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SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH EDUCATION: IMPLEMENTING STEM EDUCATION IN THE HIGH SCHOOL MINORITY CLASSROOM THROUGH DESIGN BASED RESEARCH

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I am submitting herewith a thesis written by Alyson Pointer entitled "SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH EDUCATION: IMPLEMENTING STEM EDUCATION IN THE HIGH SCHOOL MINORITY CLASSROOM THROUGH DESIGN BASED RESEARCH." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Teacher Education.

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SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH EDUCATION: IMPLEMENTING STEM EDUCATION IN THE HIGH SCHOOL MINORITY CLASSROOM THROUGH DESIGN BASED RESEARCH

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Abstract

STEM education, science, technology, engineering, and math education, incorporate many important aspects to benefit student learning. The NGSS, the major science education reform document focuses on engaging students to several scientific practices including modeling, argumentation, engineering design, and computational thinking. In this action research, I focus on questioning and modeling to improve my practices as an educator to benefit the overall student learning goals of using both modeling and questioning to understand content with more depth. Modeling has been proven to be beneficial to student learning. Designing a model that has the room to change as learning progresses allows for the creation of ownership in the learning process (Schwarz, et. al, 2008). Questioning promotes student interest by building through students' prior knowledge and targeting areas where students are interested in exploring (Lustick, 2010). There are the different types of learners and through modeling the students will be able to address the different types of learning by creating their own questions and be able to answer those questions. This paper focuses on the implementation and changes that I make in my own classroom of Biology I to allow students to incorporate the practices of inquiry and modeling through implementation in the topics of genetics and ecology. Teacher implementation of these methods has the potential to improve student learning. Using design based research, I monitor, reflect and change my instructional practices related to modeling and questioning. The purpose of this action research study was to develop and implement model-based science curriculum through two projects to improve my pedagogical knowledge and skills related to modeling and questioning. I used design-based research to improve my teaching through modeling and questioning.

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CHAPTER ONE:

INTRODUCTION

STEM Education

Science, technology, engineering, and math, or STEM, education covers many different bases in education. In the younger grades, K-5, it encourages an exploration of the sciences through, for example, design building a product or coding. In the younger grades, STEM bases are being laid as foundations to encourage better understandings of the subject matter. In the higher grades, 6-12, it covers many different fields and the different variations of those fields. STEM education can encourage the exploration of subjects like sociology or psychology to the studies of mechanics or building. STEM provides support and foundations for the needed for success within the fields of science and math.

STEM education has become a major focus in the Next Generation Science Standards, or NGSS, implementing the three equal parts incorporating a 3-D design dimension. The first dimension is known as the practices, the practices are used to "describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems" or as skills to be used in the different fields (Achieve Inc, 2013). The first dimension has a close relation to the scientific inquiry. Using both scientific inquiry and the practices laid out in the first dimension, students will have a foundation for being able to use STEM to solve problems. (Achieve Inc, 2013.)

The second dimension covers the crosscutting concepts. The NGSS describes this as, "a way of linking the different domains of science... [using] patterns, similarity, and diversity; cause

and effect; scale; proportion and quantity; systems and system models; energy and matter; structure and function; stability and change" which also links it back to the other aspects of STEM such as technology and math (Achieve Inc., 2013). This is also known as the "organizational schema" for the foundations of STEM. (Achieve Inc., 2013). The third dimension covers the disciplinary core ideas, or the keys of what needs to be taught in each grade level or subject area. This covers materials from "four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology and applications of science" which covers all areas of science. Over multiple grade levels and years this provides the chance for students to understand the importance of science and the different aspects of the field. (Achieve Inc., 2013)

The NGSS provides the foundations that many states are beginning to adopt or adapt from for the better understanding of the students. The 3-D design uses the foundations of STEM and is encouraging this on all levels. STEM education has a different perspective from every grade level from what can be expected but this is a building block to allow for more depth in the field and for the students to grow upon the practices. Students can start building and designing fun ideas like building a simple machine in the younger grades but can grow upon this to designing and constructing something more like a robot for the high school robotics club.

The states of Tennessee, while not an adopter of the Next Generation Science Standards, has adapted new standards to align standards to all of the scientific and engineering practices, crosscutting concepts, and core ideas highlighted within the NGSS. The purpose of this design-cased action research is to focus on a STEM teachers implementation of the two practices, questioning and modeling. The research question that will be divulged into during this research is:

How can a teacher improve her own pedagogical knowledge and skills related to questioning and modeling through design-based research?

CHAPTER TWO:

LITERATURE REVIEW

STEM Education in Minority and Underrepresented Students

Since this study took place in a school with high minority student enrollment, a review of studies related to minority education in STEM is needed. I provide this review in this section. Substantial number of studies have explored the learning experiences of minority student in stem field. Collectively, these studies suggest that minority students do not receive quality stem education. Among issues discussed include, course offerings, instructional strategies used and assessments.

For instance, DeWitt, Archer, & Osborne (2015) state that there seems to be a major correlation to course recommendation and ethnicity. Their study pointed out that students from a non-white background would be less likely to be recommended for the higher level courses which in turn puts major limitations to what the student can achieve in the time they are in school, because these lower level classes could impact things like grade point average or testing abilities. (DeWitt, Archer, & Osborne, 2015).

Does being a low-income and minority student impact the students representation in science education? According to Card and Giuliano (2016), that most districts are using parent and teacher screening for students to be referred for the classes at a higher level (p. 136780). If there was an alternative method, there is a chance that these students could be represented in the classroom at those higher levels. Diversity may not be rich in all areas, but there needs to be an equal representation of the diversity in the gifted classroom as all students deserve a chance. As science is not focused upon heavily until the higher grades, according to DeWitt, Archer, and

Osbourne (2015), this could impact a student's interaction with being able to do more in the science classroom.

The focus of students in science education is reliant on the students grade level. According to DeWitt, Archer, & Osbourne (2015), science becomes more of a focus in the middle school and high school years where in elementary school years there is more of a focus on English and math, This has a major impact on a student's decision for post-secondary decisions, like a job or college possibilities. In the middle school and high school age, there is still a lot of time to change plans for the post-secondary decisions; however, students will see their test scores and grades in the science classes and make decisions based off of that. DeWitt, Archer, & Osborne (2015) stated that the ages of 10 to 14 are important to forming their future goals and with science not being majorly influenced in those ages until the middle school and high school frame will impact their decisions on their future goals and aspirations. These students can be wrongfully informed on the aspects of science is or not even consider the major job and professional opportunities that can be offered from the scientific community. DeWitt, Archer, & Osborne (2015) stated that, "students who aspired to science-related careers at age 14 are almost three and a half times more likely to end up studying for a degree in the physical sciences or engineering", which is different than expected with the low level of focus in science that is currently seen (p. 2712). There is a connection between the choice's students make for their futures and the low activity science has in the students early education. These implications mentioned above will further impact those in the lower level classes and the minority students that have been placed there by teacher discretion because they are lacking the interaction within the sciences and the lack of confidence in themselves. (DeWitt, Archer, & Osborne, 2015).

DeWitt, Archer, & Osborne pointed out that, there is an important role of family in the decisions the students make for post-secondary. Those with the higher social and economic resources have the ability to support students wanting to pursue futures within the science fields. This greatly hinders the students in the minority fields and lower social classes as they are more limited in the post-secondary decisions. (DeWitt, Archer, & Osborne, 2015).

According to DeWitt, Archer, & Osborne's (2015) survey results, "South Asian students as well as those of Black or Other ethnicities are more likely than White students to have" desires or hopes to work in a science related field in the future" (p. 2179). The predictions based off of this showed that someone who is male, has a family member in a science related field, and comes from a non-White family has plans to obtain a job in a science related field. The students from ethnically diverse backgrounds have these high aspirations to work in a science related field but is there a barrier being put in place for those students to overcome to achieve this hope? Students, according to DeWitt, Archer, & Osborne, are heavily influenced by those around them rather than the content being presented in class. Some students will encounter these ideas in school to hope to make the connection but the age that science being brought in at a heavier rate may need to be earlier than what is presented currently. (DeWitt, Archer, & Osborne, 2015). There are a lot of things that will discourage young students to pursue a degree in a STEM related field. According to Malcom & Malcom (2011), "although the passage of laws banning discrimination on the basis of race and/or sex reduced the number of overt practices that shaped the university and workforce cohorts of previous years", have allowed more access to the field by minorities but have also allowed more limitations and obstacles for those seeking to have a job in the field (p. 162). Students in the classroom of today do not want to, or cannot, face these obstacles put in place which influence their decisions and further pushe the students to change

career paths or leave the field. There are those who have made progress in the field and were able to overcome these obstacles put in place. These students are able to overcome the obstacles through supports from faculty and mentors within the program. If these supports here changed students paths, could supports in secondary education make an impact as well? (Malcom & Malcom, 2011).

Another line of research, Wong (2016), suggests that minority students are not well represented in STEM careers. Wong (2016) states that there are differences in careers that are in science fields and those from science fields. The ones focusing in science will be those incorporating the scientific skills sets such as research and field work. Those that are from science are more applicable to the focus in science as it is being used or where it is being applied and how. Wong states that "minority ethnic groups seem to fare better in careers from science" meaning those that are being able to apply what has been learned within the science field (p. 981, 2016). (Wong, 2016).

Identity is important within the science classroom, as well as all other classrooms. Brown (2004), has described this as "psychological behavior grounded in categories of social conduct that are initiated by emotionally significant events", which means that in the classroom identities can be shaped by a variety of different reasons (p. 812). This school where the context of this thesis was conducted is a large minority and English as a second language population. Using discourse to support science and the formation of these identities in the science classroom is useful. When students are using science and participating in the science classroom they are forming a new identity or reshaping an identity to become accustom to the practices of science and the importance of science. (Barton & Tan, 2009).

Barton and Tan, 2009, studied methods that combined science with the context of culture. By combing the different aspects of culture and discourse into the nature of a classroom, it created a space that allowed students to blend the two evenly to articulate their science knowledge. In the classroom, this allowed for there to be an advantage to these students that they normally would not get to see or experience. Due to some cultures, there is a lack in some areas of the education field, science being a focus that was left behind to literacy and math skills. The students who used this hybrid space to explore and learn in science were granted an opportunity to grow and develop skills in the classroom, much like this study strives to accomplish. (Barton & Tan, 2009).

In this school, there is also a high level of students who have migrated to the country and English is not their first language. These students will struggle more in the classes as they do not have the full literacy skills as the other students. The addressing framework of this paper, modeling and questioning, allows the students to focus on discourse in the classroom to better their literacy skills and learn in the process. By tying back in the cultural practices of these students and their diverse backgrounds the students are presented with an area where they can grow and demonstrate skills in the science classroom. Culture, from all backgrounds, is important in science and by bringing the culture into the classroom through discussions, projects, videos, and questions the English as a Second Language students have a higher chance of understanding and growing. (Lee, 2005).

In another context, pointed out by Basu and Barton (2005), science in the minority classroom causes issues in the science classroom such as “boredom, anxiety, confusion, and frustration” that impacts the students views and outlooks of not only the class but the overall field (p. 466). Basu and Barton (2005), also discuss using “funds of knowledge” in the science

classroom where tying in cultural experiences into the classroom (p. 467). This idea ties in the home life of the student with their school life and allows for there to be more of the real world context in the life of the student as the gaps are beginning to bridge. Students will be able to see science more across than just a class that brings on anxiety. By tying in real-world problems, like performed in this study, students are able to see more of what is going on in their world. This allows for tie ins of project based learning and the building of the important science skills of modeling and questioning. ((Basu & Barton, 2005).

With support to addressing cultural issues, classroom cultures are built on different levels as each student has different aspects to bring to the room due to their background. Teachers are lacking in ways to fix the gaps in the science classroom as the classroom has a large cultural interaction. In many classrooms, there are issues that arise which can impact the students behaviors because there is a gap in communication skills. This can impact the way a teacher is able to teacher her classroom. By lacking the supports mentioned above, students are being educated in the science in the ways they could be (Brown, 2004)

The role of both the teacher and learner play an important part in education. Teacher education programs need to begin to include different types of cultural education within the courses they require the preservice teacher to take. This would open up a different perspective to the teacher of where students may be coming from or issues they may be taking on. Students also need to be prepared to take on more challenging roles within the educational framework with the teachers supports. The teachers are not there to fail the students but to give the chance for the students to learn how to grow and change as the class goes on. The students should be gaining knowledge in the content and leaving the class at the end of the course knowing more than when they came in. This comes from multiple sides but one of the most important will be the student.

If the student does not contain the drive to learn the content, then no matter what the teacher, school, or community does to influence the student there will be little to no gain within that student's education standpoint (Hammond, 2001).

Teachers should aim to address students on all levels. Using practices that are targeted to engage and address as many learners as possible will allow for students to be more successful as it allows for students to be addressed in a broader range. This includes the English Language Learners and the minority students who have the different levels within the classroom. Providing frameworks and ideas could broaden the playing field for students on all levels. Being able to relate the content back to students lives in different ways and making in meaningful to those students could drastically shift the view of science in the student's eyes and make a shift of the science community being more open and accepting to the minority part of the community. Being able to provide equal opportunity to all in the science community and seeing more roles being filled by people of different backgrounds and ethnicities would allow for a more diverse scientific community (Holliday, 2001).

The role curriculum and instruction play in education of students, especially education of minority students is very critical. Therefore, in this study, I focused on improving my pedagogical skills related to modeling and questioning through design-based research by incorporating opportunities for student learning, The question that follows is can be I proven by having students effectively engaged in modeling and create more opportunities for students to engage in questioning? Modeling has not been incorporated by many teachers in lower and middle grades as modeling is not as significant as a practice (Holliday, 2001). Therefore, the students who are now entering high school are missing the vital resources of using models to be able to learn within the classroom (Holliday, 2001). Questioning becomes an issue when students are needing to address scientific concepts and not the scientific curiosities the students

have (Chin & Brown, 2010). By improving teacher questioning through different methods there is the hope that it will help improve the student questioning and inquiry when tied into scientific content (Werder, 2016). Consequently, students will engage in learning more meaningfully and more effectively. By incorporating both the modeling and questioning practices into the classroom, students are given skill development in the areas of mathematical and computational thinking (Sneider, et. al., 2014, p. 54). Sneider et al (2014), describes that by "combining multiple parts of mathematical and computational thinking that there is the incorporation of the supporting skills for students like inquiry, modeling, data analysis, and statistics" (p. 54). These supports allow for thinking to go further into the science field and allow for the supports to be seen directly (Sneider, et. al., 2014.

Modeling and Questioning in STEM

In science, using questioning and modeling are two of the most important aspects. Modeling represents ideas, systems, or experiments within the science classroom and questioning ties into all of those (Holliday, 2001). Science depends on questioning through the formation of hypotheses. Students struggle in science as they are not introduced to these concepts and ideas until later within the schooling career (Schwarz, et. al, 2008). Focusing on these two concepts within this paper, the question focusing is still:

How can a teacher improve their own pedagogical knowledge and skills related to questioning and modeling?

I elaborate on each of these concepts and their potential contribution to student learning when implemented in the classroom effectively.

Questioning

Student questioning overall seems to be an issue when coming to students being able to perform scientifically (Chin & Brown, 2010). When students are presented with a problem within science classes the questioning is laid out for them already. Students being able to generate their own questions allows for the focus to be on the content, exploration, and overall big ideas within the structure of the class (Chin & Brown, 2010). Students generating their own questioning can be directly tied to their own motivation for the content. Students generally are supported in their own way to use the problem solving skills that is provided by being able to create their own questions. (Chin & Brown, 2010).

Questioning in science is just as important for the teacher as it is the student. Students being able to answer their own questions leads to more of student engagement and discovery which in science is meaningful to the learning (Werder, 2016). Teachers can help shape current thoughts that the students have by giving out guiding questions to lead students down a certain path. The teachers are majorly dependent on students being able to produce their own effective questions as well. Werder (2016), points out the importance of co-inquiry, where having the student-teacher interaction when making questions impacts student creation of questions. A major point from Werder is that one question being asked can lead to another question that has more depth than the previous. The students are getting more involved with the detail of the content by going further in depth. This will lead to the relationship students need of asking questions and answering their own questions. (Werder, 2016)

Inquiry-based learning relies heavily on the teacher being the facilitator, being the person who leads students down the path of being able to take the content and current knowledge to form questions. Being able to move away from the direct learning benefits students in being able

to learn in their own way and explore the content in depths while the teacher is there for supports and to redirect students when needed. Students making their own questions are given the ability to use their own voices and put the questions into their own words rather than given a question that uses words they may not know or given in a format that they do not understand. By students having this major input in the questions it leads to the ownership of those questions and the ownership of the content they have learned (Werder, 2016).

The other side of inquiry is answering the questions that have been created. The teacher comes back in at the major facilitator role here, where the guidance will mean the most to the students. The teacher provides the resources to answer the questions; whereas, the students will be working to answer them. These answers show the student experiences with the content, what worked, what did not work, and what still could be improved on. Students having a role in both allows them to feel more connected to the work as their voices are being heard and their questions being answered (Werber, 2016)

By allowing students to create their own questions, ask the questions, and seek to answer their own questions the students are extending their learning beyond what is just presented and allowing for the exploration that is lacking in many other content areas. This allows for teachers to see what the students know and what the students want to know directly by the types of questioning that is being asked. Are the questions simply based on memorization of the content or are they based off of higher, more critical thinking based questions? (Chin & Brown, 2010).

Many of the questions currently being asked within the science classroom, “limit their discussion of questions to basic concepts such as convergent/divergent, open/closed, and higher/lower order cognitive load categorizations,” where students are merely memorizing content rather than working with in (Lustick, 2010, p. 496). Going back to the teacher being the

facilitator to the questioning, another important aspect of being this facilitator is providing a focus question for the students to start the guidance in the inquiry process. This focus question needs to provoke thinking in a new level and allow for the full engagement of students being able to inquire more to answer that question (Lustick, 2010).

There are multiple frameworks to be able to design the focus questions mentioned by Lustick. Bloom's taxonomy and Webb's depth of knowledge provided foundations and frameworks that allow for scaffolding of questions to make the questions go into the higher level of thinking but it may still impact the actual quality of the question. The overall quality of the question will directly relate to the students ability. Lustick had four types of questions pointed out, Type I focusing on syntax based questions, Types II and III focus on questions that can be answered when referencing texts or notes, and Type IV allows students to take scientific material and find possible solutions for that material. These levels of questions need to be combined in the focus question, or focus questions if needed, where students of all skill levels are able to be involved in answering the questions. (Lustick, 2010).

Through the ability of problem-based learning, students are able to use questions to allow for the connection between science and their lives. Students in problem-based learning are given problems that need to be solved. This allows for the tie in of student questioning as students are going to go through a multistep process to create the questions needing to be asked to address problem-based learning objectives. This increases the discussions as well which could promote more question from the students. Students are curious about thing they are not familiar with. In this study, students are taking on focus questions and objectives being addressed through problem-based learning to further their own questioning skills. Problem based learning allows for there to be a tie in of the direct skills needing to be addressed, modeling and questioning, by

creating focuses for the students to try and solve and create the model effectively explaining how the student approaches the overall main idea and their ability to fix it,(Dahlgran & Oberg, 2001).

Modeling

Modeling has always been important in the scientific and math fields but the process of modeling has changed over the years. In science, being able to use models while developing the skills and concepts allows students to understand the content in a different way (Schwarz, et. al., 2008). Modeling allows for there to be a more hands on approach depending on how it is approached. Through student modeling, students are creating models that show the concepts covered in science to allow for them to have a better understanding of the concept at hand. Incorporating modeling allows for students to have the hands on approach in learning science (Schwarz, et. al, 2008). The other side of modeling is the teacher model, where the teacher represents the material needing to be understood in a few different ways. This is a less hands on approach with the students but allows for the visuals to be addressed in the project. (Schwarz, et. al, 2008).

The hard thing about incorporating modeling in the high school setting is that in elementary school the models were not as heavily focused on. This has been one of the recent shifts towards STEM however, where students are working with models more now. But the current students in the classroom are lacking the experience in modeling as the modeling was not incorporated until they were in the middle grades. The teachers experiences with modeling has also been limited as well, most do not know how to effectively incorporate modeling in the classroom. The teachers need the practice with the models as well to be able to further the students' knowledge using models. (Schwarz, et. al, 2008).

As teachers become accustomed to models in science, the models can be used to predict what could happen in the future through presenting and explaining current ideas in the scientific world. Students building their own models allows for teachers to see how the students are understanding the content and making progress in the application of that content. Models can be represented differently through drawings, chart and diagrams, 3D objects and other assorted items. All of these models have the ability to change as time goes on as well. Students are able to make corrections to the models as needed to be able to accurately represent the information at hand. (Schwarz, et. al, 2008).

The teachers ability to evaluate the models students are making and their effectiveness are very important. Quigley uses different methods to track the changes students are making to the models over time and track those changes to see how the students are understanding the content. The benefit of this allowed students to focus on the activity at hand where the measurement made predictors of how the student could be doing in the future and track of their current practices. But this allows for the teacher to also make corrections in the learning process for the student to better understand what is going on in the class with the specific content at hand. (Quigley, Mcnamara,, Ostwald, & Sumner, 2017).

Students in the overall process of modeling will need to begin with the model construction. The students need to make the original model to represent the idea at hand whether it be a physical 3D model, a paper model, or an online model. The construction of this model needs to represent the different aspects of research and design methods. From there the student needs to be able to revise the model as the learning progresses. Students will need to further investigate and update the model as it changes. Modeling is different from person to person to the model may not be understandable to all but should have a general basis of what is

represented. These modeling practices have major importance on how the students are able to perform academically and increases their chances to do gain knowledge (Quigley et. al, 2017).

Modeling relies on other practices in the classroom but the most important would be inquiry. Holliday, 2001, points out that there is the hold back of teachers using modeling in science as the inquiry aspect is not consistent across all boards for the modeling practices (p. 57). Inquiry provides supports for the model as it provides the interest in the concept. These inconsistencies in questioning lead to the issues where students are not able to rely on modeling practices. The other issue pointed out is that there are other practices that need to be incorporated in the classroom that provide value as well. If the modeling is not providing the results desired is the process effective? (Holliday, 2001).

Modeling does provide results that are sometimes unnoticed as time progresses however. If the teacher is incorporating the model effectively then the students will have academic gain in one way or another. Modeling is beneficial to students who have the different styles of learning and the teacher will benefit from the effort and time being put into the models. The models allow students ways to see change in their thought process and time goes. This also allows the teacher to improve on their own personal methods as they teach the construction of the model (Holliday, 2001).

Modeling also progresses scientific inquiry. According to Halloun (2006), there are two types of models, “represent, investigate, control, and impose order on, physical systems and phenomena, and put together scientific theory coherently and corroborate it efficiently” which are important skills for students to master (p. 653). By incorporating both types of models, students are able to represent the experiments they are performing and showing their thoughts through the process as well as being able to put together the confirmed theories in science and

defend them using the educational research at hand. There are multiple processes that could be modeled which are demonstrated through this paper. Modeling in the classroom provides supports for the students learning. Students are able to better understand the concepts at hand, the overall scientific processes needing to be known, and the views of science overall. The students learning styles are being addresses and students on all levels are able to learn by this. This provides the supports to the teacher to further student learning (Halloun, 2006).

By allowing both modeling and questioning into their personal practice the teacher can use supports to change their practice and better the students learning. Through the process of design based research, a teacher implements practices, reflects, and changes the practices to better the students ability in the classroom. This benefits the change that comes through the classroom on a consistent basis and allows the teacher to always be improving for the better.

Teacher modeling in science is a different process than the student modeling. According to Maia and Justi (2009), a science teacher should be focusing on the "'learning how' rather than [the] 'learning what'", which means teaching the idea or concept through the flow of a model (p. 604). This allows the teacher to show the developmental thinking of scientists over time and allow for the justification of the scientist thought processes in the discovery of the material. By tying in modeling in the science classroom it allows for three things in the student benefit, "s (i) sort out and build explanations of scientific phenomena, rather than merely memorizing facts and definitions; (ii) define and revise problems over time; and (iii) search for information and data sources" which allows students to be able to engage in more of the education practices needed to be successful in the science field (p. 606). (Maia & Justi, 2009).

Model based teaching in the science classroom can greatly benefit the students in the process of acquiring knowledge. By providing a model for the students to follow there is a

greater chance that the students will see success, as the process has been implemented for the students. The teacher needs to be prepared to do this process through, as the unprepared will falter or have issues in the process. By adequately preparing and providing the model for the students, the teacher is showing a way to think through a process or create the process to promote thinking. (Maia & Justi, 2009).

Modeling in science can often be limited through the science teacher. The teachers need be be able to incorporate more examples in the classroom, through either the thinking process or demonstrative models, to allow students to gain more knowledge. Teachers should also incorporate the idea of predictive models, where students make a model of an idea or concept that could happen, for instance climate change. In certain subject areas of science, some models are easier to apply where others are not. In the field of chemistry, ball and stick models allow for an easy representation of atoms and bonding. In Biology, the models of biogeochemical cycle allow for students to be able to see a process in the works like the water cycle. In physics, the incorporation of Newton's cradle could allow for a different view of Newton's three laws. This allows for the tie in of questioning in the modeling process as well. (Direl & Verloop, 1999).

Modeling also allows for students to build relationships with information presented to them to the investigated subject. The teacher needs to engage in the modeling process by allowing the students to create the model and use questions to address issues within the model. This needs to become a consistent part of the modeling practices within the teachers room. The developmental process of creating a model, for both the teacher and students, allows it to be shown how the thinking process was used to create the model . This allows a teacher to engage in process to improve the modeling process and allow for the needed changes in their instruction to improve the overall process of modeling. (Justi, 2009).

Teacher modeling is important, again, but by being able to tie in the role of questioning in the aspect of modeling allows for there to be more engagement and interactions with the models. Rea-Ramirez (2009), points out that by using one of the two types of questioning, “supporting questions and discrepant questions”, allow for different types of interactions with the models. Supporting questions allow for there to be support in the investigation of the model and by tying in the different aspects of their culture in the model. Discrepant questioning allows for students to investigate issues within their model and divulge on how to fix those issues. The teacher thus has created the model for the students to follow, the students create their model from that, and then investigate why their model ended up differently. The students are gaining essential knowledge in the process and allows for there to be more engagement in the modeling process. (Rea-Ramirez, et. al, 2009).

CHAPTER THREE:

METHODOLOGY

Design Based Research

The methodology chosen for is design based research (Isidro, 2019; Ada, 2018; Kong, 2012). The theoretical framework guiding this action research project is design-based research. Design based research "is a methodology that aims to study learning in authentic learning environments through the design and implementation of instructional strategies " (Isidro, 2019, p. 3). The idea behind design based research is to make a change to the in instructional strategies to benefit those who are learning the material. The changes will range from technology changes to the instructional methods in which the material is taught in this personal study. Design based research has many characteristics, listed out in the literature as "(1) the research must be situated in actual educational contexts; (2) interventions must be based on learning theory/ies, and aim at generating design principles that emerge from theorizing as grounded in the data; (3) the design process is iterative (i.e. going through design, implementation, analysis, and redesign steps repeatedly); (4) the research must account for the context in which the design was implemented; (5) the research involves the use of qualitative and quantitative measures; and (6) the research involves a collaboration between researchers and practitioners" (Isidro, 2019, p. 3).

Overall, design based research needs to be based out of an education context. The basis of the research needs to come from steady theories and foundations within the educational framework. The process overall needs to be effective to benefit the students when implemented within the classroom, by supporting this process with the different theories as well as supporting data there should be a significant gain in the knowledge of the content. An idea behind design

based research is that within the different methods of implementation it could lead to reforms within the curriculum or improvements in instruction. (Isidro, 2019; Ada, 2018; Kong, 2012).

The idea of design based research was used in the research by Ada (2018), "to improve educational practices through iterative analysis, design, development, and implementation" to be able to apply this to the real-world setting of the classroom supporting new methodologies within the classroom for instruction (p. 6). Design based research is there to support, "researchers and practitioners... to produce tools, approaches, theories and products" to use in the field that are field tested and effective (Ada, 2018, p. 6).

One of the major component of design based research is dependent on the educational context. Design based research is there to support the area you are applying it to as well as the learning designs and processes within the classroom. There are methods that will work better in lower grades compared to middle schools and high schools or even higher education. Students are dependent on the learning concepts and these concepts need to be taught in different methods for the students to be able to understand and apply them. For example, in this personal paper the use of project based learning was used in the high school context to collect relevant data on my personal practice as a teacher. The students were given two separate project to address major concepts and tasks related to content. This was a major practice to the material. Data from the pre- assessment and post assessment will be included later on but the data collected from both was an influence on how to incorporate the project, grouping, and the questions being used to address the models. (Ada, 2018).

Design based research can help with teacher's' effective use of instructional technologies as well. The idea is that design based research brings in new ways to learn the material within the classroom using technology. As technology is constantly changing there are new advances;

however, one of the major ones is “student-owned mobile devices and mobile web application” (Ada, 2018, p. 6). The rise of technology has provided new outlets for students to be able to do work through this. There is the new chance to do more effective research on topics covered in class and new ways to practice and discover materials. A popular option for the computer based is now games and interactive applications. This allows students to learn material in a way that is more applicable to them due to them accustom to technology, where they are used to having it almost constantly.

Being able to design new methods and testing the interventions of these methods, the mobile learning or technology based learning is a major support. Being able to incorporate technology into the classroom allows students to seek improvements in their own practice as well as be able to advance with others in today’s world as technology is ever changing and improving. This allows for there to be an increase student engagement. As stated previously, students are now accustomed to growing up in the age of technology where technology is constantly changing and adapting. By being able to incorporate technology into the daily practice students are progressing in learning how to use technology more and more to their benefit. Students are some of the most up to date on the technology changing and being able to use the technology more in class to provide a more fruitful and engaged response to the material compared to the other routes provided. This incorporates one of the major aspects of STEM education, technology. (Ada, 2018).

Within the design of this paper there is the focus on using design based research to influence the choices of how to incorporate the project through problem based learning. The design of this study was for students to be given a problem to solve by using questioning to design the end product model of how to solve the problem. The model needs to be changing

through time, as models in science are ever changing. Problem based learning is "student-centered learning and classroom discussion using clinically based problems", where students are encouraged to contribute to discourse and solving the problem at hand (Kong, 2012, p. 60). Problem based learning encourages more than "memorizing vast amount amounts of information in a static format" and instead using problem solving formatting to learn (Kong, 2012, p. 61).

The entirety of the lesson plans and incorporations of those into the classroom focused on being able to use aspects of problem based learning to better my own personal practice. Problem based learning presents materials in a format where students are "required to work in a small group to identify what they know, to identify what they do not know, and to generate questions in what needs to be... learned" (Kong, 2012, p. 61). This format works well in the high school setting as it promotes the questioning skills students need. There is also the chance to scaffold grouping within the problem as groups can be arranged in different ways to benefit the learners needs. This all promotes student directed learning as students are able "to set their own pace of learning [in recognition of] previously learned material", which allows for the incorporation of new learning as well as using the previous material to influence this new learning (Kong, 2012, p. 61).

Design based research overall allows the teacher to incorporate different practices in the classroom then allows for there to be reflection and change to those practices to better the students overall learning. By making these needed changes as identified the teacher is also identifying different areas of strengths and weaknesses of their own to improve upon, which is the main reason for selecting design based research as my practice. By allowing the implementation of design based research, I was able to make the needed changes in my classroom to allow for better supports of practicing questioning and modeling. By selecting areas

that needed more supports and changes, I was able to take a chance to reflect directly on what did not work in my classroom, reflect back on my personal practices, and make changes to the instruction for the next semester to allow students to have the chance to improve their own practice in questioning and modeling as I was giving better supports and constructs. I was providing better supports fort the students to succeed in my classroom and through what is expected in their work.

Context and Participants

The period of time these projects were covered is over two semesters, fall and spring and was covered over three different Biology classes. In the fall, the classes consisted of 23 students total in one class. The class was 74% of African American students, 17% African students who were English language learners, and nine percent white students. In the class 13 out of 23 students were male and the other 10 were female. Three of the students in the class were receiving supports through an individualized education plan and nine students fall into the RTI, response to intervention, umbrella where the students are getting math supports, reading supports, or supports on both. RTI stands for response to intervention, which is a multitier process of providing necessary supports to students who fall under the range. Each tier ranges from their supports with tier I being the least amount of supports and monitoring and tier III being those who need the highest level of interventions. (What is Response to Intervention?, n.d.)

The spring was presented over two classes, one class being an honors level Biology course of 19 students and a college prep, or regular, Biology class of 25 students. The honors level Biology course is 32% white, 61% African American, 5% Hispanic, and 5% Hispanic as an English language learner. In the class, nine out of 19 are male and 10 out of 19 are female. There are two students receiving supports from an individualized education plan and three students

receiving the RTI supports as well. The honors class is a little different from a regular honors course on the other hand, the class size was originally about 8 students being too small to support. Students were hand selected by the teacher, an instructional coach, an administrator, and a guidance counselor to be in the class based off of academic performance in the fall, past science Tennessee Comprehensive Assessment Program exams, and other teacher recommendations. This class is a true mix of honors leveled students and non-honors students, the ability of these students can vary greatly. The college prep Biology consisted of 68% of African American students, 16% white, 12% African students who are English language learners, and 4% Hispanic/Latino who is an English language learner. 15 out of the 25 students in this class were female, where 10 out of the 25 were males. There are five students receiving supports from an individualized education plan and 11 students receiving the RTI supports as well. The entire school is labeled as a Title 1 school, where a lot of the students coming to the school are low income and receiving additional supports within the school to meet the needs of the students.

Intervention

The intervention in the context of this study included teaching science through modeling and problem-based learning with an explicit focus on promoting students' questioning, effective grouping and communication. In these classes, there were two projects designed to focus on student driven modeling and students centered inquiry through the idea of problem based learning. Both of the projects were designed for students to create their own focus questions for the project and design a model of their ideas to support the problem being presented in class. Both of the projects as well started off with one day being inquiry based on why the project needed to be solved and drive the meaning of the content to the students. This also applied to the

ability to make it relevant to students lives as it allowed for them to invest their own ideas and interests in the project. In each of the projects, students were driven to create their own questions based off of the main problem or focus question and answer their own questions to eventually be able to solve the problem or focus question of the project. These guiding questions students are creating allowed students to guide their own way through the project in different groups. Each group had a variety of results based off of this idea as well. Students being able to answer their own questions they have created leads to the generation of the model in class and the changes the model needs as more questions have been answered.

The first project was originally designed to go into the heredity module of Biology where the cell cycle, meiosis, and genetics are covered. This project covered standard BIO1.LS3.2, "Explain how protein formation results in phenotypic variation and discuss how changes in DNA can lead to somatic or germline mutations" (Tennessee Academic Standard for Science, p. 61, 2017). This project designed on the idea students were going to have to create the genetic crosses of different plants and animals to sustain a colony on another planet. The first day, students were presented with the question of, "could humans survive as needed if we needed to restart and colonize on a new planet?" Students were presented with that question and given material to think about through a guided reading and a short video. Students were asked through a survey, appendix one, on what exactly people would need to survive and focusing on water, land, food: crops, and food: livestock students were broken up into focus groups to discuss exactly what they thought would be needed from that. The survey results allowed for them to be split by what was most important, or second depending on how groups filled, to them. Other things were mentioned but from the project standpoint, these were the focuses. In the focus groups they discussed what they thought was completely necessary in the discussion and students were then

regrouped from there into their main groups for the project, so one person could be the focus on the project.

Once the students were split into their project groups, they were to pick an assigned role. The following days of the project were chunked out for the students to take on the material slowly and not be overwhelmed. The second day focused on the introduction of the project, selecting and confirming with the teacher the roles, and beginning to create the guiding questions. The following four days focused on each chunked portion from: how they would plot and use the land, how they would reserve and use the water, what plants they picked and what the possible crosses could be from the new plants, where they would plant, how much they would plant, what livestock they picked and the genetic crosses of the livestock, where they would house the livestock, needed resources for the livestock. Students during this time were to do the needed research, create and show the genetic crosses, and create the model showing their choices. The chunking of this is to take tasks that are specific or similar in one day and focus on those specific tasks. This allowed for students to to take the tasks on as needed and pace themselves as well. The project was given out all as one but chunked into sections through pages. Students were able to move at their own pace in the project within their groups as they moved from task to task. Students were also able to slowly build upon and answer their own questions within the project and build the model as needed; where, the teacher was there for supports in the project and to help as needed. The final product of the project contained students choices of the material needing to be addressed and the final model showing their choices. The students were given about two weeks, due to some unforeseen schedule changes, to complete the project in class with their assigned groups. Please see table one below for a summary of project one.

The second project focused on the module with Ecology. This project focused on standard BIO1.LS4.3, “Identify ecosystem services and assess the role of biodiversity in support of these services. Analyze the role human activities have on disruption of these services.” and BIO1.LS2.1, “Analyze mathematical and/or computational representations of population data that support explanations of factors that affect population size and carrying capacities of populations within an ecosystem. Examine a representative ecosystem and, based on interdependent relationships present, predict population size effects due to a given disturbance.” (Tennessee Academic Standard for Science, p. 61, 2017).This project focused on populations of certain environments, the relationships within that environment, human roles in ecological services, and human impacts on the roles and the environments. The first day on this project again was focused on the driving force of the project again and it tied in a little with the last project as well. The idea behind this project is, “are we as humans harming the planet in anyway?” which ties back into the last project focusing on recolonizing if we needed too. Content for this was given through a guided reading of an article in class focusing on human impacts with pollutions and overuse of resources and then a second where there are services we provide that are beneficial like restoration of species in the environment, hunting for population control, and others. Content for this project however, was presented day by day so students could not move as freely through this project as needed. In reference to the Table 1 below, you can see how the project is designed and set up based off of the content standards, time period, objectives, and pacing. The pacing is very specific as it is expected to take the day by day process but be managed over the 10 day time frame. This allowed for students to progress together. In the second project students were given about seven classroom days to complete the project and make

the presentation. Table 1 below, compares project one to project two showing both the similarities of the project through set up but the differences in the projects.

Table 1: Project Summaries

Focus Area	Project one:	Project two:
Content Standards	BIO1.LS3.2: "Explain how protein formation results in phenotypic variation and discuss how changes in DNA can lead to somatic or germline mutations"	BIO1.LS4.3: "Identify ecosystem services and assess the role of biodiversity in support of these services. Analyze the role human activities have on disruption of these services." BIO1.LS2.1: "Analyze mathematical and/or computational representations of population data that support explanations of factors that affect population size and carrying capacities of populations within an ecosystem. Examine a representative ecosystem and, based on interdependent relationships present, predict population size effects due to a given disturbance."
Focus Questions/ Targets	Could humans survive as needed if we needed to restart and colonize on a new planet?	Are we as humans harming the planet in anyway? Other Focuses: populations of certain environments, the relationships within that environment, human roles in ecological services, and human impacts on the roles and the environments
Objective (overall)	I will determine if life would be viable on Mars through creating a meal plan for a fake colony.	I will determine the different aspects and roles of the pieces of the environments. I will determine if humans have an impact on any of the services and if that impact is positive or negative.
Time Period	Ten classroom days.	Seven classroom days.
Pacing	All tasks assigned at the beginning of the project, students self-paced.	Tasks assigned and chunked out per days, tasks could be managed over a period of days but no more than one task assigned per day unless there is a transaction.

CHAPTER FOUR:

RESULTS AND DISCUSSIONS

In the two projects, there were changes from project one to project two and then changes from fall to spring. There were areas the students struggled in: grouping, modeling, and questioning and discourse. The adjustments made by myself as the teacher were there to encourage students to be able to do better within the projects which incorporate the use of STEM practices. Focusing on improvements in the grouping allowed for students to be able to focus on being able to work well together in the small group settings, improvements in the modeling practices allowed for students to be able to learn from their mistakes when creating the model, and improvements in questioning and discourse encouraged the other two skills to improve for the better as well as for the students to not feel afraid to voice their opinions and voices in the scientific community as well as their own projects.

There were also areas that the students did well in: presentations and research. These areas need minimal changes but these skills are built in for the students success. The process of being able to complete quality research implies to other subject areas. The skill of presenting ties directly in with the STEM core values as in many of those concentrations there will be a presentation of ideas or content, or even in areas outside of STEM presentation skills are a quality to have and be able to do for the future. The students already have this skill so by expanding upon it students will be able to think at deeper levels as well as be more creative with their thinking skills. All of the skills mentioned have importance to being the students and those issues being addressed in the different ways, through changes or feedback, allows the growth students need to improve these skills. And through growing the skills of the students, the teacher

benefits by being able to target content and non-content specific strategies to include within the classroom for future students as well.

Through the details below, there is discussion in the changes observed in students' engagement and work with each of these areas as well as the improvements or minor changes made in my teaching on each of these areas to follow.

Grouping

The first iteration focuses on grouping. Every project implemented in the class had a major reliance on grouping. The grouping used in the projects relied on mixed abilities of students but the first round of grouping was random. The grouping within the class allows students to work together to formulate ideas and concepts within the classroom and solve the overall yearning problem tasked to the students through the projects. The goal of grouping here was for the students to work together and benefit from each other in the learning process. Each student in the group has skills others may not have and the ability to help each other by using their skills. The process of the implementation, revisions, results, and conclusions are described below.

First Implementation

For the planning process, when focusing on grouping originally it was only considered the grades of the students. With the fall there was only one class of Biology where this has been implemented. Planning for grouping involved considering grades and then student interactions with each of the projects. Students were ranked academically by grades first and then the day of the first project students were placed into focus groups. Students were placed into focus groups based off of students interests within the questions asked and what needed to be focused on in the project. Please see appendix A for survey questions to determine focus groups. For example,

students who interacted with questions focusing on resources the students were placed into the resource focus groups based off of their interactions with the questions. From the focus groups, the students were selected randomly from the groups for the following day for their project groups. The focus of academics were based on splitting the classes based off of grades. Students placed in the high group were the top 25 percent of the class, the middle was the middle 50 percent of the class, and the low was the lowest 25 percent of the class. This was so the the split would be evenly conveyed across and could be applied to the classes the following spring as well.

In the fall, students in the first project were placed into grouping randomly based off of the focus groups set in the first day of the project. In each group there was one student in the higher end of the class, two from the middle group of the class, and one from the lower end of the class all based off of academic performance in the class; however, the students were chosen at random for the grouping activity front the focus groups used on the first day. There was one group, due to class sizing that had one from each section to total out at three rather than four in the group, which means one middle student was missing from the group. The issue with this type of grouping is that students did not always complete their portion of the work and by random grouping these students seemed to be placed together. Those groups where students with a low work ethic seemed to work at a much slower pace with the teacher check ins and supports being used much more frequently, mostly to encourage the groups to work harder and more as a unit. Students in certain groups who had high grades but low work ethic were in correlation with missing grades but high test grades. The grading in the class focused a majority on testing and not the daily work performed in class.

Group roles were also assigned where in each group there would be a leader, project manager, treasurer, and participation monitor. The group leader was there to maintain the idea of what the end goal was and to make sure time was being managed efficiently, the project manager was in charge of resources and materials, the treasurer was in charge of maintaining group funds, and the participation monitor was there to make sure everyone in the group did something during the class period. The roles were designed to ensure everyone had a part within the group and would be able to work efficiently; unfortunately, by the students being able to pick their roles rather than being assigned it did not work as well as thought out.

The grouping showed that students who picked their own roles picked what would be convenient for them. In a lot of groups, the low students picked participation monitors. This was because they could avoid the work and challenge presented through the project. The group leader should have been targeted as the high student in each group but most groups had it taken over by a middle level student. There was one group where the group leader was the high student. This group showed that having the high student there, this student could lead the groups through the project more efficiently by tasking out the problems and addressing the questions being asked in the group. The other roles were taken on by the high and middle students were the project manager and treasurer. These roles were still significant but it was mixed well between who was left in the group and the results were mixed. The high students who ended up a treasurer resulted in those students being bored and easily distracted in the class by other things going on. Those students not being challenged in class resulted in other groups being distracted because the students were wondering around after completing their part. The middle student who ended up as treasurers were different as the pace was a little slower and the tasks presented to those students were more challenging. The high level students who ended up as the project manager did well in

those roles as they were the ones responsible for the final product model. These students were able to construct the model but there were frustrations with the model becoming messy as edits went on.

The second grouping plan incorporated in more of a focus with academics still and levels of interaction between students. The interactions were based off how students previously worked together through labs, other groups, and small in class projects. Focusing on if students worked efficiently, together as a group, and how they did as an individual. A majority of the students in the fall did not always complete their work or the work was not being turned in. This impacted the students abilities placed into groups. The students students were still ranked by the percentages for academic results but as the groups were being made missing work was looked at as well as the amount of absences or notes taken by the teacher that mentioned students behaviors in class like wandering or causing others to be off task. Even with this all considered, a lot of the work fell back to one or two students in the groups. The students when placed in the groups, some took over because they wanted the project to look a certain way or because no one else was helping when it came to the project.

The second project grouping was addressed differently as students did not get to select their roles within the group and the groups were not chosen at random. The groups did maintain similar roles within the second project and the students were still able to pick their own roles within the project, so this aspect was left unchanged. There was no longer a need for a treasurer however and this was changed to researcher. This role, researcher, was in charge of keeping up with a list of resources used in the process of creating the model that came offline or that the groups used that were not their own thoughts and ideas. This did include pictures and images students used in the project.

The roles made an impact still as students did change a little bit from the last project. The students who took on harder roles seemed to step back from the harder roles into easier ones. This enforced some of those who had easier roles, like the low level students, to take on more challenging roles. This round a lot of the low level students actually ended up taking on the task as the researcher. The students struggled keeping up with those resources used as students were pulling from multiple sites and forgetting where they were exactly they were getting the information. The change from project one to project two is that groups were taken from random grouping selections to being picked by who completed work and who could work well together. This change allowed a few groups to be able to perform better in the process; whereas, some still did not have the major changes. There were rewards in place as well to encourage students in both projects to work together. The groups that worked together and everyone did their part, everyone in the group would receive a ticket for the classroom reward system where students receive rewards on Friday. Students would work harder to receive the prize and this worked better for some students over others depending who was motivated to receive the prize.

Overall, the effectiveness of the grouping did not work well. The groups were not coherent and the students did not work well together. This discouraged students wanting to work with others as the trust was broken by those who did not do their part. The students who did no work did not receive the grade they wanted on the project which was their punishment for not working but not all of them seemed to care. The students were more focused on the distractions around them and what was going on with others than themselves.

Reflection and Revisions

Grouping was not a strength in the classroom in the fall. The students were placed randomly or with little cohesion to how grouping would work. This is how grouping had been

addressed all semester and it had seemed to work in portions but for the bigger and more serious projects the students seemed to not have the ability to take on what was needed to be successful. The roles have the concepts of being able to work but not every role worked in the way desired. The role of participation monitor, for example, was a role that lead to be very unsuccessful. The student who took on this role did little or no help within the actual project and only made sure others did the work. This role was designed to make sure everyone was doing part but by not laying that out clearly in the beginning that fell apart in the process.

Addressing changes in the grouping would allow for the groups to run more efficiently and effectively. The first major change is the considerations to be made within the grouping and the grouping dynamics. Having learners from each group level of learning, high, middle and low, is important as they each will have the chance to learn from each other (Webb, Baxter, & Thompson, 1997). These groups needed to consider more than learning levels on the other hand. Considering aspects like how students interact, their ability, and work ethic became other important key in placing the students within the groups. Student interaction becomes important as students who do not get along do not need to be placed in the same groups where each refuses to do work. The ability also ties in here as it brings in what makes them valuable to the group. Some students have strengths in arts where other have strengths in presentation and design and by tying in both abilities the students are more likely to contribute to the grouping and project overall. The last part being work ethic needs to come into play as students who do not complete their work do not need to end up in the same group or having the same roles across the classroom. This all came into play when planning the project in the second semester. It still started off with being academic based of the percentages in class but then rolled into the notes the teacher had taken on the students. Missing work was also considered but in the second

semester there was a lot less missing work, with the exception of a few students. Those students were noted and not placed into groups together. Those students were also monitored more in the project as well to make sure they were doing their part.

The second major change was in the roles. One role, the participation monitor, needed to be absorbed by all other roles within the group. The participation monitor will be addressed in the daily exit tickets the students will be completing, for the example of the exit ticket please see appendix B. This way students can be honest and open about what each person did and the roles could be more specific and task oriented. The change for the last role became the role of the designer. Students in each class have an artistic ability to where each group could have someone that could take on this role without the other roles being impacted. This gave each group someone who was directly responsible for the end product model and keeping up with that model. The other roles kept their same tasks.

The last major issue in grouping was one that was difficult to address. Attendance has been an issue in the groups due to students being absent, out of school suspensions, and in school suspensions. This made some of the groups lack members during some of the essential time needed to work on the project. This lead to an extension on the time to work on the project as needed. In the first semester there were supplemental worksheets provided for those who missed for a variety of the reasons; but, there were a few different ways that this was addressed in the change for the second semester. The first was that for students who were placed in the in school suspension, there were requests to pull those students as allowed for the project just for the block needed. If there was no ability to be able to pull the students then there were parts of the project provided for the students to be able to work through as well and bring back with the next day to discuss. If students were absent and able to alert their groups beforehand those students were

given the same luxury of being able to work on a part at home and bring back the next day. The major issue was addressing those who have been suspended for extended amounts of time; whereas, there was no chance for them to be able to complete the project at school with others. These students were given the chance to do the project at home and complete the model through a technology based format if they were able or on paper if not. Those students did miss the grouping aspects of the project was the major downside. There is not possible way to avoid the school suspensions when it comes to addressing the major issues. Fortunately, most of the out of school suspensions would only occur for a day or so.

Second Implementation

For the second semester, grouping was addressed differently. There was a higher criteria to why students were placed in their specific groups. The criteria still focused on academics but now also included student interaction, ability, and work ethic. This was so students who did not always complete their work would end up in the same groups. The second time around, grouping started on early in the semester. Watching how students interacted became important as this would influence how the students were placed by the time the project came around. Also, by monitoring students in the spring as well, their ability was easily tracked. There was the issue of work ethic when thinking about ability on the one hand. Some students were able to perform academically but had a very poor work ethic which moved their grouping statistics around. For example, one student who was in the higher percentage of the class lost his chance to be placed as a group leader as he would not complete daily work. His role became more focused on things that interested him like being the designer. He was placed in a group that he could still answer questions but his main goal was not leading the group through the project. The students who typically did well on test achieving proficient or advanced but, lost a majority of their work or

did not complete or turn in work were not placed in the higher group either. The focus shifted from the high group being test focused but also their other grades were majorly considered. The students now who were high were not only high achieving academically but high achieving in their daily work.

The group sizes also changed based on the size of the classes. The honors class had 19 students enrolled. In the honors class for each project there were three groups containing four students and two groups containing three students. The four groups were kept on having a high, two middles, and a low student in each. The groups of three had a high, a middle, and a low and one role was absorbed by the group by choice. In the regular Biology class there were five groups of four and one group of five. The groups of four kept the regular context whereas the group of five had to have some of the roles split and addressed. It was targeted that the group of five would consist on either an extra high or middle student by not wanting to place two low students in a group together.

When creating the groups for the first project the students were first ranked academically based off of test grades, amount of work completed and turned in, and other classes enrolled in and the grades in those classes. The last portion was not considered as heavily as a majority of each class contained freshman who do not have a lot of previous academic performance. From there it was noted about the students ability. Focusing on the students strengths like leadership, art and creativity, ability to work with technology, and other focus areas the students were noted for the strongest and second strongest ability. Finally, by working through who could and could not work together the students were placed into the groups for the first project and evaluated there on how they did. Every day the group did the exit ticket check in. These check ins through the exit ticket allowed students to say where their groups were, how each person in the group

was doing, and how they would have rated themselves and why. The students were honest here and the honors students specifically were not afraid to say who was not doing their work. This allowed for the teacher to come back and do the needed check in with those students the following day. This encouraged each person to do their part and the students to do their work as needed to be completed. This seemed to be a better fit for the grouping so the methodology was kept for the second project.

The roles were adjusted as well where each group still included a leader, project manager, and treasurer. The project manager role was absorbed to take on the designer role. With the shift from having a participation monitor to the designer there was now someone directly in charge of the model and designing the model. This also allowed for each person to be held accountable for describing what they did in the project that day. This became a part of a daily check in with the groups as they would check off what they did and write a few sentences each day and then also describe what each teammate was doing as well. This was for the accountability measure that each person was doing something in the project each day as well as provide an attendance record for each person in the group. This was completed each day at the very end through the exit ticket. The students were able to provide honest feedback through the exit ticket and also state where they were in the project each day.

Summary

The changes made in the project from the first semester to the second worked incredibly well. Students knew what their roles were in each group and were also placed into groups they could work well in. Students may not have been overly happy about their groups at first but by the end of the project the students were happy with what the end product came to be and what each person was able to do. Grouping becomes important as it teaches each student that they

need to be able to rely on each other as the project goes along but also makes each student aware of their responsibility to making sure they do not only complete their part but they also ensure that their teammates complete their parts. Table 2 provides a direct summary of each step of the process. The comparisons of fall to spring in Table 2 are simplified in a direct manor that allows for the revision changes to be seen which are supported below by the following research.

Grouping is very important in science. It allows for students to be able to work and depend on each other in the progress of the class. Heterogeneous grouping benefits all levels of students within grouping. The lower level students are getting the chance to work with the higher level students and the academic resources those higher level students have. These students have more of a chance to grow from learning from their higher level peers than those who are on the same level. The benefits come more of the medium level students than the highest level. The medium level students allow the lower level students to ask and interact with the material where the high level students are directing straight on how to do the project or task at hand without truly explaining the why behind the content. There is also the disconnect from the highest level to the low level students. The students on the high levels have more of the academic knowledge and lack the ability to break it down and explain it to the low level because of the lacking content knowledge through vocabulary or context of the material the lower level students are missing. There is also the disconnect of ability between the two, the higher level students have more access to the content through being able to understand what is going on easier through the resources provided to them in the past; whereas, the low level students are lacking these skills to work with the content. (Webb, Baxter, & Thompson, 1997).

High level students also benefit from the heterogeneous grouping. In this grouping setting these students are able to take on more of a teacher based role for the grouping. The high level

Table 2: Summary of Grouping Implementation

Fall Semester	Revisions	Spring Semester
Planned grouping by academic performance.	Student interactions and abilities were not very well considered.	Students were grouped based on academic performance, social performance, and abilities.
Students were given roles within the project but allowed to select their own roles.	Roles need to be taken on by academic ability of students, low, middle, or high and by the students specific skill sets.	Students were placed into groups and given their assigned roles based off of the abilities of academics, performance, and skills.
Students roles were not well defined or well supported for the grouping process.	Students roles were changed to be better suited for each project and the description of the roles were changed.	Students were assigned roles with specific tasks and students were given a daily accountability of each performance.

students are able to explain the content themselves which means the students have to know the content at hand and how to use the content. The medium level students work equally as good but that is less supported. The medium level students have been shown to participate more within the grouping dynamics. (Webb, Baxter, & Thompson, 1997).

Grouping also comes with the rules and sizes placed on grouping. This project allowed for grouping of four students per group and the students were mixed in the groups based on ability and other important aspects. The students benefit from working with one another through the process of being able to show their strengths and skills while being unafraid to ask questions. The students are given roles within the group that promotes the active learning goal that is desired from the teacher. Students roles in grouping focuses on the "function or responsibility within the learning groups" (Saleh, el. al., 2007, p. 316). Students, from learning in the first project in the fall semester, need to be assigned their roles within the grouping. This is an efficient way to make sure students are doing their part of the group work within the group project, specifically focusing on the middle level students in the grouping. Assigning roles within grouping also provides the focus that each person is doing their correct part. Students being able to pick their roles may leave out the high level learner from taking on the teacher or leader role within the group or the middle level students being able to participate in the way desired. The roles play a key part in the groups collaboration as one is not stepping over another's defined duties. (Saleh, et. al., 2007).

The other important aspect of grouping is the ground rules for the group being established. This was established as expectations within each of the projects each semester. Expectations are going to change as time goes on due to the new grouping dynamics as well as the changes in behaviors of each students but the ground basis of expectations do stay the same.

These expectations need to be laid out for students to understand what is expected of them in the long run of the projects and what is expected of them in the given roles. Each role needs to have a specific set of tasks laid out for the day and making sure the roles are sufficient for being able to do the work is highly important. That is why the adjust from losing the participation monitor was important. The group absorbing that role and becoming responsible as a whole for it as a whole gave back another person in a chance to show a new valuable role within the grouping dynamics. (Saleh, et. al., 2007).

The ground rules of group interactions also impact behavior which influences how the groups do and the time taken for the projects. By laying out simple steps like decisions need to be discussed before putting it on the final product allows students to have the group interactions where everyone will be involved. This also ties back into the questioning aspect as students are now using the ground rules to be able to use the higher level thinking skills to create questions within the groups and this overall benefits the learning progress of each student. Overall, having the ground rules and the grouping roles benefitted students in being able to interact within the projects which promotes learning of the content addressed. These collaborations being more structured allows students to gain more comfort in their work and also within their abilities in the classroom. (Saleh, et. al., 2007).

Fiero (2012), points out that in students futures that they will be working within the mixed ability groups. These groups rely on the mixed ability of the different people within the group but these skills need to be developed while still in school. In the groups, the students were using the ideas of metacognitive circles, where students are receiving feedback from peers to make decisions and influence ideas for the project. These students are having the discourse needed within the groups to improve what ideas each have for the project. These circles allow for

the feedback from each other rather than from the instructor. These circles allow students to think about their decisions within the process. (Fiero, 2012).

A major issue is that each student in the class is expected to show growth in the classroom. Students come in at different levels and by using the group work there is the chance for growth in each level. The group work allows for students to grow in their own ways and share knowledge between each other. As each student takes on different assigned roles within the group they are able to focus on what they are good at but still be able to ask questions and learn as there is progress in the project. The high level students take on the role of a leader or teacher within the groups, where the middle and low level students take on a very interactive role when creating the different aspects of the group like the model or are able to focus more understanding the content. The changes in the grouping structure of this project benefitted learners across the group and gave the teacher more of a chance to interact with the groups and receive honest feedback of what was going on during the projects.

Modeling

There are the multiple different types of models that can be used within the classroom. Focusing on two broad types, the teacher models and the student models, there are some major differences. The teacher can model different aspects within the classroom from how to work out a problem to creating a poster in class, both of which are addressed in these projects. The student model also has some major ranges but for these projects the students were completing the model focused on showing and displaying problems the students were solving, how they solved them, their decisions, and the end product. The students were also going to have to rationalize their decisions within the end of the model. The results below discuss the changes made within the

classroom for the students model to show their decisions and rationale throughout the project. The changes made were to allow student to be more successful.

First Implementation

As there are multiple different types of models, students need to have the ability to familiarize themselves with the construction of the different types of models and being able to make changes to the models as needed. For the first project, there were different models planned out to be used. The first project had a plan of showing the template model of what needed to be included and areas to include things without giving major details of the project away. The students were given the resources for the first project on the second full day after roles had been decided and determined and the questions were complete. This allowed students for them to see what they were working with right off and to plan out how they were going to set up the final product model. By providing the template model, seen in figure 4.1 below, and the resources off was in hopes to encourage students to focusing on the composition of the model. Students also had the grading rubric to show what they were going to be graded on when it came to the project. To also encourage students to be working on the model there were two group check ins implemented. The teacher meet with the groups to discuss progress, check in on the model, and to give back feedback on the projects. These days were planned on day three and the day seven to check on the students. The days did have to be moved in the result to day four and day eight as some groups had not yet started the model on day three and the amount of students missing on day seven.

The plan was for students to make poster based models of their ideas. The students needed to have different colored paper, markers, access to technology, and a few other resources to complete the project. The issue with this is a lot of students did not pre plan out their model

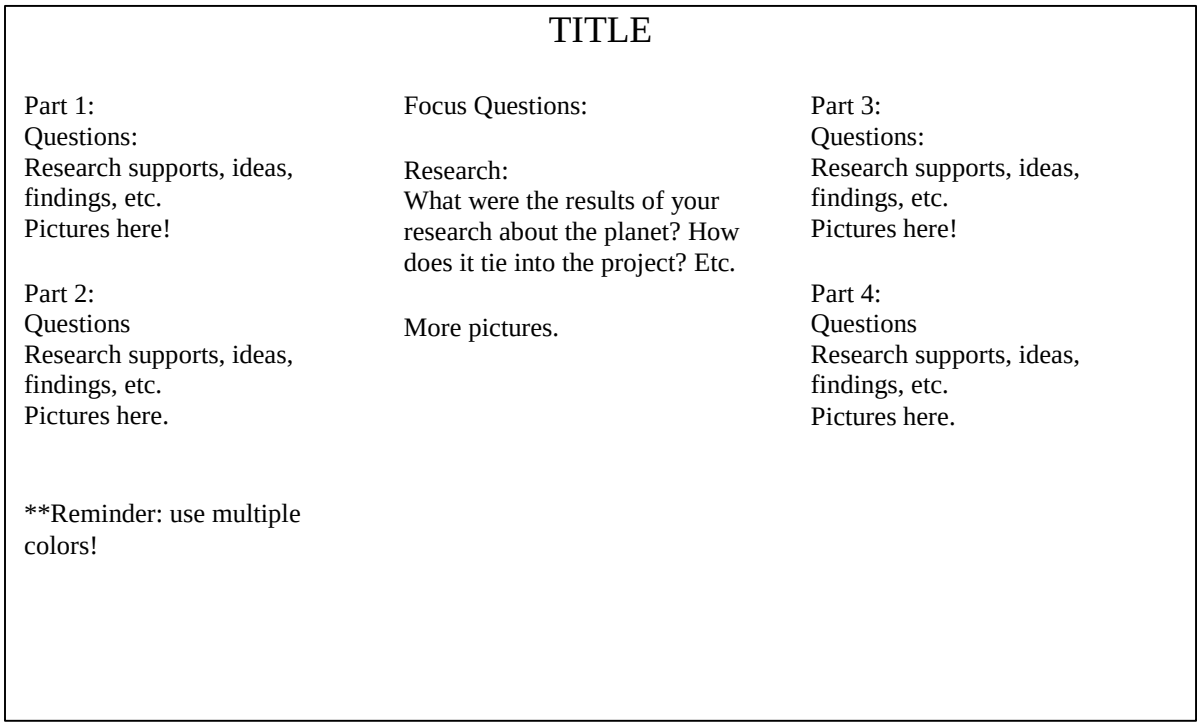

Figure 4.1: Modeling through product

and based it off of the template model entirely. This lead to issues of running out of space and making the idea of what it should look like before construction. The rough draft was not encouraged here as it should have been as the model is supposed to have the ability to change when the rough draft should have the ability to change until the ideas and representations are correct.

In the fall on project one there were issues with being able to build a model on poster board representing their different ideas and aspects of the project that were important. Students were given a template as a model to begin with so each group could have a model to build off of if they needed ideas. The template for this model is shown below as Figure 4.1. This model just gave the students an idea of how to set up their own model on the poster board but as students were making the models there became the issue of being able to change the models. Some of the

students did not take in account that changes would need to be made to the models as they progressed. For example, one area they may have over filled with information and needed to be able to take some things out as needed but after making the model there was this lack of ability to be able to do so or that the changes became messy and sloppy due to the amount of changes needing to be made. This was actually an issue seen a lot within the final projects. Students were going up the sides of the posters or drawing arrows to connect their ideas to the correct resources and it started to look not uniform. It was hard to read and determine what parts were where and what was supposed to go together.

When going from project one to project two in the fall changes were made so the model could be built without the mess, so building the model electronically was one of the best routes possible for the time being. Students were able to build their entire model through google sides and turn it into a presentation based model like the first project. The greatly allowed for creativity as well as the changes were able to be tracked through google. All google documents tracks changes and there is the chance to go back to an older version of the product. This allowed students to go back as needed if there were major mistakes made. Each student was also able to work on the model at once due to it being shared between them. This became the inspiration to the changes that were made from fall semester to the spring semester.

The plan for the second project was to move to the technology based project. The idea of being able to use the google chrome books would allow for students to see what changes were being made throughout the project. This also gave the chance for those who were in the in school suspension or at home to make contact to those in class through the google hangouts that accompanies the document. The downside is that conversation had to be monitored by the teacher to make sure students were on task and working. Those who used this and were able to

do that received part of the class reward of a ticket for the drawing. This also still used the idea of being able to make changes as the time goes on but also be able to revert back to the original changes if needed. This was actually a perk for one group of students where one students drive became corrupted and the current version of their project was lost. The students were able to go back to the project from the day before and make the changes to get themselves caught up.

The second project went a lot smoother in class as the students were able to edit the project without the stress of leaving the old details behind or having to make the messy cover up. Students were also able to converse as groups about the project in more way than one, through out loud conversations or through the message portion on the paper. This also allowed for the project to have direct flow of what the students were trying to say. For example, as seen in figure 4.2, one of the project had this direct flow: introduction, focus questions, the parts laid out with questions and answers students created, and the final conclusions of the project. Others used portions of the project to tie back in the focus question in the model in multiple places. The downside is that some students still did not fully do their portion of their work. Others in the group made up for their portion but then left those students to be on their own during the presentations. Those students were not fully prepared or invested in the project which showed in their presentations. The model for the second time showed improvements through the first as there was no longer the mess and there was the flow of the model.

Reflection and Revisions

Reflecting from the very first project, there were changes that needed to be made before being able to conduct the second project. The first was the overall task of the model. The first model ended up being messy for some students and there was the major lack in cohesion and flow for the model. The model in some aspects made little to no sense when it was put together

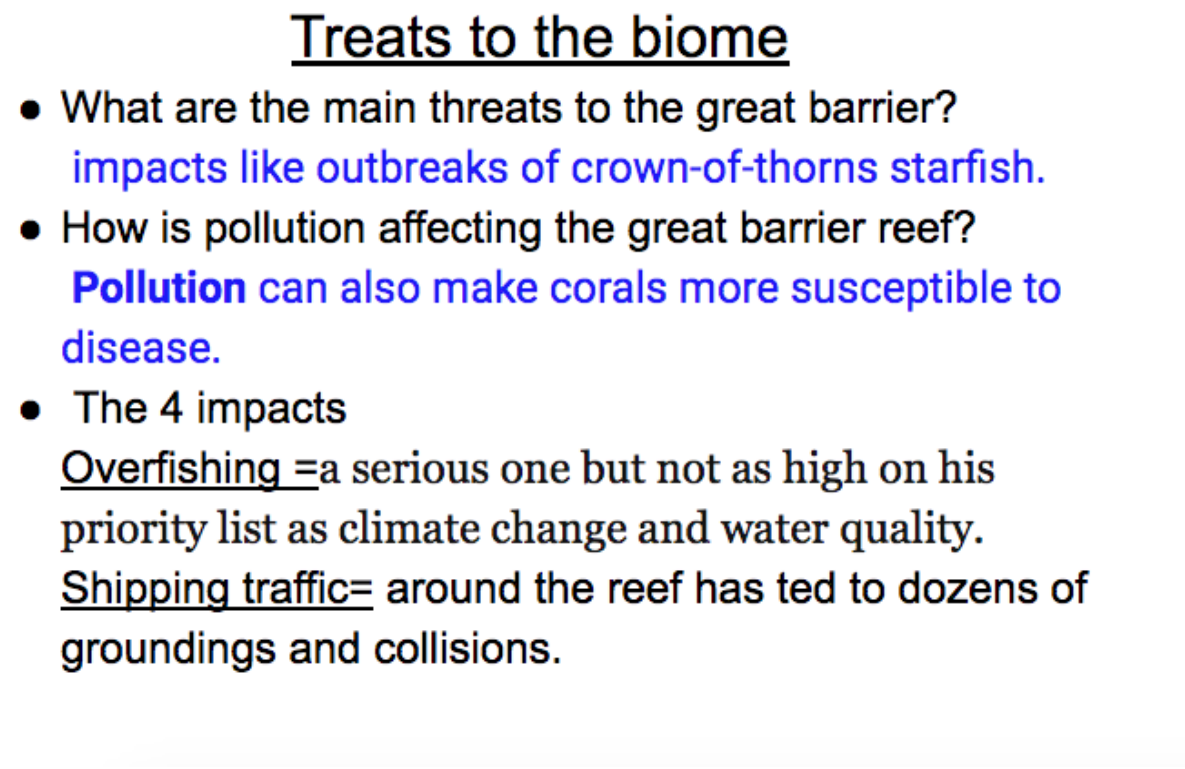

Figure 4.2: Project Sample Fall

and presented. The change of being able to have the second model be presented through technology allowed students to track changes and be able to make less of a mess as they were going through the process of making the model. This way there could be a layout and process of being able to make it.

The change here from fall to spring, however, is both model concepts were kept but altered in different ways. The examples and outlines were still given to the students but now the students incorporated the idea of making rough drafts of their models before completing the final one. On the first project, the end product being produced on the poster was kept but students were given alternative methods to produce the model. Students were given notecards, different types of paper, and practice posters to work with on the project. This allowed for students to create an idea of what the model was supposed to look like in their heads and make changes before putting it all in one official place. The second project being technology based allowed for students to still design and work through the modeling process. Every change could still be tracked and watched and the students still were able to come out in the end with a solid model.

The other major change was incorporating an actual checklist when completing the rough drafts and the final model. The checklist was based off of the final rubric and allowed for the groups to self-check themselves as they made the model. This was to ensure that students did not miss anything essential as they were building the model. This was done in hopes the students would be able to fully invest in the model making process and be honest if something came up missing in the process of making the model. The rubrics can be hard to break down and chunk out for what is actually needed. The rubrics can also be overwhelming as it included everything for the project that is to be graded in one area. By taking out the model portion and converting it

into a checklist the students should have more success in seeing what needs to be done and what does not need to be done.

Second Implementations

From fall to spring, and keeping the idea that models are all different and can be represented differently, the idea of keeping the poster model but with some edits was a change. The students were still provided with the model basics from diagram one. The students having the ability to practice making the model made a major change. This was incorporated now into the rubric that a rough draft needed to be drawn out, described, and approved by the teacher before making the final model. This allowed students to make multiple rough drafts and for the teacher to be able to provide feedback on each of the drafts. Most of the groups took advantage of being able to build the multiple rough drafts and for these rough drafts to have the teacher feedback on them to ensure that the models were built effectively. The teacher feedback allowed the students to focus on the problems, like if something was done incorrectly, if they maybe needed to add in or take out some information, or change the questions they were using on the project. In a few of the projects, the second implementations showed students that mistakes were okay to make. One of the rough drafts presented by a group showed the incorrect break down of their budget. The feedback here allowed students to see that the budget was wrong and go back and make the changes needed before making the final model of their ideas for the project. Another group forgot to have the pictures for the project and describe where they would go on the model so making the edits before that happened allowed each group to see where changes could be made. The models presented at the end of the second project looked cleaner and were more efficient than they were in the fall. The projects looked better and students took the model

provided by the teacher as a model rather than something that they have to do. Each model was different and included the multiple colors desired.

Students at first did not understand that the project needed the concept of flow, where each task easily flowed into another without having to move around and look everywhere on the posters. A lot of the students wanted to split up the different parts of the projects but not in efficient ways. The students who were able to split it up at first showed research, then decisions, final budget expenses, and final thoughts in order. Others who could not find that ended up with research, then summarizing each section and decisions with updates on budget, and final thoughts on the project. Some of the students also needed to focus on taking down the amount of information on their rough drafts. The students overwhelmed themselves but through feedback they were able to cut out what was not as important.

Another major change was going through the process of using a checklist based off of the grading rubric in the process of making the model. This allowed for students to see if they were completing the project to the rubrics satisfaction which checked for all parts of the model being there and making sure all material was covered. This also tied back into the new grouping roles as one person was now the designer of the project. Students were still getting their needed materials for the project through checking them out which made the teacher aware of the students groups progress and being able to check the groups off as they progressed through the project. This allowed for the teacher to be more aware and active in the process of students creating their model. Students were missing, as stated above, the idea of flow in the model a lot. This checklist allowed for there to be specific feedback focusing on that portion. There was a portion of a glow, what looked really good, and a grow, what needed to be worked on. For a majority of the class the grow was the flow of the model and suggestions on how they could fix

it. Maybe by giving details of how to lay it out or referencing back to the outline model provided by the teacher the teacher focused feedback specific on the groups that allowed the models to end up better. Another area in the modeling the checklists provided help on were the mechanics of the model. Students were forgetting aspects like including five pictures, seven to eight different colors, and showing the created sections. This was pointed out through the rubric and the feedback on each rough draft. Students were given reminders about the expectations which increased their chances for success.

The models ended up showing students exactly what their end thoughts were in the project. The students were also able to take the model and describe it out through the presentations. The models from there were able to show students ideas, research, and thoughts later on in the school year as well. For example, as a review over viruses as we were touching up on previous standards the students were able to create posters of the represented viruses, describe those viruses and draw pictures, the take and apply the characteristics of life to the viruses. The change from where students were at the beginning of the class to the current progress showed growth in being able to construct models. Please look at

Through the examples at the end of the second project, which were created through google slides, students thought process are displayed. The Figure 4.2 displays samples from the fall semester; whereas, the second shows samples from the spring. The sample from the fall is from the group with two English Langue Learners, as there may be some spelling errors. In here, although it is two separate portions of the projects, there are some differences in the models. The students in the fall focused on multiple questions on slides, did not offer the needed citations, and did not full mention the four issues listed in the slide fully. The students lacked the fully needed flow of the model and supports listed. Where in the spring, as seen in Figure 4.3, the students are

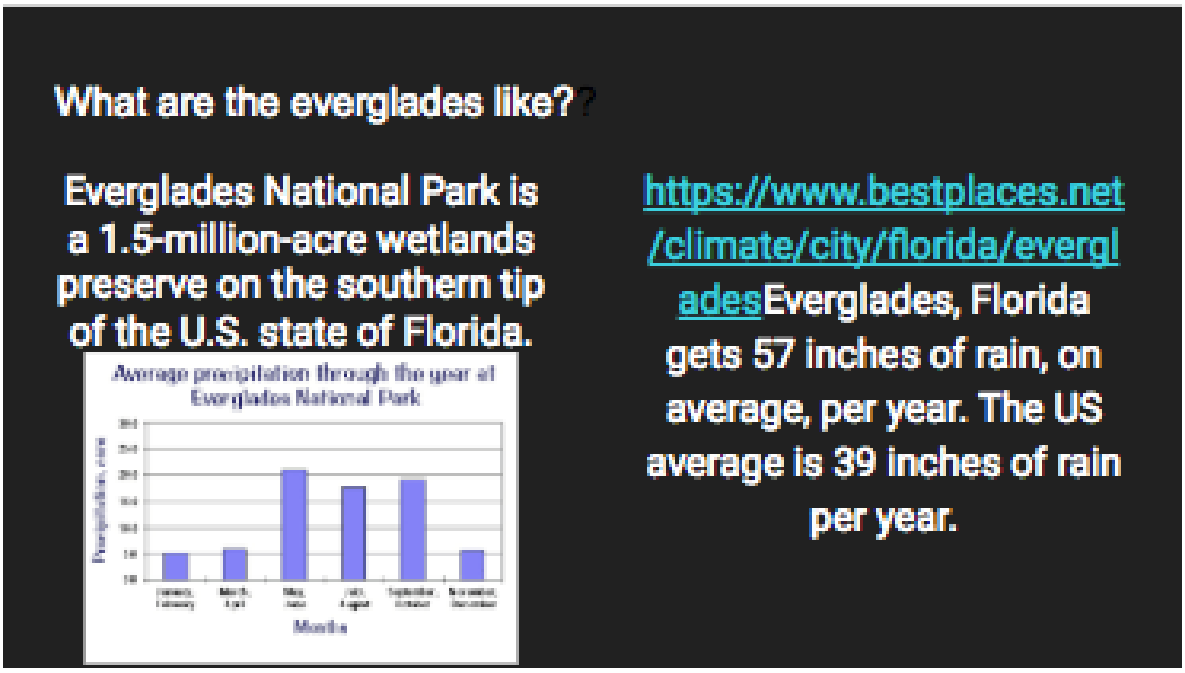

Figure 4.3: Project Sample Spring

focusing on one question asked in the project. The question in figure 4.3 the students are focusing on is "What are the everglades like?". The students are providing a chart which was cited and information cited as well, then discussed on that information a little. The question was easily described in the process of the PowerPoint even if there was a little information missing from the slide.

Summary

Modeling allows for students to express their thoughts and ideas of presented materials in class. Modeling is more than what students produce and the idea that there are different types of models are very important. The idea of teacher modeling is an importance. But what do those two things have to do with each other? Students need to be shown how to create models in the concept of making one. If you do not know how to make one then how will you be able to make one? The teacher here comes into play with what needs to be shown to the students for them to

be able to make a model. If there is too much detail in the teacher model the students could become overwhelmed or if the teacher provides a model could students be lacking the creativity to make theirs different. Table 3 represents the changes in the classroom during the year to allow for the projects to be processed and represented in an efficient way. These changes, represented in Table 3, represents modeling in a different way and the research below supports this. A few ideas used in the project for modeling were the product model, the process model skill model, and the personal samples. The product model shows the students what the end desire or goal for them to create is. This does not have as much detail as some of the other models but can show the idea of how to set up the model they are creating. The process model was very vital in both of the projects as the process model leads the students through the process of using their thoughts and the processes needed to create the model. This was influenced in creating the changes from the first project to the second project as well as the changes from the fall to the spring. Another important model is the skills based model. This ideas was implemented in the spring when the students were shown to create rough drafts of their models to make the needed changes within the models. The students need to be able to go back and check their progress within the model as well as be able to edit it. That relies on the teacher showing students how to do that. The last model used in the projects was the personal samples. This allows the students to see the process the teacher uses to create the model. This was done on a day by day basis through the chunking of the project. The benefit of using the multiple different kinds of models allows for students to use what is best for them in the creation of the design process. It allows the students to work on and develop their skills of creating models (Catapano, 2013). Please see Table 3 for a summary of the implementations, changes, and second implementations results.

Table 3: Summary of Modeling Implementations.

Fall Implementation	Revisions	Spring Implementation
Project model one was made on poster. Students were given a product model to follow and allowed to start with minimal checkups.	Poster model was kept for the project. Students projects were not neat. Students were enforced to make rough drafts and practice using the materials. Students were also given a checklist to account for missing materials.	Students made a better end poster project. The students did two or more rough drafts before starting on the poster.
Project model two was created via PowerPoint. Students were given task per day to slow down them making the model. The models ended up better than the first.	Students were given the same starting materials as above. Checklist, ways to create rough drafts, and practice were incorporated.	Students change allowed for students to see the missing details on each slide and for the overall model to improve.

Modeling in these projects were for students to be more engaged in the process of creating their models. This increases student discourse and discussion as the students are talking through the process of creating the model in the project and allows for students to take the needed roles in the groups to be able to make the models. This is not an area of strength for the students at the start but it is always an area students can improve upon. This gives an alternative method to teaching students beyond giving the lectures on the content and guided worksheets for the students to be able to work through. According to Jackson, Dukerich, & Hestenes (2008), "Modeling method is successful with students who have not traditionally done well" in the science content area before (p. 17). Modeling gives the chance for students to be able to improve on their own with the teacher there to guide them through the process (Jackson, Dukerich, & Hestenes, 2008).

Students need to engage in models in science as the models in science can be vastly different from models in other classes. Models in science can do multiple things like show the processes of different systems, represent ideas and analogies, and many other things. Students should be able to develop and use the models in science to use them for the for a multitude of reasons like, "to make predictions, formulate questions, design and conduct investigations, explain phenomena, and communicate and justify ideas" to create the bigger picture of what is going on in the scientific community. The major issue that needs to be addressed within the scientific modeling on the other hand is for students to be able to reflect on their modeling practices (Forbes, et. al,, 2015).

Considering what each of the model is to represent, the students here are specifically creating the models to communicate and explain their ideas. Students were instructed to answer their own questions when it came to creating the model but there were issues in this relaying to

the model itself. The changes made for students to be able to track their ideas through rough drafts and through the electronic models allowed for them to go back and be able to check themselves. Forbes used the supports of the reflective questions, which was incorporated into the daily reflection of the projects, to have students go further in the the model and make sure they are correctly representing their ideas. The students are engaging in the important scientific practices that allows them to further their knowledge and advance their thinking within the science fields. (Forbes, et. al., 2015).

Modeling in science is harder to incorporate in the later years as the elementary and middle school years do no rely on science as much and even when there is a focus in science the modeling was lacking. In higher grades, modeling becomes much more incorporated but the practices are not instilled there. Modeling is there to support natural phenomena and generate predictions but with students getting use to the skills needed to work with models the students are not completely ready to construct a model that describes what they are attempting to represent. This does incorporate the process of being able to evaluate and revise the models as needed. The skills of being able to evaluate their own models and revise edits to properly say what they are trying to say allows for students to create the more accurate models and designs. (Schwarz, et. al., 2009).

Modeling practices support the process of students to be able to understand key concepts within science but also how the scientific knowledge is created and processed through. The process of modeling allows students to explore key scientific core ideas. This deepens their understanding within the scientific world and allows the student to become more engaged with the content at hand. The focus of these projects overall were for students to collaborate within the construction of the model to end up with a product that equally represented all of their ideas.

The idea of roles within grouping and being able to understand those roles also impacts the way students interact within the groups. This shows the way they are able to understand the scientific practices, with a focus on the modeling. The groups that did not work as well together or have the defined roles in the first project had models that were lacking in the needed content to properly display their thoughts and ideas (Schwarz, et. al., 2009).

Modeling has some specific practices that need to be incorporated when coming to produce and edit the models. According to Quigley et. al. (2017), there are seven practices that students need to be able to incorporate in their modeling practices which are, "(1) identifying the anchoring phenomena to be modeled, (2) constructing a model, (3) testing the model, (4) evaluating a model, (5) comparing the model against other ideas, (6) revising the model, and (7) using the model to predict or explain phenomena" (p. 3). Using all of these practices allows for students to create an effective and thorough model (Quigley, et. al, 2017).

Focusing on two key parts, evaluating the model and revising the model, is a skill students need to focus on. The students need the ability to come back and revise the models to make sure they show the accurate representation of what the student is trying to display as thing changes through a process. The students can create a model but the editing of the model was a major issue. The results from making the changes and adding in the rough drafts seemed to benefit the students better as there was never an official design being worked on until it was the final product. The students showed major gains with the changes in the modeling practices implemented

Questioning and Discourse

In the classroom, students always have questions. The questions may or may not relate back to the content at hand but by being able to take and shape these questions the teacher has the ability to encourage students taking responsibility for their own thoughts and processes. The

questioning also leads into discourse and discussions in the classroom. Below, in the projects the teacher guides students through being able to take their own questions, answer them, and discuss their answers in the process. This tied back into grouping as students were creating and aiming to answer the questions in the group setting. Below is the discussion on the students ability to create questions and answer them and the teachers implemented changes for the students to have higher order questions and more in depth discourse on the content.

First Implementation

The plan for the students to be able to ask and create the guiding questions throughout the project was based off of the questions students were asking in class so far and by others being able to answer them. The questions students were asking in class were content focused and ranged from high questions to low level questions. The students were not practicing their question practices in other areas though as it was assumed by the questions they had asked in class they would be able to formulate questions. However, by being put on the spot the students seemed not to do as well as expected. It may have also tied into the fact that they were creating the questions as a group. There was also the planned discussion implemented in being able to create the questions. There was an entire class period to creating the questions, as well as getting adjusted to the groups and picking their roles, on the first go around of the project and the students needed to fully in depth. The students were planned to be placed at tables to allow the discussion to become easier, where all four members of the group were sat the the table facing into each other to allow for the discussions to become easier. The groups were also strategically placed around the rooms so that the discussions could come at ease to the groups without interrupting the others and the students were able to find their tables when they came in as a note card with their name was placed on the back of the chair.

In the first project in the fall, students were tasked with creating five overall guiding or focus questions to lead them through the process of the project. Each questions was to focus on a specific area within the content of the project from the budget to the materials needed to what is the overall task. The teacher provided a focus question for the project of, “could humans survive as needed if we needed to restart and colonize on a new planet?”, on the very first day of the project and this was the driving question on the project. On the first day within their groups the students created the focus questions needing to be answered by the end of the project. These questions were lower order questions at first with questions like, “What is in our budget to spend?” or “What is needed for human survival on the planet?”, and while these questions were not completely lower order thinking questions there was the chance to address more within the questions as the project progressed and as a teacher there was missed opportunity. The students were not asked to go more into their questions other than by having teacher feedback and in the fall with some of the groups abilities the questions were on target with where students were within the class. The missed opportunity was not fully addressed in the second project either but was a closer target to what the teacher wanted to see for the end goal.

In the class in the fall there were some students who were English as a Second Language learners. These students were provided assistance by the ESL, English as a Second Language, teacher. She came in and by having and formulating a discussion with those who had a lower English speaking proficiency, allowed those students to have a voice in the group. These students were able to help with guiding questions as she was able to communicate with them in effective ways. One, who was paired with another student that spoke his language, needed these supports as he spoke little English. His questions with his group though were more thought provoking as the ESL teacher provided the needed supports to both students.

In the second project the students were taken from asking five overall guiding questions to asking two to three questions per section in the project. These questions being asked were similar to the ones at first but could be broken down and were not as wide as the first ones. The second project was ecology based so some of the questions were, “What kind of different populations would I see in this environment?”, “How do those populations interact within that environment?”, and “Do humans have major impacts on the environment?” and these questions were still not on target with being higher order but this allowed students to break down into smaller questions. These questions were able to be answered easier by the students and the groups.

Previously in the class, students were encouraged to ask questions throughout notes, labs, and activities as needed. Then there was the chance for other students to try and answer these questions. The ticketing reward system here encouraged students to speak out about their curiosities as long as it was content related and those who answered back gained in confidence if they were able to answer correctly and if not were still rewarded for making the effort to answer. The questions created here were actually shared out the next day as a class to see how each thought their questions were and to try and make them more challenging if needed, which it was. The hard part was that without supports students could not make the questions more challenging. For example, using the question of, “do humans have major impacts on the environment?”, the students could not change the question to focus on how the humans impacted the environment and possible changes that could be implemented to possibly fix the impacts like deforestation. The students questions scratched the surface of the issue but did not touch on the full issue at hand.

All of the questions above lead to discourse and discussions within the groups. Students being able to ask questions are important but being able to discuss and attempt to answer their own question leads to the scientific process that supports the STEM bases of engineering and science designs. This ties back into grouping and where the grouping in the first two projects were not as successful as it could have been. The learners being a high, a middle, a middle, and a low in each allows for each person to ask questions and try to answer them. The low student could be asking the lower order questions a middle student or high student could answer. The middle students asking questions can lead to the higher student being able to answer. Any one asking the questions, the low, the middles, or the high, can lead to the research process and group discussions needed to answer questions. The students are working together and talking through the problems; unfortunately, this result was not seen in the fall implementation due to the failure of the grouping. The grouping did not encourage discourse and it seemed to put a lot of weight on certain students doing tasks and leaving others behind who did not do the tasks or the groups as a whole did not work well together. Making the adjustments in grouping, listed above, and questioning practices below were hopeful to encourage the students discourse through the projects.

Another issue within the groups and the discourse in the groups is the students being able to discuss their opinions and options without there being tension within the group or someone not being heard. From project one to project two there were the adjustments in roles as well as the daily checklist being added in to see how each group was doing. This was an idea to help and make sure every student had been rightfully heard within the project but this still did not seem to be a solution to work as some were just overly quiet or unsure what to do. Discourse is an important part of group work within the projects as the groups decisions need to be shown rather

than just one person's decisions. Group discussions are important in the process of working together. Some groups had this as a strength whereas others had this a weakness. Disagreements are a part of working with groups but is it worth some students not being heard within the group? Or those students not being able to speak up comfortably?

Reflection and Revisions

To address the major problems seen in the fall there were some adjustments made to the process of teaching questioning and then in the projects overall. The changes being made here incorporated students starting to take on creating questions earlier on in class for the second semester. One of the major changes in teacher questioning came to teaching students the different types of questions that could be asked or depth of questions that could be asked in class. Providing resources like Webb's Depth of Knowledge, where there are levels of words to create questions, allows students to create more in depth questions by using the keywords or categories provided there. In the spring, as a teacher, using the words or levels of questioning through Webb's Depth of Knowledge and other resources the teacher increased the rigor of the questioning in the classroom. This encouraged students to begin to ask the more in depth questions as well without knowing that the questions were more exploratory and using the higher levels of thinking. Also, when the projects came around the students were provided with a list of word by level to use. A select few of the honors students had seen the list before through another class and were accustomed to seeing these words split into the different levels for thinking. By providing this resource to the students the students were able to add in more details and levels to their thinking.

Another area of fixing the discourse issues were allowing students to have more open discussions in class and assigning roles when speaking needs to occur. When in class, before the

project occurred, students need to gain the ability to speak comfortably with their peers present. This was a growing skill that would start with resources like think-pair-shares in class where students would be given a question to try and answer, pair with the person next to them, then share out what the two came up with in class. This allowed for students to be able to share both sides of the discussions and be open to talking in the class. Another way this was addressed before the project was through students being called out more on a random basis to answer things from the bell ringer to questions in class as well as the exit tickets. This was to allow them to become more comfortable answering and if they were not comfortable answering then they were allowed to ask someone they were comfortable with around them for help. This shows the interdependence of asking others for help. Going back to the more open discussions aspect, there were small groupings being held on a daily basis where the groups were given a task. Within each group students needed to show that they talked through the task with their group then displayed it on the daily task, like a poster or a discussion sheet. For example, when making a class poster on a virus, each person was assigned specific questions to answer and share out to their group. That person became more responsible for that task and this translated over into the projects.

When the grouping was addressed in the project each person had a reason to speak out and then showing on the daily accountability sheet there was something that they did that day, like influencing the design of a part of the poster, speaking of something that they found within the research, help in creation of the questions, or something of that aspect. This translated from students being comfortable to do this aspect from earlier smaller tasks within the class.

Second Implementations

For the second semester, there were the incorporation of new resources and practicing making questions earlier on in the semester before the project began. In the use of using a resource like Webb's also calls for more practice when using the material. Students earlier in the progress of the course were taught the skills of being able to create questions by taking vocabulary words and making questions to help remember those words. This is also an area where there was a visible split in skills from one class to another in the spring semester. Some of the students within the honors course were already practicing the skill of creating questions and having civil discussions in another class that benefits them in the preparation of college readiness. The students in Biology were not yet on this skill level so each class had to be addressed a little differently in the preparation of creating questions. The honors students were producing the higher level questions already and due to that those skills were able to grow more; whereas, the Biology students were not that far along. The Biology students had to focus on aspects of what are the different types of questions, what needs to be addressed and what does not need to be addressed, and what specifically would benefit being asked. With honors, those students were targeted into creating more rigorous questions to be used and focusing on the questions all being on a higher level in the Webb's Depth of Knowledge frame. By the time the project came around the students were creating questions of a little more rigor but the issue arise creating them together in a group and deciding what was best for the group.

The results from this is where students were able to create questions in the projects there were beneficial to leading the groups through them that now focused more than just general questions. The students did have a mix of the higher level questions and the lower level questions as well which was improvement over all of the lower level questions. For example, in

the ecology based project students were asking questions like, “what are the cause and effects of human impact on ecosystems and biodiversity?”, where the students were aiming to do more than ask what the original impact was. This was a vast improvement using the resources provided to them in the class and being able to practice. This also lead to an increase in the discussion of the question. Focusing on the question above the students lead into research and discussions on topics like deforestation in the tropical rainforests or over fishing in the oceans depending on their ecosystems. The students discussed, with the deforestation, how the environments are being destroyed and how the populations of different animals are losing their homes which could lead to extinction. There is still room for growth but the students were attempting to answer their own questions in a focused manor.

Summary

The change from the semesters showed that students were able to create their own questions attempt to answer those questions. Focusing on adding in Webb’s Depth of Knowledge, there are four levels to be focused on. The four levels are from the lowest to the highest, “recall and reproduction, skills and concepts, short-term strategic thinking, and extended thinking” (Webb's Depth of Knowledge Guide, p. 5, 2009). By using words from each level students were able to create more of the higher level thinking needed for the questioning skills as well as the lower level questions. However, using just the words alone are not enough to address the question but the question also needs to be applied. Through the application and answering the questions students are now thinking on higher levels. All of the levels are essential to building off of one another as well. The students need to be able to recall the information to be able to take it and interpret it the information. The change in students questions from fall to spring allowed for students to be able to do more. For example, looking at figure 4.2 and 4.3, there is a

distance difference in the abilities of the students from fall to spring. The students in the images listed above were addressing two different aspect of project two but the students questions were different. In the fall semester, figure 4.2, students were asking a lot of questions that could be answered simply. In figure 4.3, the students asked a broad question that could have been answered over a few slides and address so many other aspects of the project. By using Webb's, it was the first step in students being able to complete the object of questioning and answering their own questions. (Webb's Depth of Knowledge Guide, 2009). The results of the changes in the implementations can be seen in Table 4 below, where it shows the changes from fall to spring. The student data supports these changes in Table 4 as the process of questioning changes in the groups represented by Figure 4.4 and 4.5.

Looking back at project one, the students created specific questions to get them through the project. The second was adapted to have students create questions each day for support as well but overall questions were still created. Looking below at Figure 4.4 and Figure 4.5, you can see a comparison of the fall to the spring. Figure 4.4 came from a regular group of students in the fall where Figure 4.5 comes from the honors class in the spring. In the fall the questions were simple and could be worked through easier and did not require the amount of thinking needed to get the students through the project. In the spring, the questions want students to go deeper and engage in the research needed for the project. The students could then use the research to support their answers as they go through. Please see the images below at the end of this section.

Before students can create their own questions and be able to discuss those questions they need to be taught how to create their higher order questions. Most questions start off as lower level questions focusing on main ideas, vocabulary, and basic understanding of the content. The formation of questions and building upon the skill of making questions leads to higher cognition

Table 4: Summary of Questioning and Discourse Implementation

First Implementation	Revisions	Second Implementation
Students lacked the higher order question making abilities. Students did not practice making questions in class.	Students from the beginning of the year added in skills to practice making questions through vocabulary and other areas.	Students questions changed from asking more in depth questions or asking questions that could be investigated.
Students were not provided with ample resources to make needed higher order questions.	Students were provided with a list of words through Webb's Depth of Knowledge to allow the questioning skills to expand.	Students questions ranged from easy to the higher order and provided supports of the model.

Guiding Questions: You need 5 total questions to lead your way through the project. The end result will be a built model that will be based off of these guiding questions.

Example:	What is my end product need to look like?
Question 1:	How much money is needed to get all the needed food?
Question 2:	What resources would be the easiest to keep up?
Question 3:	What are the needed extra resources to have?

Figure 4.4: Fall Guiding Questions Examples

Guiding Questions: You need 5 total questions to lead your way through the project. The end result will be a built model that will be based off of these guiding questions.	
Example:	What is my end product need to look like?
Question 1:	What portion of money can be spent to allow for maximum amount of food to be produced?
Question 2:	What other resources are needed to supply the food?
Question 3:	How can we use those resources to support the colony?

Figure 4.5: Spring Guiding Questions Examples

and refines problem solving skills. Chin points out that the skill of being able to create their questions is a reflective practice within the learning processes. The higher order questioning process is not a place students are comfortable in as this is not usually something they are accustomed to doing. (Chin & Brown, 2010).

Students are needing to create questions that focus on being knowledge based. Using resources like Bloom's taxonomy and Webb's Depth of Knowledge allow students to use basis words to build their questions off of. Students using these resources were able to create questions that Chin, 2010, referred to as wonderment questions. These questions were questions to explain or fix issues that the students had with the content (Chin & Brown, 2010). According to Bevins & Price (2016), Inquiry needs to be based off of three concepts, "scientific knowledge, evidence-generating and handling practices, and psychological energy" which allows students to have all hand in on the science practices.

A second major part is that the students were creating questions as a group. The teacher is now there for supports and to help direct the students, the students were able to directly create the questions for each of the projects. Focusing on the discourse of the groups, there were ground rules established in each of the groups and depending within the groups roles established. Werder (2016) established similar ground rules to help avoid the possible arguments that could be seen within the groups. This leads into more discourse within the groups and the ability to impact the individuals within the learning process as well. The individual learners now have the chance to grow on their own. The students are sharing a purpose, which can be seen in the process of solving the problems of the project, and a process, of creating questions within a group that can be shown when creating the model (Werder, et. al., 2016).

Lustick (2010) focuses on the importance of the focus questions that the teacher provides. The teacher needs to be able to formulate the focus question to guide those through the project or focus of the day. According to Lustick, "an effective focus questions can bring a relevant immediacy to classroom proceedings" and make the content more accessible (p. 497, 2010). The students will be more driven to work with the content if there is a reason why to work behind it. The focus questions also provides support for students own inquiry skills and the students to be able to work through a question to solve it. Focus questions are important to be implemented every day in class and then by increasing the rigor of the questions students gain the important skills to answer the questions as the questions get harder. However, the focus questions need to have relevance to students lives and need to meet the needs of the students. This increases students chances of being able to work with the science content as in the future if they work with science the focus questions will be the driving force behind the research or task they are committing too. (Lustick, 2010).

The focus questions also have possibility to encourage students to work on inquiry themselves. The focus question benefits the teacher in multiple ways as it can provide a possible structure for the lesson plan or unit plan and then provides the supports of the classroom. Lustick mentions that there is the best fit through the discourse that comes with using the questioning practices in the classroom. Using the focus questions does not require a teacher to take a lot of extra steps to implement and the results the students get out of it are worth it. Some teachers are sing questioning practices currently within their practice but the focus questions gives the driving force behind the lessons. In science, "a focus question would allow for students to experience authentic scientific inquiry about a relevant" scientific issue or phenomena that they would not come across normally. Students investing in the inquiry process allows them to learn valuable skills that can lead to the better questioning skills and discourse skills needed within the classroom to be successful (Lustick, 2010).

Overall, questioning and discourse worked better after the implemented changes were put into place. Also supporting these changes outside of the project allowed for the students to truly grow their skills. Questioning and discourse are important skills for the students to have and to work on in their secondary years before moving on to post-secondary careers and schooling. Being able to find a driving force behind what you are doing, the question or why, and then supporting it by having the needed conversations allows there to be the support behind doing what needs to be done.

Presentations

Presentations are important for students to be able to convey their thoughts, ideas, and discussions from the assigned projects. The students need to be able to speak in front of one another without the fear of being told that they were wrong or by being able to take the criticism

to fix the problems presented. Presentations, focusing on group presentations, allow students to have one another to convey the ideas of the groups. The skills present themselves in the future as jobs rely on their workers in certain aspects to present information when needed or be able to relay it as needed. The students here were able to convey their ideas and easily describe them. This was a strength presented in the classroom for a majority of the students and to strengthen the skill would allow students to be able to do more as needed.

First Implementation

In the fall, there were two types of presentations. It was planned originally for both projects to be presented as whole class but, the presentation for the second project changed. The first projects, the students were to take their posters and describe the posters in front of the class relaying their decisions as a group, the questions used to focus on in the project, and their end result from the collective research and the project. It was planned for each presentation to last approximately four to six minutes and cover all the essential information of the project. There were planned checks a couple days before the project to make sure each group was on track, which they were not.

The first set of presentations did go over better than expected though. As the models did not end up as desired, the students in each group could describe a section of the project for the most part and why the decisions were made in that degree. The models did not portray exactly what the students may have tried to say on the poster but the research presented, decisions made, and questions answered were all shown with support. In one group however, there was one student who was English as a Second Language learner where he did not present in the class presentation due to his low level of communication skills through speaking. Instead, he was asked to write about his group project for the presentation. He was able to convey through

writing his group's project and ideas well and describe them in detail. He did have assistance provided as needed and throughout the project from the ESL teacher as well as others in the class. The other students generally picked one main topic area of the project to describe it. This allowed each student to be more of an expert on that area like the focus groups from the very first day. The students paced themselves well, spoke clearly when presenting, and were respectful as the presentations went on. This was surprising as the presentations were expected to turn out like the models but all of the students communication skills were better than expected. Each student stayed within the target range for time as well.

This lead to the change in plans for project two. As the whole class presentations went over so well, the presentations shifted to small group presentations for the next part. Here with the presentations, students were targeting the project in groups of fours. Then the groups would split to present. Two students would present to the first round of five other groups and then they would switch out and listen to the other five groups as those presented. Each student was given a sheet to take notes on as they went around to listen to the presentations. These presentations were to last for ten minutes, which was extended past the original plan of four to six minutes, to allow students to be able to record notes on the projects.

The presentations for the second project also went well overall. The students were able to take the chrome books and present the information to each of the rotating groups and still had a partner to depend upon as needed. Each partner either took turns presenting the project overall or the students took turn slide by slide. A change though from project one to project two that allowed this to run smoothly is that students the day before presentations were given presentation practice sheets, appendix C, where each could determine their roles for presenting and pick their own presentation partners for the groups. By practicing the presentations, compared to the first

time, the students truly took on different roles each from low to high and were able to present the material needed. The one alteration was for the student who spoke little English and was not able to present in front of others, he was tasked when presenting to be able to provide supports. He stayed for the presentation but took over technology controls for the person presenting so he could still be an active part in the presentation process.

Reflection and Revisions

As stated above, the presentations went over well. There were a few minor changes made from fall to spring however. The first major change was completing a flip in the presentation styles. For the first presentation, it was still completed on poster board and each student needed to know each part. The first project in the spring was where the students did the rotation groups for the projects and each got to see in detail the posters that were created. The second project, being electronically based, was more efficient for allowing students to present to the class. This time students could be responsible for knowing their specific content within the slides but also needed to be able to answer any questions that the class had asked. The change in presentations were for the ease of the students and for students to become to the different type of presentations possible.

Students were also encouraged to work on the presentations before presenting each semester for each project. This was missed for the very first project in the fall but incorporated into the second which showed that students were able to do a little better with the presentations. This allowed for students to create a needed script of what needs to be discussed as well as allows students to become very familiar with the content being practiced. The practice included a little step by step walk through worksheet with questions to help guide students through the presentation process. This allowed students time to practice, choose who was going to work with

what, and who was going to work with who. Being able to practice allowed students to be prepared when it came to the real presentations in the days allowing and for there to be less of a stutter when presenting. This also showed students what to expect when it came to time constraints as each project called for students to be able to present within a specific time frame and not go over or under the frame of time given.

Another idea of change were for students to be able to provide their own feedback within the presentations for the other presenters, Appendix D shows this resource. This was planned to be practiced for the very first presentation in the spring and then incorporated for the second project. Since the way the presentations were switched this allowed for the practice to go over in the small group setting and for the students to grade the presentations in groups. From there, the students would be presenting to the class as a whole and the graders would now be individual. The teacher was there for support for both and to filter out any hurtful or mean comments. Students did not put their personal names on the rubrics for feedback but each student had to turn it in individually to ensure that the feedback would be beneficial for the presenters. This allowed for the presentations to be taken a step up and for students to begin to learn to reflect on their practices both as a group and individually.

Second Implementations

When the presentations were flipped for the projects, the students seemed to do better after the alterations. The students were now presenting the posters first in the small group settings. By encouraging first of all the practice students felt prepared to give the presentations. The students were given the practice sheet to complete and fill out to turn back into the teacher to check of being prepared to present as well as determine who would present first or take the first task. Each group did seem to take on a different approach in the spring. Certain groups would

focus on switching between the two presenters which allowed students to be responsible for the entire poster and then have the other presenter there for support. This worked as the support student was able to go back and cover anything missed by accident and still allowed for students to take notes on the project. Each presentation stayed on target for time for the most part which overall was impressive, as both presenters influenced the time and one or both were keeping track of time.

The notes taken for this project now focused on being able to provide feedback. The students focused on a glow, or what went well with the presentation, and a grow, or an area of improvement for the project. There was also a grading rubric to be checked off as the presentations went on to make sure each task was completed and everything was incorporated into the slides, like the amount of pictures, focus questions being asked and answered, different colors and ideas being incorporated for creativity. This was the practice round of this so the teacher was able to help students create their feedback by giving the model examples of how to write a glow and a grow, which is where the students struggled the most. Each wanted to glow to be something similar to, “the model looked nice” or “I like the use of colors”, where when the teacher presented the model it focused on things like, “you made eye contact with different people during the presentation and described the issues in the presentation well through answering the focus questions”. Once that model was provided the students were able to focus their glow and grows to be more beneficial to the groups though not as beneficial as it could be.

When the second presentations came around the students were using the PowerPoint to present on the smartboard. Students in practice used the chrome books and the openness of the room to practice these presentations the day before presenting. Each person in the group needed to present on the project in one way or another and the groups needed to have the flow of moving

from one presenter to the next. The presentations were within the time frame, as the teacher would provide a thumbs up when at the minimum and warnings if the groups were close to going over. The projects also had all of the key elements, like slide minimum reached, number of pictures, required, and the creativity aspect. Some students completely shifted the and made their own with the presentations by including things to make the class laugh and to keep the attention of others, like puns or pictures with jokes. The students presentations were achieved the target of providing information on the researched and completed project.

This also incorporated the full run of providing feedback individually. The model of how to provide feedback was presented again before the presentations started. The students were still able to grade the presentation through the checklist and then able to provide where each group did well, the glow, and one area for improvement in the groups. The feedback, though not the greatest, could be complied up for each group to review the next day for a self-check of their own. This allowed for students to reflect back and see how they thought the presentations went. This pointed out to somewhere they may have spoken to much or presented content that could have been confusing and needed more clarification. This also pointed out to those who may have not faced forward to present, spoken softly in the presentations, or other skills that needed to be worked on in the presentations. This allows students to practice the skills a little more and better themselves for the presentations that will occur in the future.

Summary

Presentations and the ability to discuss findings are very important skills for the students to have. Being able to discuss findings from research and the choices made shows a lot of skills and ideas the students are using within the project. The project focusing on the end product being the presentation, the skills the students possessed were surprising. The students were able to

effectively say what their choices were and why they made those choices through the research. The downside of this for part of the study were the end product models. Addressed earlier, it was pointed out that the models were messy and did not show what the students thought and researched in an effective way. The students possessed the skills to be able to talk through it more than create it from scratch. The change in the presentations starting with the poster going to technology based and then in the spring being poster based then technology based but the change in presentations types allowed students to grow from small group presentations to whole class presentations. Table 5 represents the minor changes made in the progression of the presentations which now supported by the research below. The presentations changes, represented in table 5, allowed for the minor changes to be made to better the progression of student learning.

Why do students need to do presentations? A lot of support through the project or problem based learning has supports of students conducting their own research, leading themselves through the learning process, and then presenting their results to the teacher. There is the option to create presentation materials, or the models, by both hand and through technology. Students need to be familiar with both types of models and be able to present both types of models. With the rising generation being accustomed to technology, the technology based created presentations and models should come easier. Students feel comfortable with using the necessary technology to create the needed parts of the documents at hand but the end product did not turn out as planned for a list of the students. The other side of this is that students were still able to discuss their decisions within the small group presentations and through the questioning of whole class presentations. (Ezquerra, et. al., 2014).

Table 5: Summary of Presentation Implementations

First Implementation	Revisions	Second Implementation
Presentations went from whole class to small group.	Switch the type of presentations to allow for practice before making a large presentation.	Presentations went from small group to whole class. Students were less intimidated by the size of the class when presenting.
Students were encouraged to practice the presentations.	Students added in the practice to allow for students to be familiar with content and practice what needs to be said.	Students presentations went smoother and students felt at ease to present in the classroom.
Students did not provide feedback on each other's projects but took notes.	Students were given a reflection sheet to be completed on each project.	Students were able to provide areas where students did well and areas that needed improvement.

For the teacher here, focusing on the presentation skills helps students in other classes currently being taken as it shows students that being able to speak in front of other is okay and through the future as a lot of college based or professions require the collaborative group work for different assignments and then the showcase of that group work. Students have a higher motivation as well to do work through problem based learning. This does not have direct correlation through doing the research aspect and model creation with the presentation aspect but the skill was still worked on in this class. Teachers using these skills allow for there to be a benefit for the students. (Siew, Amir, & Lu Chong, 2015).

Presentation skills allow students to do more than just communicate with others. Students gain confidence and knowledge by doing project based learning and then being able to present after the project. These skills translate to the future if the students were to work in groups and be able to present within the groups. The ability to be able to practice as groups was also a skill that was vital to the students abilities as it gave them the chance to pick out the details they needed to focus on, the time frame for the presentations, and be able to focus on the content.

Research

The ability to be able to perform research and apply it to project is a skill students need to be able to convey. As the skill is a little different across contents, for example in English it would be used to make an argumentative essay where in science it could be used to present information on an important topic, the skill of being able to find valuable and reliable research is important. Students need to learn on sites that can depend on when doing research, like peer-reviewed articles on google scholar, as well as the websites that should not be trusted, like Wikipedia as it can be changed by anyone on the world wide web. Research is an important skills that will be utilized in many ways in the students futures.

First Implementation

Another ability the students showed academic strength in was their capability to do academic research. There was a small presentation to remind students of how to find academic based sources over nonacademic sources like a science journal over Wikipedia. Each project required research in some way, shape, and form. The students needed to conduct the vast amounts of research, pick out what is important, and then use that information to construct their project.

In the first project, which focused on life on mars, the students needed to describe what the surface of mars was like and what it would be like living on the planet if needed. There was an example given in the fall which was planned to where the class watched a portion of The Martian and read sections of The Martian by Andy Weir and compared the information pulled from the movie and book to research they found through scientific websites and articles. This was incorporated early on in the project to allow students to see what kind of information was good and bad. It was also planned to give to the students the way the author himself did research on the planet for him to be able to write the book. Students were able to point out which research was more important and valuable for the first project. By using websites where information was pulled from scientists and was acclaimed to be valued, the students were providing research on the planet that was correct and efficient. One issue that had to be addressed is that some places, like Wikipedia, have the correct information for the project to be completed. The students questioned why they could not use that as a resource, so as a teacher it was shown that Wikipedia could be edited as needed to change based on opinion. This allowed students to see the viability of certain resources over others. The students here were given questions to answer and checklist

to make sure everything had been answered properly on the checklist. This was to make sure all essential made it to the project end product model.

For the second project, being based on Ecology, students were given an environment to research and describe in different ways and aspects. Students showed the information that was important and avoided using the unreliable resources when creating the project. Through using places like websites from the national park services to science articles the students were able to represent what the environment would be like. The students in this project were given questions to answers or areas that they needed to describe through a checklist. These questions focused on the research portion and did not tie directly back into the focus questions the students were to write for each section. The students were to write and shoe the focus questions to the teacher before being able to see the research questions in class which was a motivator to complete the focus questions to allow the students to move on in the project.

The down side to this however, is that some students had not yet created citations in their classes. With the collaboration from the English department, students were shown how to create the citations needed for these projects. One benefit that allowed each of the groups to succeed was that each group did use multiple websites to find their research. The students pulled a lot of their research from three to four sites for the first project. The second project was a little more vast but students were able to pull the needed research as they went on due to the chunking of the project. Students knew to create the citations as they went along in their project.

Reflection and Revisions

Overall, the students ability to complete research was on level with where they were in each grade level. Providing students with the research questions or the checklists allowed students to see from the very beginning what was needed to be done in the research. This had

actually been done in other projects before and shown the success in those projects and activities. Students knowing how to complete research allows for the students not not be dependent on the teacher to answer their questions in class and be able to take and find the needed information to answer their questions, with the idea that the evidence for the answer would be reliable.

The hard side was being able to produce the citations needed in each area. There was a person in each group responsible for keeping up with each place information was pulled from whether it be a picture or information used on the poster or PowerPoints. This allowed students to compile a list of resources used and from there each person in the group could make the citations. In collaboration with the English teachers, and most being freshman, the type of citation being used in the posters and PowerPoints were MLA style. All of the students had previously learned how to do MLA style citations in another class or were going to go through the process of creating a MLA style paper. By taking information from the English department, there was a day where the notes focused on being able to create the citations for each of the projects as it was important.

The change that was made from fall to spring was minimal. The change is that the project manager also needed to keep up with the list of resources being used as well. The students as a group needed to complete the research instead of individually so every resource could be accounted for. This also allowed that document to be shared across the group to where on the day the students began making the references page, everyone in the group would be able to contribute or the groups would work together to make the citations.

Second Implementations

With the minor change of adding another person responsible for the research, the students in the second semester still only needed a short amount of time to complete the research each

day. In the first project, it relied on the information on the surface of mars. The groups created the focus questions then presented those questions to the teacher. From there each person in the group was given the research question and checklist sheet that they were to be responsible for turning in as part of the project grade. The students each completed the sheet as a group and the information was shared out. Each group did it a little differently, some groups focused on assigning parts out for each person in the groups to answer and then coming back as a group with their answers or research, by taking on questions in groups of two then coming back to answer them to share out what was answered, or each questions being taken on by the whole group and shared out to pick what was essential or what was not essential. Each group had their own method that worked and kept everyone involved for the first project. This tied into being able to create citations as the groups each now had the sheet of recordings to create the citations and each person still needed to contribute.

In the second project, the results were similar. Each day, however, there were new research questions and checklists to be used as the ecology portion of the project was essential and based on research. This time however, the citations improved from feedback from the first project! By underlining and pointing out in detail where there were issues in citations students were able to take the practice from the first project and apply it to the second. The citations were not perfect but for the most part hit the target of supporting the research and overall the citation and research supported the target of research supporting modeling and questioning.

Summary

When this skill translated into the spring the students were able to perform in the same manor. It was a skill the students had acquired on in an earlier stage and show progression on in this class. Another major difference was seen here in the spring comparing honors to the Biology

class as well. The honors students already were building citations in the college preparatory class a majority had been taking. This is where those students were able to get a little ahead of the Biology class. Students showed a quicker mastery on the research and writing citations by using the skills shown in another class. Using the information from Table 6, research is important for the whole group to become a part of as well as allow for the students to be able to participate in being able to conduct academic research.

The hard part of tying in research is the inquiry aspect. For research to be effective, students need the ability to ask questions. This was an issue that the project had come across, students were not very good at creating their own questions but were good in doing the needed research on the project. When students were trying to create their own questions for the project, the questions lacked the higher order thinking process students needed but students were able to conduct research and figure out their problems through the project.

Being able to direct and teach students to be able to do research is a complex task. Research tying back into inquiry skills as it "facilitate[s] students' understanding of science concepts and expose them to process skills such as observing, measuring, classifying, testing, and predicting" where the skills lead to students being able to do more within the scientific community (Bernard, 2011, p. 52). Using inquiry here is important because it gives students a task to research rather than the content. For example, in the first project students were instructed to find out what would be necessary to sustain life on Mars. If the students were told to complete research about Mars, what exactly would they come up with? Would it be random facts about the planet or would it be just general information? By giving the exact task of what do we need to have to sustain life on Mars students now have a higher focus in the project and the students are able to conduct more refined research (Bernard, 2011).

Table 6: Summary of Research Implementation

First Implementation	Revisions	Second Implementation
One person responsible for research.	Change in roles to allow for another research role.	More accountability in researching and allowing for there to be the chance for multiple track records for research.
Students were reviewed with on places they could not use and how to create citations.	Reviews with English Teachers and checklist incorporation were enforced.	Students were graded on how they created their citations and used a checklist to make sure all parts for research were covered.

One area where research has been conducted before in a lot of schools and districts is in a science fair. Usually those types of projects provided the opportunity for students to show individuality but also struggle with the fact of how much detail goes into grading and judging the project. The nice part about using this project which was designed for the students, is it still did increase ownership of the project as well as increased interest. The work was chunked out for the students which increased the ownership. The students were easily able to navigate through the research portion of the task and they took ownership for what they found. This also increased their interest as it was a different task than they had completed before. The ability for students to complete the authentic research supports their ideas and tasks at hand they want to solve. The increases the ownership and interest in the project as it goes along as they are created something they started off with from a simple question or a simple task. (Bernard, 2011).

Secondary curriculum across the board does not always support research. There are generally tasks in types, like writing a research paper or conducting a science experiment for a science fair, that does require the research but in a lot of other areas that does not happen. Students are presented with content and then focused on working with that content. One of the major issues that was covered here were databases for students to use when conducting research. Students were provided with outlets more than google to use for researching. Students were also provided with resources on how to write citations. The students were guided away from using places like Wikipedia or the highlighted information below a google search link. Students were given the necessary resources to be successful. (Fessakis, Dimitracopoulou, & Komis, 2005).

Research within the classroom is becoming more important as it is a skill necessary for college or other post-secondary options. Students need to be able to sort through factual information and the nonfactual information to see what is right and what is not right. This comes

into play currently as there are a lot of scientific issues being addressed in both politics and the news. Students need to be able to sort through what is good information and the bad information so they can make the right informed decisions for themselves.

CHAPTER FIVE:

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and Recommendations

This study proved that using the methods from design based research are effective. The changes implemented in each design area proved to be fruitful for the students in more ways than present in the class. The benefit for the teacher is that the education in the classroom is what is best for the students and what practices work and do not work. Design based research utilizes the changes from one set of instruction to the next. Using design based research in the science classroom allowed students to explore more into the content as the projects were implemented through problem based learning. Problem based learning focuses on giving students a problem to task to solve. From project one to project two and the changes from fall implementation to spring implementation showed that combining the effects of problem based learning and the design based research students had the chance to grow in many areas and strengthen their skills in others.

Through design based research there were changes in grouping implemented from the first project to the second project and then from spring to fall. The changes allowed students to work more efficiently in groups and have designated roles within grouping. The ability to change the roles within grouping and assign those roles allowed students to gain comfort in their skills and abilities. This also allowed for a daily check in for students to summarize what they did within the group and what their group members were able to do. This held each member accountable. The changes from fall to spring showed that grouping went smoother and the students were able to produce more from these changes.

When making changes to modeling, it was more efficient to make the changes to benefit the students and not the end product models. The changes that were implemented for the students showed up in the model in the long run. The changes included things from increased model samples and types for the students to see, the ability for students to create rough drafts of the models, and for the students to be able to track their changes and processes through creating the models. This allowed students to feel more comfortable in the process of creating the model and relates to other changes made within the projects.

The changes made in the process of questioning was taking it from making a few questions to guide through the project to making questions for each part. With questioning, there was a practice that was being used in the classroom before this study but the change of adding in and using the focus questions allowed for students to shape and formulate their own questions. The focus question was a main target to be answered by either the end of the project or by the end of the day. By adding in extra supports, like giving students resources from Webb's Depth of Knowledge or Bloom's Taxonomy, the students were able to see that there are levels of questioning and create the higher order thinking questions needed to guide them through each project.

There were also a few parts that went well and did not need many changes, or major changes. Those areas the students are displayed skills that were on target for the level needed in class. The small changes made allowed students to grow in the skills needed, like changes in the way presentations occurred or things similar. Some classes were higher level than others and had extra resources available to them during this time as well. The honors class was able to do better research because a class a majority of them took focused on the college readiness skills needed to be successful.

Design based research made the teacher consider changes in the classroom that would benefit the students. The changes proved to be effective and efficient and in turn improved things like the classroom culture and classroom environment. Making changes is vital to the future as education is a constantly changing field and no class is alike. Being able to teach to the different learners by incorporating all the different aspects and making the needed changes in a classroom allows the classroom design to change from semester to semester and for the teacher to be accustomed to the needed changes to occur.

By evaluating my own teaching process and taking in the aspects of design based research proposed by Isidro (2009) who states that design based research is there to implement the need changes in the classroom, making the changes in grouping, modeling, and questioning allowed for my students to grow their skills over time in the science classroom. In the spring students were able to design effective models and ask questions based on higher levels of inquiry. Design based research benefits the students more in the classroom. The changes made in grouping by assigning roles and addressing the composition of groups allowed for students to have better groups and more details laid out to be able to be successful in their work (Fiero, 2012; Saleh, et. al., 2007; Webb, Baxter, & Thompson, 1997). By incorporating the checklist system, rough drafts, and practicing in the modeling portion allowed for students to create an end product model that they were able to defend and show their though processes (Catapano, 2013; Schwarz, et. al., 2009; Quigley, et. al, 2017). By providing students with the ability to see how questions are made, practice making their own, providing focus questions, and allowing needed materials to be used when making to questions furthered students skills in asking high order questions (Chin & Brown, 2010; Lustick, 2010; Werder, et. al., 2016). All of these changes implemented as a teacher also grew my skills and my knowledge of my students. This will be a

practice to continue to use in the classroom as time goes on, new students come in, and for all learners to be addressed.

Design based research brings in the major incorporation of exploration and redesign. According to Papavlasopoulou (2019), design based research, “is a hybrid method, as it is not a replacement of other methodologies but builds on the use of multiple procedures and methods from both design and research methodologies”, which means a mixture of both old and new method to be able to apply to the different types of learners within a classroom. One point from design based research is to have a “theoretical goal” for an end product compared to the regular method of formative assessments (Papavlasopoulou, 2019, p. 3). Changing the formative assessments form the old methods of multiple choice tests that are not applicable for all learners there is more of a chance for a student to experience success within the classroom. Student success can correlate to other issues within the classroom as well, like the student engagement. (Papavlasopoulou, 2019).

Using the ideas from Papavlasopoulou, incorporating the design based research allows for the implemented changes to be used in the classroom to better the instruction for the students in the class. This means making changes to teaching practices through notes, projects, concepts, assignments, and activities. By making the changes the educator is able to see what works best within the classroom for the students.

Ada (2018) points out that the teacher taking ownership of student learning leads to be the driving force for learning the content. The teacher is changing the practices within the room to better the education of the students by applying proven methods that have worked and supporting those ideas with fundamental research that proves the changes to be effective. The last major part is the teacher reflection of what worked after the implementations. If there were

aspects that worked in the process, those need to be kept with little to no changes. In the projects above, after the changes were made to the grouping, modeling, and questioning and discourse portions the students were able to easily reach the learning targets in a shorter amount of time with less distractions and struggles. The two portions that were kept the same allowed for the teacher to reflect and incorporate new portions to further the learning of the students. (Ada, 2018).

By using design based research a teacher can change major processes within my personal classroom. By incorporating design based research in these projects and reflecting on modeling and questioning practices, there was room for improvement. By incorporating studies to make the changes through design based research, it allowed the students to make a gain within the class, the content, and personal skills to be used in the future.

Challenges in the Study

In this study, there were challenges as a researcher and during the data collection process. The first challenge was through the process of classroom management. The struggle here interlines with the challenge of having a new principal as well as having a class of new freshman students in the school. A majority of the students in the fall did not know the full demands of high school; whereas, the students in the spring understood the demands and requirements of high school and their behaviors. Although the small management issues were difficult, the projects did progress but it did not progress in the ways fully intended.

Another major challenge in the study was creating and adapting materials for the tasks needing to be addressed in the project. All of the materials in the class were created by myself to be used. The challenge was finding materials that would address problem based learning that could be addressed through design based research as well as address the components of modeling

and questioning. This goes with the time it needs to plan and create these materials to be able to implement these needed materials in the correct time frame. The fall of 2018 the state of Tennessee adopted new science standards, so being able to create projects for the standards that I do not fully understand the demands and material needed was a challenge. The standards called for most of the same content to be covered but more in depth or added new content to be covered. The challenge was difficult but also a fun way to implement the new standards and change the learning process for the students.

Time for the implementation and data collection has also been a major restriction and challenge. A majority of the students are not on grade level in my classroom. This is shown in the classroom through the TNReady testing scores, or the state mandated tests, as well as the scores on the tests within the classroom. Time came in as a restraint in the classroom through this as there was the need to get students the material needed to be on grade level, cover the required content, and incorporate the needed practices and projects to further the students abilities. It is a hard challenge for the teacher to make the needed decisions in the classroom to do all of the needed tasks when students are only seen once a day for a ninety minute period.

Recommended Changes for the Study

There are a few recommended changes for this study. The first of the recommended changes will be to incorporate all standards and parts of the module into the studies. For the module of heredity, there is also the standards that cover the cell cycles, meiosis, and mutations. There is a missed opportunity for the students to create questions to guide them through the process of modeling mitosis, meiosis, and making the predicted changes for mutations. The students would have the opportunity to add more learning, questioning, and modeling for that module beyond creating the Punnett squares. There is also the incorporation of pedigrees here as

well, which could be sued to track generations in the Mars project if an option were incorporated. In the ecology module, there is the chance to add in the biogeochemical cycles for modeling and questioning as well. This ties into one of the standards already in the project relating to the human impact and carbon cycle correlations but there could be the chance to create a model of the cycle, and use questioning to answer the process of what could happen if one part were to be lacking or missing.

The second recommendation change will be in the grouping section. The students were placed in groups of four with one low student, two middle students, and one high student. This needs to be kept but there needs to be the change of incorporating and enforcing a seating charge. This could add in the interactions within the group if set up correctly of having shoulder partners and face partners. By adding this in the students could be assigned partners to work with throughout the project and someone to depend on throughout as well. This official assigned seating would also prevent any classroom management issues that could be at hand as the groups and students that have issues with each other, talk to each other, or distract each other would be placed in a way that would discourage and limit their interactions. These recommendations would allow for the projects to run smoother and for there to be a chance to collect more data as the projects go. This would also strengthen the students abilities in the areas of modeling and questioning as the students would have more practice.

Limitations to the Study

From the fall to spring there were limitations to the study that occurred. In the fall, there was a transition period for a new principal coming in and discipline being handled by the time both projects were being implemented. In the fall as well one project fell at the beginning of the testing window and a the project had to be extended a few class periods beyond planned. In the

spring, as the first project was ending there were some days the county had closed for snow and illness. This extended out the time of the project and there were adjustments made for the presentations as students were missing for the illnesses. The second project fell into a window where there was inclement weather due to flooding. The time of the project was cut back daily after the closing due to delays in opening the school.

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APPENDICES

Appendix A: Project One Survey Questions

The survey questions for the first project were as follows:

1. What resource would you find most important when colonizing a new colony?
    a. Land
    b. Water
    c. Resources: Crops
    d. Resources: Livestock
2. Why would that resources be the most important?
3. After your first selection, what would be the second most important resource?
    a. Land
    b. Water
    c. Resources: Crops
    d. Resources: Livestock
4. Why would that resource be the 2nd most important?
5. Are there any possible resources that are missing?
6. Describe how you would colonize a new land or area with an unlimited amount of resources.
7. What potential issues could be seen from having limited resources for the new colony?

Appendix B: Daily Participation Exit Tickets

Daily Exit Ticket, incorporated in the second implementations. The work rating is on a scale of 1 to 10. 10 is the highest rating where each members work is rated. 1 is the lowest, suggested to be used if the person did nothing. Absences were noted in that section if the student was absent.

Group Participation Exit Ticket				
Name of member:				
Work rating				
What did each person specifically do today?				

How is the current progress on the project?
How is your current progress as a group member/ what did you contribute today?

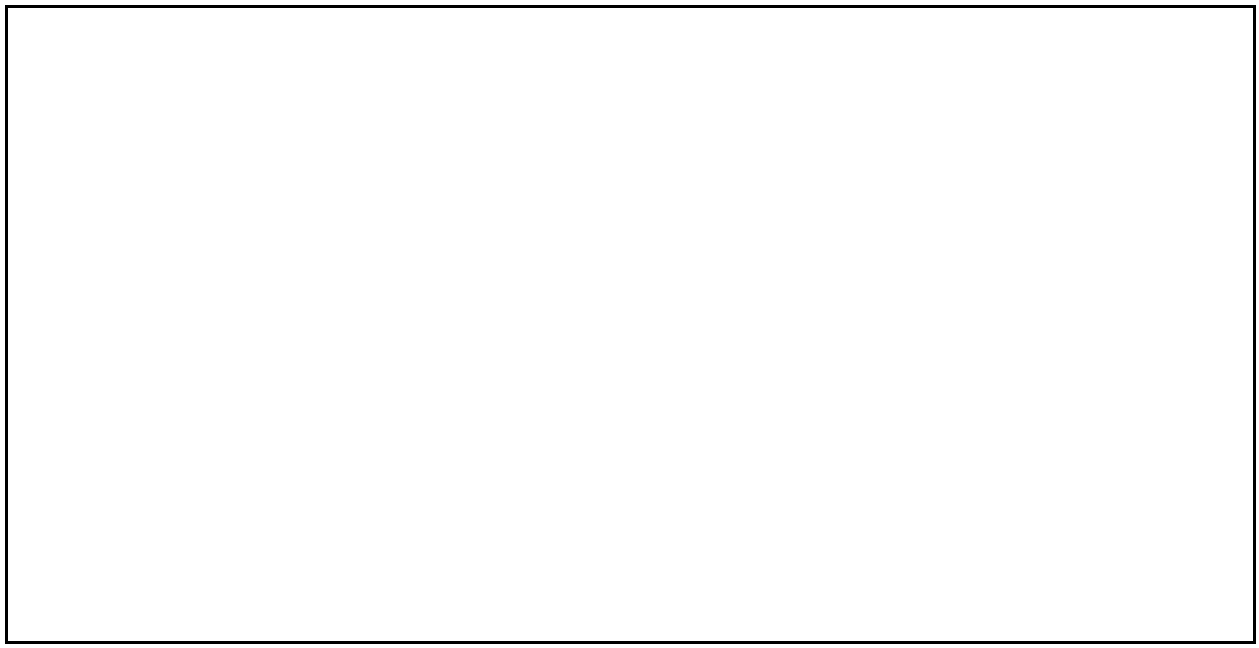
Is there any issue within the group I need to know about?

Appendix C: Presentation Practice Sheet

1. Who are the members of your group?
2. Who will be presenting what content? Will one person be presenting as a whole or will the members be taking turns? Will people be choosing slides to present? Give detailed descriptions.
3. Do a dry run of the presentation and time yourself. Record your first time here. Was this time in the range it needed to be? Where could you make adjustments to make it shorter or longer as needed?
4. Have your partner tally as many times there are awkward pauses, filler words such as uhm or okay, or where they could not hear you. Have them record where there were issues. How could you address changing these issues?
5. Enroll your needed changes and practice the presentation with these incorporated. Retime yourself and see how you did. Complete a self-evaluation of where you think you could improve.

Appendix D: Presentation Feedback Forms

Group Members:		
Checklist:	Grow:	Glow:
❑ No more than 5 items per slide ❑ 5 or more colors were incorporated into the project ❑ Each section listed questions and answers ❑ All content was covered, parts 1-5. ❑ There were at least ten pictures in the presentation.		
Notes:		



VITA

Alyson Pointer was born in Knoxville, TN, to the parents of Richard and Melissa Pointer. She is the youngest of three siblings: Jason and Clinton. She attended Oliver Springs Elementary School, Oliver Springs Middle School, and graduated from Oliver Springs High School. After graduation, she attended Tennessee Technological University where she obtained her Bachelor in Science in Secondary Education: Science. She did her internship for Residency at Midway High School under Shawn Hirt in Midway, Tennessee. After graduating Tennessee Technological University in the Spring of 2017, she accepted a job at Austin East Magnet High School teaching Biology. Alyson also started at the University of Tennessee in the Fall of 2019 for her graduate degree focusing on Science Technology, Engineering, and Math Education. She has plans to obtain her Doctorate degree in Science Education shortly after completing her Master's.