughts, future studies could benefit if students were allowed to gauge whether or not they believe the new concept. A scale could range from 0-3 (0 being fake and 3 representing true) and students would be able to gauge the new concept.

**Conclusion**

Station learning clarified students’ misconceptions, increased academic achievements, and was a motivating teaching strategy for science education. Students found station learning to be intrinsically motivating because it emphasizes on the visual and kinesthetic learning styles. Once the students were able to become interested, group members were socializing and solving problems together. This interaction allowed groups to achieve their goals and raised students’
self-efficacy. Witnessing group members experience achievement built students’ confidence. All three parts of motivation were achieved through station learning, which allowed students to have confidence in their work and achieve academic success and clarify their misconceptions. These findings suggest that science show be conducted through a social and collaborated interaction to raise motivation, thus clarifying students’ misconceptions and achievements.
References


APPENDICES
Appendix A

Interview Questions

1. What is the difference between climate and weather?
2. What is climate change?
3. Can you explain or draw the greenhouse effect?
4. Name all of the greenhouse gases that you know?
5. Do the greenhouse gases act the same as the greenhouse effect?
6. Explain where all of the greenhouse gases came from?
7. Name some power plants that do not create greenhouse gases?
8. How can increased greenhouse gases increase temperatures that lead towards climate change?
9. Can climate change have negative effects on plants?
10. If plants are negatively affected, what will this do to animals and habitats?
11. Can the carbon dioxide in the atmosphere create carbonic acids in the ocean?
12. Is climate change causing the glaciers and ice caps to melt?
13. How is it possible for melt water to change climates?
Appendix B

Pre and Post-Test

Multiple Choice

1. Higher concentrations of greenhouse gases in the atmosphere will __________?
   a. cool temperatures on Earth
   b. raise temperatures on Earth
   c. allow temperatures on Earth to remain the same
   d. allow temperatures to fluctuate throughout the years

2. Which of the following is **not** considered a greenhouse gas?
   a. Water vapor
   b. Methane
   c. Sulfur dioxide
   d. CFCs

3. Which of the following is **not** considered a source of greenhouse gases?
   a. Cows
   b. Coal
   c. A burning forest
   d. Dams

4. Nitric oxides are considered the strongest greenhouse gas, what is its source?
   a. Coal power plants
   b. Nuclear power plants
   c. Automobiles
   d. Refrigerators

5. What is considered the leading cause for plant and animal extinction due to climate change?
   a. Habitat Loss
   b. Increased temperatures
   c. Ozone depletion
   d. Sea levels rising

True or False

6. _____ Cows are considered a source of greenhouse gases because they produce methane.

7. _____ If the oceans become more acidic, most of the coral reefs will dissolve.

8. _____ If we prevent the rivers from becoming polluted, this will reduce the rate of climate change.

9. _____ High concentrations of greenhouse gases will eventually melt the glaciers and polar ice caps.

10. _____ Climate change has no effect on plant life.
Short Answer:

Answer the following short answer questions in 2 to 3 sentences.

11. How can climate change lead to plant, animal, and habitat extinction?

12. Name three clean energy sources that do not produce carbon dioxide.

13. Explain the process in which carbon dioxide from the atmosphere can dissolve calcium carbonated organisms in the coral reef?

14. Explain how melt water can disrupt oceanic currents, thus changing the climate in coastal regions?
Appendix C

**Pre and Post – Test - Coding**

<table>
<thead>
<tr>
<th></th>
<th>0 Points</th>
<th>1 Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All other answers besides “B”</td>
<td>“B” – raise temperature on Earth</td>
</tr>
<tr>
<td>2.</td>
<td>All other answers besides “C”</td>
<td>“C” – Sulfur dioxide</td>
</tr>
<tr>
<td>3.</td>
<td>All other answers besides “D”</td>
<td>“D” – Dams</td>
</tr>
<tr>
<td>4.</td>
<td>All other answers besides “C”</td>
<td>“C” – Automobiles</td>
</tr>
<tr>
<td>5.</td>
<td>All other answers besides “A”</td>
<td>“A” – Habitat Loss</td>
</tr>
<tr>
<td>6.</td>
<td>All other answers besides “T”</td>
<td>“T” – True</td>
</tr>
<tr>
<td>7.</td>
<td>All other answers besides “T”</td>
<td>“T” – True</td>
</tr>
<tr>
<td>8.</td>
<td>All other answers besides “F”</td>
<td>“F” – False</td>
</tr>
<tr>
<td>9.</td>
<td>All other answers besides “T”</td>
<td>“T” – True</td>
</tr>
<tr>
<td>10.</td>
<td>All other answers besides “F”</td>
<td>“F” – False</td>
</tr>
<tr>
<td>11.</td>
<td>Point 0</td>
<td>Point 1</td>
</tr>
<tr>
<td>No response</td>
<td>They will die</td>
<td>Wildlife and humans may not have food and shelter to live. Many habitats will be destroyed and farms, decreasing populations of both wildlife and humans. Humans will decrease</td>
</tr>
</tbody>
</table>
### 12. Ecosystem shift due to habitat fragmentation.

<table>
<thead>
<tr>
<th>Point 0</th>
<th>Point 1</th>
<th>Point 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only one correct response, i.e. solar panels</td>
<td>Two correct responses, i.e. solar panels and windmills.</td>
<td>Three correct responses, i.e. solar panels, windmills, and dams</td>
</tr>
</tbody>
</table>

### 13. CO₂ goes into ocean water and creates H₂CO₂ or carbonic acid.

<table>
<thead>
<tr>
<th>Point 0</th>
<th>Point 1</th>
<th>Point 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nothing</td>
<td>CO₂ goes into ocean water and creates H₂CO₂ or carbonic acid.</td>
<td>When CO₂ (from decaying algae or equilibrium) and H₂O combine it creates H₂CO₂ or carbonic acid, it eventually decreases the pH in the ocean. The acidity can dissolve the calcium carbonated organisms such as coral and shelled organisms.</td>
</tr>
<tr>
<td></td>
<td>Or carbonic acid dissolves shelled organisms</td>
<td></td>
</tr>
</tbody>
</table>

### 14. Heat from ocean stops

<table>
<thead>
<tr>
<th>Point 0</th>
<th>Point 1</th>
<th>Point 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>It doesn’t</td>
<td>Heat from ocean stops</td>
<td>Heat transfer from the ocean will alter and reflect that change to coastal regions. Flooding will change inland area climate</td>
</tr>
</tbody>
</table>
Appendix D

Climate Change Learning Stations

Station One: “Greenhouse Effect”

1. Based on the diagram, why is the temperature inside the “greenhouse” warmer?

2. In your own definition, what is the “greenhouse effect?”

Station Two: Styrofoam Atmosphere

1. Referring to the documents, what are the five main greenhouse gases, their sources, and which one absorbs more heat?
   a. 
   b. 
   c. 
   d. 
   e.

2. From the graph, what can be concluded from an increase of CO$_2$ in the atmosphere and the temperature?

3. What are some non-greenhouse gas producing energy sources (clean-energy) and one greenhouse gas producing energy source (dirty-energy)?
   a. **Clean Energy**
      i. 
      ii. 
      iii. 
   b. **Dirty Energy**
      i.

4. If your air conditioner is powered by a coal plant, how can turning on your air conditioner relate to climate change?

5. If the Styrofoam balls represent different concentrations of greenhouse gases in the atmosphere, then which atmosphere would have more “greenhouse effect?” Why?
6. Each Styrofoam ball has the same heat source in the middle representing the heat on Earth from the sun, what are the different temperatures from each atmosphere?
   a.
   b.
   c.

   What can be concluded from these results? (think about greenhouse gases and the “greenhouse effect”)

7. If the entire Styrofoam ball represents the whole atmosphere, then where are greenhouse gases existent in Earth’s atmosphere?

**Station Three: Plant Migration**

1. From observing the plants under the “greenhouse” and plants not located in the greenhouse, which plants look healthier and what are some physiological effects?

2. If plants cannot live in their new climate, what will eventually happen?

3. If plants (especially crops) cannot migrate fast enough to a proper climate, what will happen to wildlife and humans?

4. Referring to the forest shift graph, what will happen to forests in Ohio?

5. How do humans have an impacted on plant migration?
Station Four: Acidic Oceans

1. From the diagrams. How is it possible for atmospheric CO\(_2\) to become dissolved in the ocean and create carbonic acid?

2. What do the coral and shelled organism weigh?
   a. Initial Weight: Coral _______________grams
   b. Initial Weight: Shell _______________grams
   c. Post Weight: Coral _______________grams
   d. Post Weight: Shell _______________grams

3. From the initial weights and post weights, what is the fate of calcium carbonated organisms, such as the coral and shells that live in the ocean? What did the carbonic acid do to the organisms?

4. What will happen to biodiversity hotspots, such as the coral reefs, if CO\(_2\) concentrations continue to rise in the atmosphere?

Station Five: Ice Melt

1. Based on the diagram and graph, how do greenhouse gases relate to polar ice caps and glaciers?

2. If the glaciers melt, what will happen to cities near the coast?

3. If the glaciers melt, what will happen to oceanic currents?

4. If the ocean currents change, how will the climates on the coast change?

5. Based on your previous answer, what is the difference between climate and weather?
Appendix E
Climate Change Learning Stations - Coding

Station One: “Greenhouse Effect”

1. Based on the diagram, why is the temperature inside the “greenhouse” warmer?
   
   It’s hotter because the glass is absorbing energy, just like greenhouse gases.

2. In your own definition, what is the “greenhouse effect?”

   Natural occurrence where greenhouse gases in the atmosphere absorb heat from the sun and retaining heat on Earth. When unnatural amount of greenhouses gases are released in the troposphere the temperatures increase on Earth.

Station Two: Styrofoam Atmosphere

1. Referring to the documents, what are the five main greenhouse gases, their sources, and which one absorbs more heat?
   
   a. Carbon dioxide ($CO_2$)
   b. Methane ($CH_4$)
   c. Nitric oxides ($NO_x$)
   d. Water vapor ($H_2O$)
   e. Ozone ($O_3$)
   
   Carbon dioxide ($CO_2$), methane ($CH_4$), nitric oxides ($NO_x$), water vapor ($H_2O$), ozone ($O_3$), synthetic gases

2. From the graph, what can be concluded from an increase of $CO_2$ in the atmosphere and the temperature?

   Greenhouse gas concentrations are correlated with temperature

3. What are some non-greenhouse gas producing energy sources (clean-energy) and one greenhouse gas producing energy source (dirty-energy)?

   a. Clean Energy
      i. 
      ii. 
      iii.
   
   b. Dirty Energy
      i.

   A. Wind Turbines, Solar Panels, Hydroelectric Power, Water (Wave) Turbines. B. Car exhaust, Coal Power Plants, etc.
4. If your air conditioner is powered by a coal plant, how can turning on your air conditioner relate to climate change?

Using air conditioner burns more coal at power plant and increases CO₂ in atmosphere, thus increasing atmospheric temperature.

5. If the Styrofoam balls represent different concentrations of greenhouse gases in the atmosphere, then which atmosphere would have more “greenhouse effect?” Why?

The denser Styrofoam because there are more greenhouse gases to trap heat

6. Each Styrofoam ball has the same heat source in the middle representing the heat on Earth from the sun, what are the different temperatures from each atmosphere?
   a.
   b.
   c.

What can be concluded from these results? (think about greenhouse gases and the “greenhouse effect”)

Temperature readings and includes explanation such as, the Styrofoam that is less dense is reading a great temperature because there is less greenhouse effect holding in the heat. The greater concentrated atmosphere reads lower because no heat is escaping, or more greenhouse effect.

7. If the entire Styrofoam ball represents the whole atmosphere, then where are greenhouse gases existent in Earth’s atmosphere?

Above Earth’s surface and scattered throughout the troposphere.

**Station Three: Plant Migration**

1. From observing the plants under the “greenhouse” and plants not located in the greenhouse, which plants look healthier and what are some physiological effects?

The plants under heated conditions look drier and unhealthy compared to the plants outside the “greenhouse.”

2. If plants cannot live in their new climate, what will eventually happen?

They will die and hopefully they will have enough time to migrate. This migration is also known as ecosystem shift.
3. If plants cannot migrate fast enough to a proper climate, what will happen to wildlife and humans?

Wildlife and humans may not have food and shelter to live. Many habitats will be destroyed and farms, decreasing populations of both wildlife and humans.

4. How do humans have an impacted on plant migration?

Humans can begin to control greenhouse gas production to stop altering climate change. Humans increase habitat fragmentation decreasing the available locations to propagate (i.e. reducing ecosystem shift).

Station Four: Acidic Oceans

1. From the diagrams. How is it possible for atmospheric CO$_2$ to become dissolved in the ocean and create carbonic acid?

CO$_2$ enters ocean through equilibrium CO$_2$(aq) $\rightleftharpoons$ CO$_2$(g), the through biological degradation and photosynthesis mainly through living and decomposing algae. CO$_2$(aq) + H$_2$O creating H$_2$CO$_3$(carbonic acid) and eventually decreases the pH in the ocean.

2. What do the coral and shelled organism weigh?
   a. Initial Weight: Coral ___________________grams
   b. Initial Weight: Shell ___________________grams
   c. Post Weight: Coral ___________________grams
   d. Post Weight: Shell ___________________grams

All initial weights should be heavier than the post weights

3. From the initial weights and post weights, what is the fate of calcium carbonated organisms, such as the coral and shells that live in the ocean? What did the carbonic acid do to the organisms?

When CO$_2$ and H$_2$O combine it creates H$_2$CO$_3$(carbonic acid) and eventually decreases the pH in the ocean. The acidity can dissolve the calcium carbonated organisms such as coral and shelled organisms.
4. What will happen to biological hotspots, such as the coral reefs, if CO₂ concentrations continue to rise in the atmosphere?

When CO₂ and H₂O combine is creates H₂CO₂ or carbonic acid, or eventually decreases the pH in the ocean. The acidity can dissolve the calcium carbonated organisms such as coral and shelled organisms. Many species that depend on the coral reefs for habitats will eventually die.

Station Five: Ice Melt

1. Based on the diagram and graph, how do greenhouse gases relate to polar ice caps and glaciers?

When CO₂ concentrations are correlated to the temperature and therefore, increased temperatures caused by an increase of CO₂ is increasing ice melt.

2. If the glaciers melt, what will happen to cities near the coast and oceanic currents?

The cities will flood and the ocean currents will stop changing how heat is transferred in the ocean.

3. If the ocean currents change, How will the climates in the coast change?

Heat transfer from the ocean will alter and reflect that change to coastal regions.

4. Based on your previous answer, What is the difference between climate and weather?

Weather is the measure of atmospheric conditions over a short period of time, where climate is the conditions of the atmosphere in a long period of time.
## Questionnaire for Intrinsic, Self-Efficacy, and Self Determination Motivation

### Intrinsic motivation

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found learning science interesting</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I enjoy learning science</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I enjoy science that challenges me</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I feel a sense of accomplishment when I understand science</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The science I learned is more valuable than the grade I received</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

### Self-Efficacy

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe I can master the knowledge and skills in this science course</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I believe I can earn an “A” in this science course</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I’m sure that I will do well on this science tests</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I’m expected do as well or better than my peers in this science course</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am confident that I will be successful with the labs and projects in this science course</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

### Self-Determination

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Usually</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>I use strategies that ensure my success in this class</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I work at learning science</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I prepare for my science labs and tests</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>If I have trouble learning science, I try to figure it out</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Grammarly found 28 critical writing issues and generated 11 word choice corrections for your text.

Score: 66 of 100  
(weak, needs revision)

<table>
<thead>
<tr>
<th>Category</th>
<th>Issue Count</th>
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<tbody>
<tr>
<td>Plagiarism</td>
<td>✓</td>
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<tr>
<td>Contextual Spelling Check</td>
<td>8 issues</td>
</tr>
<tr>
<td>▲ Spelling (7)</td>
<td></td>
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<tr>
<td>▲ Commonly confused words (1)</td>
<td></td>
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<tr>
<td>✓ Ignored words</td>
<td></td>
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<tr>
<td>Grammar</td>
<td>16 issues</td>
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<tr>
<td>▲ Faulty parallelism (1)</td>
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<tr>
<td>▲ Confusing modifiers (1)</td>
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<tr>
<td>▲ Modal verbs (1)</td>
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<tr>
<td>Punctuation</td>
<td>3 issues</td>
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<tr>
<td>▲ Punctuation within a sentence (1)</td>
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<tr>
<td>▲ Capitalization (2)</td>
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<tr>
<td>✓ Closing punctuation</td>
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<tr>
<td>Style and Word Choice</td>
<td>1 issue</td>
</tr>
<tr>
<td>▲ Vocabulary use (1)</td>
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<tr>
<td>✓ Writing style</td>
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</tbody>
</table>