EVALUATING THE IMPACT OF COLLABORATION STRATEGIES ON ENGAGEMENT IN A VIRTUAL 7TH GRADE SCIENCE CLASSROOM

by

Jeanine Marie Piatz

A professional paper submitted in partial fulfillment

of the requirements for the degree

of

Master of Science

In

Science Education

MONTANA STATE UNIVERSITY

Bozeman, Montana

July 2022

TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND 1

Context of the Study 1
Focus Question 3

2. CONCEPTUAL FRAMEWORK 5

Learning Environment 5
Real World Relevance 5
Motivational Theories 6
Cooperative Learning 8

3. METHODOLOGY 10

Demographics 10
Treatment 11
Data Collection and Analysis Strategies 14

4. DATA AND ANALYSIS 16

Results 16

5. CLAIMS, EVIDENCE, REASONING 28

Claims From the Study 28
Impact of Action Research on Author 30
Future Research 33

REFERENCES CITED 37

APPENDICES 40

APPENDIX A: Student Pre and Post Treatment Attitude Survey 41
APPENDIX B: Student Interview Questions 45

LIST OF TABLES

Table Page

1. Data Triangulation Matrix 14

LIST OF FIGURES

Figure Page

1. Race and Ethnicity Demographics of Sample 10

2. Working alone vs. working with others survey results.....16

3. Learning science online this year is going to be hard survey results.....17

4. I can learn science online better if I am able to discuss assignments in small groups survey results 19

5. When learning science online, I would rather work on my own than with others survey results.....20

6. I feel that working with others helps to keep me engaged while Learning science online.....21

ABSTRACT

This descriptive study evaluated the effectiveness of collaboration strategies on engagement in a virtual 7th grade science class during the Covid-19 pandemic. Previous research indicates that student perception of teacher support and promotion of mutual respect in the classroom are important factors beyond teaching strategies that impact student engagement (Ryan & Patrick, 2001). Students need to feel they have some control over their learning to maintain engagement (Keifer, Alley, & Ellerbrok, 2015) and according to Wentzel (2012) and Wentzel & Wigfield (2007) their engagement is strongly connected to teacher and peer interactions. This suggests that virtual learning effectively omits the very elements that students need to be highly engaged and motivated, presenting significant challenges in science education. A qualitative research design was used for this investigation. During the treatment, students were assigned to projects that required them to engage in virtual collaboration using resources such as Google Meet. The technique of triangulation was used by collecting data from student attitude surveys, individual student interviews, and teacher journaling in addition to frequent member checking and professor feedback from the instruments to help ensure validity and reliability of results. The attitude surveys were administered using a 5-Point Likert scale while individual student interviews were conducted using a random small group sample of online students. Results from the various instruments concluded that the motivation behind high engagement for students while learning online had little to do with the collaboration strategies implemented. Students' engagement and desire to succeed while learning science online was dependent largely on two factors: their connection with the teacher and the degree of communication and participation within the collaborative groups. This indicates a need for teacher awareness regarding the impact of relationship building with students. Furthermore, students need to be provided with the time to build a rapport and learn how to effectively communicate with each other within small groups before they can productively and effectively engage in any collaboration strategy.

INTRODUCTION & BACKGROUND

Context of Study

Our district has adopted a 50% hybrid learning model for the 2020/2021 school year with the intent to decrease the number of students in the building to maintain social distancing due to the COVID-19 global pandemic. This means only 50% of the middle school students registered in the in person learning model are physically in the classroom while the other half are remote learning from home. About 38% of the total middle school population are in the optional all remote learning model. The remaining 62% of the total student body was placed into the hybrid model meaning only about 31% of the total student body was in the building at one time.

This has presented unprecedented challenges in science education. As an attempt to maintain equity, the district's policy is to provide the same lessons to remote learners as the in-person students receive. Equipment cannot be shared, and labs cannot be performed due to sanitation precautions. Consequently, small group and collaboration work must be reimagined. Students will need to still receive a rigorous and relevant science education allowing them authentic opportunities to engage in inquiry-based investigations while learning in a virtual setting.

Research points to the fact that there are other factors involved in students' engagement other than teaching strategies alone, such as student perception of teacher support and teacher promotion of mutual respect in the classroom (Ryan & Patrick, 2001). Interactions between student and teachers have a significant role in students' classroom engagement and motivation, which can be promoted by providing a learning environment that is responsive to students' individual needs. This may take the form of teachers offering student choice so they can select

tasks they find interesting. Students need to feel they have some control over their learning in order to maintain a high level of engagement (Keifer, Alley, & Ellerbrok, 2015). According to Wentzel (2012) and Wentzel and Wigfield (2007) young adolescents' academic motivation, engagement, and sense of school belonging are strongly connected to interactions with teachers and peers.

The previous research clearly indicates that the heart of students' motivational drive and engagement are hinged on the very things that virtual learning can so easily strip away – social interactions, collaboration, choice, relationships between teacher and peers and a sense of school belonging. Finding ways to keep students feeling connected to their teachers and peers as well as allowing them choice in what they investigate, while learning science in an online environment is critical to not only their academic success but to their overall well-being.

However, there are advantages for many students in virtual learning that do not exist in the brick-and-mortar world. There are students that are able to flourish when removed from being forced to learn in a social setting where their individual preferences and needs may not get met (Swan et al., 2015). Students have the ability to work at their own pace at whatever time they want or when it is convenient. During asynchronous learning when videos are available, students can watch and rewind as much as they desire or need. A student quote from a 2015 study conducted by Swan et al. (2015), "I think it's a lot easier because you can look at what you're being taught instead of just the teacher talking to you. You can read it over and over again" (p. 312). The students that found it easier to learn virtually liked the ability to work at their own pace. Then there are the students that do not thrive in a brick-and-mortar setting due to the social aspect. When the additional social stresses and drama are removed, many students

thrive academically that would not otherwise experience much for success. For example, a pregnant teenager was able to still graduate from high school due to the flexibility of online learning and a young man that was at risk for not graduating due to being bullied daily was able to complete the remainder of his coursework virtually (Morgan, 2015).

Furthermore, we live in a technological based global economy where online platforms are growing by the day. This trend has not been bypassing the public education sector. In fact, online education in K-12 has been increasing since the 1990's. Just six years ago, during the 2014/2015 school year, there were roughly 2.7 million K-12 students in the United States enrolled in online learning to supplement their traditional brick and mortar education (Gemin, Pape, Vashaw, & Watson, 2015). Additionally, there are now five states that require one online course as a requirement for high school graduation (Herold, 2017).

Schools across the country being forced to adopt an online model due to the COVID-19 global pandemic, has opened a can of worms that may never be able to be put back. This online model has broken glass ceilings in the perceptions of what school looks like. There is no doubt that many students and families have flourished in this new school model and now have a new perspective on the possibilities of what K-12 public education could look like even outside of a global pandemic.

Providing students with the real-world skills, experience, and knowledge to navigate our ever-growing virtual world sets them up for success far beyond the middle school classroom. This immediate and near future need to ensure success in a collaborative digital world was the driving force behind this action research project.

Focus Question

My focus question was, What is the impact of virtual collaboration strategies used as a tool to promote student engagement in an online environment in middle school science?

My sub-questions include the following:

1. How does student choice in investigation projects promote engagement while learning in an online model?
2. What is the impact on student engagement when virtual platforms are used for small group problem solving collaboration?
3. What is the impact on students' attitude about learning science in an online environment when virtual collaboration opportunities are implemented?
4. What is the impact on teacher attitude while teaching science in an online environment?

CONCEPTUAL FRAMEWORK

Learning Environment

There is significant support in research that creating a positive learning environment is fundamental in the increase of student engagement and motivation. In a study of 233 students from three middle schools, it was found that students were more interested and enjoyed classes more when they found their teacher to be supportive of them (Ryan & Patrick, 2001). The results from this study show the importance of healthy social interactions, especially involving the teacher, in increasing student motivation and engagement.

Interactions between student and teachers have a significant role in students' classroom engagement and motivation, which can be promoted by providing a learning environment that is responsive to students' individual needs (Keifer, Alley, & Ellerbrok, 2015). This may take the form of teachers offering student choice so they can select tasks they find interesting. Students need to feel they have some control over their learning in order to maintain a high level of engagement (Keifer, Alley, & Ellerbrok, 2015).

Real World Relevance

In a study performed across 8 different communities consisting of a variety of science classes, with the goal to improve student motivation and engagement, it was discovered that students found science "more important to them when it was situated and relevant, applicable in local contexts, and focused on real world problems" (Engels, Miller, Squires, Jennewein, & Eitel p. 45, 2019).

This study provided great insight into how students' perceptions of the importance of what they are learning is directly related to their level of buy in, which has a direct impact on their engagement and motivation. However, there were unfortunately limitations to this study regarding the participants. Both the teachers and students involved were a convenience sample. Teachers with a personal interest in this study were recruited within a several hour proximities. This contributed to the vast variety of science subjects and grade levels used for this descriptive study.

Motivational Theories

Research has shown a decline on motivation in adolescents as they move into the middle grades, which historically has been largely contributed to factors such as onset of puberty, rendering it practically inevitable (Anderman & Midgley, 1998). This is potentially amplified when middle school students are suddenly thrown to online learning where they are expected to be on camera in front of their classes. However, further research points to the learning environment of the student as the leading indicator of change in motivation. According to Anderman and Midgley (1998), this falls in line with three motivational theories: Attribution Theory, Goal Theory, and Self Determination Theory.

Attribution Theory states that teachers can inadvertently communicate to students that their abilities are either fixed or modifiable through their instructional practices. Goal Theory consists of two main components, task goals and ability goals. Studies have generally correlated the adoption of task goals with adaptive patterns of learning where the student focuses on their own progress whereas an ability goal orientation would represent the belief that demonstrating an ability or hiding a lack of an ability, is the achievement purpose. When students adopt a more

task goal orientation, they display a greater probability of engaging in challenging tasks and display a more positive attitude about school and as a learner (Anderman & Midgley, 1998).

Schools can promote a more task goal orientation among their students according to research by Anderman and Midgley (1998) by making intentional changes such as incorporating curriculum that has an interdisciplinary focus that views mistakes as an important part of learning, thus encouraging academic risk-taking, replacing competition between students with more cooperative learning strategies; allowing opportunities for student choice and decision making; and moving away from rote learning and memorization and over-use of worksheets and instead providing enriching, complex learning experiences that encourage problem solving. In an online science learning environment, adopting a task goal orientated philosophy was practically inherent due to the elimination of paper and pencil practices combined with the need for students to work together in more creative ways within a digital world. This laid the foundation for the treatments in my descriptive action research project where students were required to work together on projects with the focus of learning and solving problems as opposed to regurgitating memorized facts with “right or wrong” responses.

Lastly, Self Determination Theory says that students need a sense of competence, relatedness to others, and autonomy. Autonomy receives the most attention and can be addressed by allowing student choice and input regarding decisions in the classroom. Contrary to this need, studies have shown that middle schoolers get less opportunities for self-determination compared to elementary years. With this in mind, Anderman and Midgley (1998) point out that students may need help in developing their self-regulation by having limited choices and having large tasks broke down into smaller, more easily obtainable chunks.

Cooperative Learning

One of the ways in which a school can promote a more task goal orientation among students was to eliminate competition by instead using cooperative learning strategies. According to Lin (2006), focusing on developing students' social and communication skills should be the main purpose of implementing cooperative learning strategies which has shown to result in less competitive behavior. Even more importantly to my own action research, is that cooperative learning has proven to help students construct their own understanding of science content while allowing students the opportunity to explore, refine, and question new ideas (Lin, 2006). For true learning to take place, students must take responsibility for their own learning rather than depending solely on the teacher. This then further aids students in the development of communication skills and scientific thinking processes that are critical in science education. Lin (2006) further addresses the fact that cooperative learning techniques "provide the social settings in which teachers can help students analyze their thinking processes and encourage all students to interact with their teachers and peers in a way that in conducive to science learning" (p. 2). This further provided yet another connection between student motivation and engagement and students' perception of teacher support that I kept in mind as I began planning the treatments for my action research project. The theoretical underpinning of the Self Determination theory set the foundation of my treatments. I provided students with the broad project topic with subtopics from which to choose within their small groups. I then provided a list of learning objectives to be included within each subtopic. Although there is little previous research on remote learning at the middle school level, all of research and findings thus far on student ownership of learning and engagement indicate such a need to an even greater extent in an online learning model. This

provided the necessary structure while still allowing student choice while promoting a collaborative online learning environment focused on learning and problem solving as a team. The purpose of my action research descriptive study was to discover the impact of well researched collaborative learning strategies within an online learning environment in order to increase student success despite the physical separation of peers during this unprecedented school year.

METHODOLOGY

Demographics

Due to our 50% hybrid model, I taught 4 sections of seventh grade science for a total of 135 students with approximately 65% of the students learning remotely from home on any given day. My action research project was a descriptive study since students can move between our remote and hybrid model on a month-to-month basis. There was also consideration of moving back to the standard model of in-person learning. Even with students all back to in-person learning in the school building, families maintained the option to keep their students 100% remote if so desired. Such moves between learning models consequently resulted in ongoing schedule changes. This did not align well for maintaining a comparison group, hence this being a descriptive study. Additionally, there is no precedence set for middle school students learning in such a blended model.

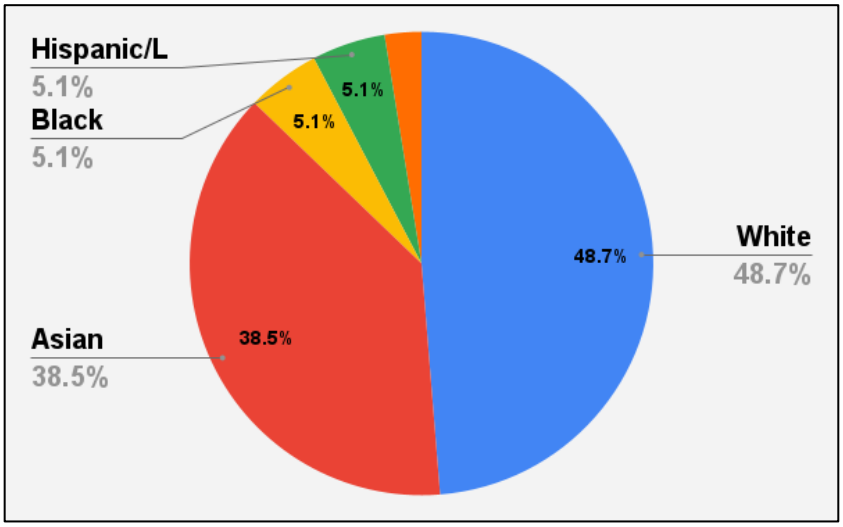

Figure 1. Race and ethnicity demographics of sample consisting of students learning online all year, *N*=36.

Considering the fluid situation regarding my students' learning model from month to month due to the pandemic, I chose my students that were in the 100% remote learning model for this study. Regardless of district decisions throughout the year on learning models, my students that were 100% online by choice remained my students throughout the year. There was district-wide movement back and forth between Hybrid and all online depending on community and school spread of the COVID-19 virus. I gained new online students while losing Hybrid model students, but the constant was the set of students that started all online with me. A total of 39 students were remote all year. As seen in Figure 1 above, based on data reported by parents, race demographics are 49% (19) White, 38% (15) Asian, 5% (2) Black, 5% (2) Hispanic, and 3% (1) identified as multi-race. Ames Middle School is a Title I school with a total population of 1,097 students of which 27.15% received free/reduced lunches.

Treatment

To answer my main research question, "What is the impact of virtual collaboration strategies used as a tool to promote engagement in an online environment in middle school science?" the first treatment implemented was a collaborative group project with individual and group components. I assigned students to small groups of 5-6 as their collaborative group. Each group member was required to work together on a task to solve a problem related to what we were learning. The first unit of instruction was Energy. I began by administering a preassessment and a pre-treatment attitude survey. The collaborative group project was on Alternative Energy Sources. Within each collaborative group, the students chose an alternative energy topic from a list of options. The options were as follows: Hydrogen fuel cells; Biofuel (algae); Wind; Hydroelectric; Solar; Nuclear; Geothermal.

Each student had the responsibility of investigating their chosen energy source. They were provided with a list of objectives: 1) Define your energy source; 2) Explain how the energy is captured, transferred, and converted into electricity; 3) Prepare a simulation or model of your energy source; 4) Include relevant science vocabular such as thermal energy, kinetic energy, potential energy; 5) Include rea-world examples and locations of your energy source; 6) Discuss the benefits and costs of your energy source.

The group of students then needed to combine their individual pieces into one cohesive larger project that could be presented virtually. As a group, they needed to choose a platform in which to present their final product such as via Google Meet using a Google Slideshow either live or using a voiceover application such as Screencastify; or they could have chosen to use the digital app Soundtrap to present their project as a Podcast or Public Service Announcement.

They were assigned this project near the beginning of our energy unit, so they had the flexibility of time to work on their individual parts. They also needed to incorporate at least one resource they found on their own while I also provided them with curated resources. Among the curated resources was access to the digital sites Discovery Education, Science Flix, and Defined Learning. I also had resources acquired from an Energy Professional Development program that was shared with the students to aid in their research.

The final assessment of their project included a group and an individual grade component. This was to reduce concern and anxiety regarding inequity of work between the group members. Also, the design of this project inherently reduces such concerns since each individual component is not dependent on another. In the event a student did not meet the deadline, the final product would not be harmed and would not be noticed by the audience.

During regular online class time, I provided students with work time using the Breakout Room feature on Google Classroom. This allowed me the ability to go in and out of the Breakout Rooms to monitor their collaboration, communication and progress while providing feedback as needed. Students were also encouraged to reach out to their group members when they had questions or needed help on day-to-day assignments and tasks. I scheduled meetings with each small group on a weekly basis to check in on how they were doing, how they were feeling about their collaborative work and to answer any questions they had. I also gave students a weekly check in form individually where they reported struggles and successes from the week.

Additionally, students were able to choose their own topic to investigate as a research project based on what they could feasibly do at home. They were able to pick their own partner with the same interest to engage in collaboration throughout their investigation or experiment if they desired. They needed to collaborate virtually to share information, data, and ideas. When the project was completed, they presented their investigation and findings to the class by creating a Poster using Google Slides. All the posters were put into one Google Slideshow and shared with the whole class.

In addition to these treatments, students were asked to solve a question or problem that required a response to be posted on Flip Grid. This allowed for students to watch and respond to one another's ideas and answers in a digitally engaging format. Students were also instructed to post questions they had about assignments or class on the stream in Google Classroom with the intent to promote help from each other to form a collaborative learning community.

The emphasis on the students staying connected to each other while learning together through structured virtual collaborative means, allowing student choice and frequent personal

check ins with me provided the foundational components of my treatment plan. Results from my descriptive study provided clear paths to future, more targeted action research questions to investigate relating to student engagement and academic success in remote learning models in the middle school science classroom. This study ran for 6 weeks throughout the unit on energy transformations.

Data Collection and Analysis Strategies

I used a variety of instruments for my data collection as seen in Table 1 below. I administered pre- and post-student attitude surveys, interviewed students, and maintained a teacher journal. A copy of the student survey and student interview questions can be found in Appendix A and B, respectively.

Table 1. Data collection matrix.

	Data Collection Methods			
	Teacher Journal	Work Completion	Individual Students' Interviews	Students' Attitude Surveys
Main Research Question				
1. What is the impact of virtual collaboration strategies used as a tool to promote students' engagement in an online environment in middle school science?				
		X	**X**	
Sub-Questions				
2. How does student choice in investigation projects promote engagement while learning in an online model?				
		X	**X**	**X**
3. What is the impact on student engagement when virtual platforms are used for small group collaboration?				
	X	**X**		
4. What is the impact on students' attitude about learning science in an online environment when virtual collaboration opportunities are implemented?				
	X		**X**	**X**
5. What is the impact on the teacher's attitude when teaching science in an online environment?				
	X		**X**	

I kept a daily journal throughout the treatment implementation. This provided qualitative data on student engagement and student attitude throughout the project in order to answer sub questions #3, #4, and #5. I was also able to notate students that did not engage or show up to their small group sessions in Breakout Rooms and monitor any changes in students' attitudes about working collaboratively compared to individually.

Student interviews were conducted using a random small group sample of online students consisting of one random selection from each of the four class periods. The interviews were held with individual students in order to receive the most honest and candid responses as possible. The interviews along with student attitude surveys provided further insight into students' attitudes about learning in collaborative groups versus individually and determined if students' attitudes changed throughout the treatments. The student attitude surveys were prepared in the form of a five-point Likert-scale.

The technique of triangulation was implemented using various instruments and methods of data collection to help ensure validity and credibility of the qualitative data that was collected throughout the study. I frequently engaged in peer debriefing, peer colleague and professor feedback from the instruments, while processing and reviewing the data. Unfortunately, I was unable to obtain the IRB exemption from my district after multiple attempts over the course of a calendar year.

DATA ANALYSIS

Results

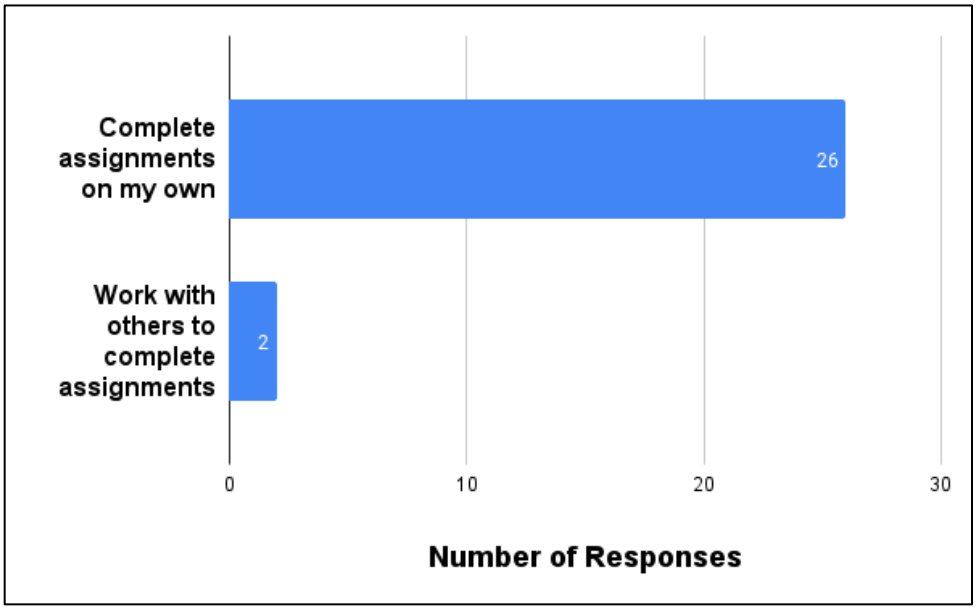

Figure 2. Graphical results of remote student preference between working alone or with classmates showing a strong preference for independent work, n=28.

I surveyed the remote students early in the year to gauge their opinions on working and learning on their own versus in small groups. Out of the 39 students that were remote, 28 answered this survey question: “Do you prefer completing work on our own or working with others?” Approximately 93% (26) reported to prefer working on their own (Figure 2). This was not surprising considering these are students and families that chose to be remote all year regardless of the pandemic status and the school’s learning model, therefore a likely connection between family history and the response seems logical they did not feel strongly about needing to complete work with peers. This seemingly strength in working independently coupled with the well-known dislike of group work among students was well represented within this survey question.

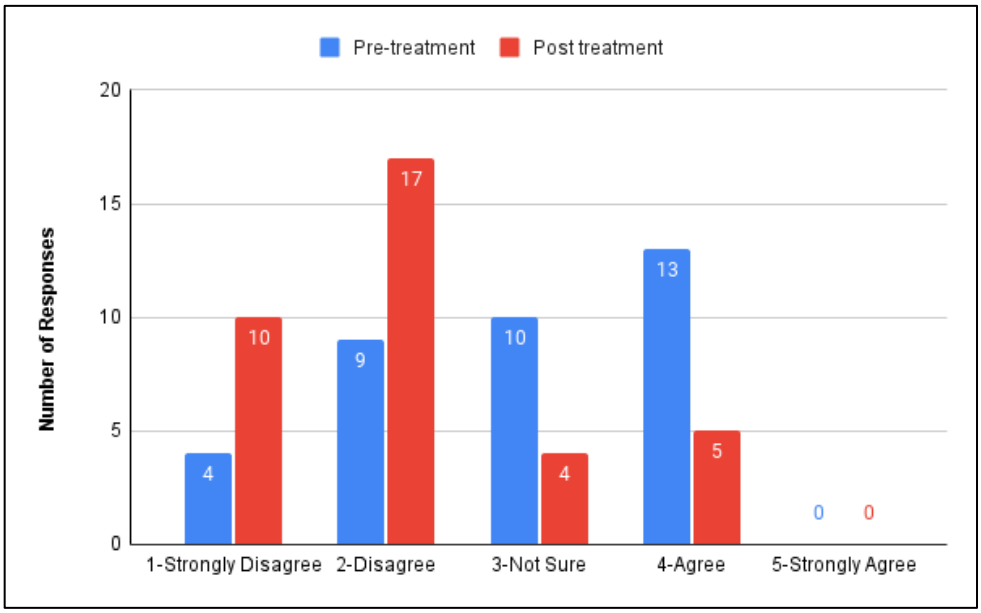

Figure 3. Pre and post survey question graphical results showing more than double the number of students disagreed that learning science online was going to be hard in the post treatment survey compared to the pre-treatment survey results indicating a positive outcome regarding their online learning experience, (N=36).

A Likert-style pre and post treatment attitude survey was given to the 39 remote students however, only 36 submitted responses. In response to, “Learning science online this year is going to be hard”, the pre-treatment responses were nearly evenly split with 36% (13) of students responding in the Agree category and 36% (13) in the Disagree to Strongly Disagree categories (Figure 3). The remaining 28% (10) were neutral. Even though over 92% of the remote students claimed to prefer working independently, they were not quite as confident initially in their ability to learn science remotely. In the post-treatment survey, there was a major shift in how students felt about the difficulty in learning science online. The disagree categories moved from 36% (13) to 75% (27) meaning the number of students that believed they could easily learn science online more than doubled.

These results naturally lead to a question of what made the students feel more confident and successful in learning science online. In a follow up question, some of the students' reasonings from pre-treatment responses were, "Because last year when our teacher left and we got a new teacher it was hard for her to teach us so I didn't learn that much that year and I also thought it would be difficult because of technical problems" and "My view in science is hands on and visual learning; I think it would be hard to do that online." The students displayed a different perspective in the post-treatment responses. One student replied with, "I enjoyed doing things alone and at your own pace feels good too." Another student stated, "I didn't have to wait on others and everything I needed was easily found on Google Classroom and the teacher was always available to answer questions or help me." Other students pointed out how they thought they wouldn't get to do experiments in the beginning since they were remote. One student said, "I really liked being able to conduct my own experiment at home. I did not think we would do anything hands on but then we did, and it was a lot of fun and I learned how to do science at home." Interestingly, none of these responses were specifically in favor of working collaboratively with other students.

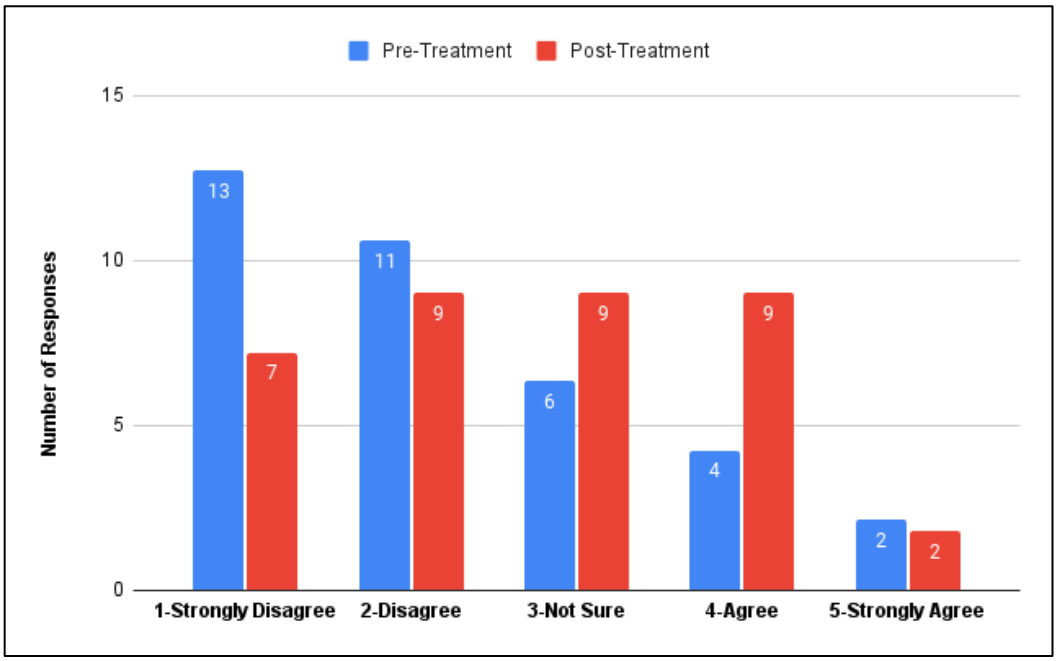

Figure 4. Pre and post survey results indicating student recognition of being able to learn better when collaborating with classmates.

The question, "I can learn science online better if I am able to discuss assignments in small groups" provided more insight into the impact of students working collaboratively while still online. In the pre-treatment survey (Appendix A), only about 17% (6) of students agreed with the statement, whereas 67% (24) responded with Disagree or Strongly Disagree (Figure 4). This coincided with their initial preference to work alone and their positive attitude about learning remotely. Results from the post-treatment survey showed a marked shift to the Agree category indicating many students experienced positive results from working collaboratively. The Disagree categories reduced from 67% to 44% with most of that shift appearing to have moved to the Agree category.

A student in favor of working in small groups stated, "I really like discussing with other people and making sure I am on the same page with them, but also learning things from others that I may not have thought of." Another response was, "I agree that I've learned better online

than [in person] but I would like it to be normal again." Even though there was a noticeable shift to the positive, there was still nearly 31% that did not believe working with others was helpful in addition to 25% not being sure. Some of the responses against working with others included, "Whenever we have small groups, not that many people actually engage in discussions" in addition to, "I like to work alone and at my own pace."

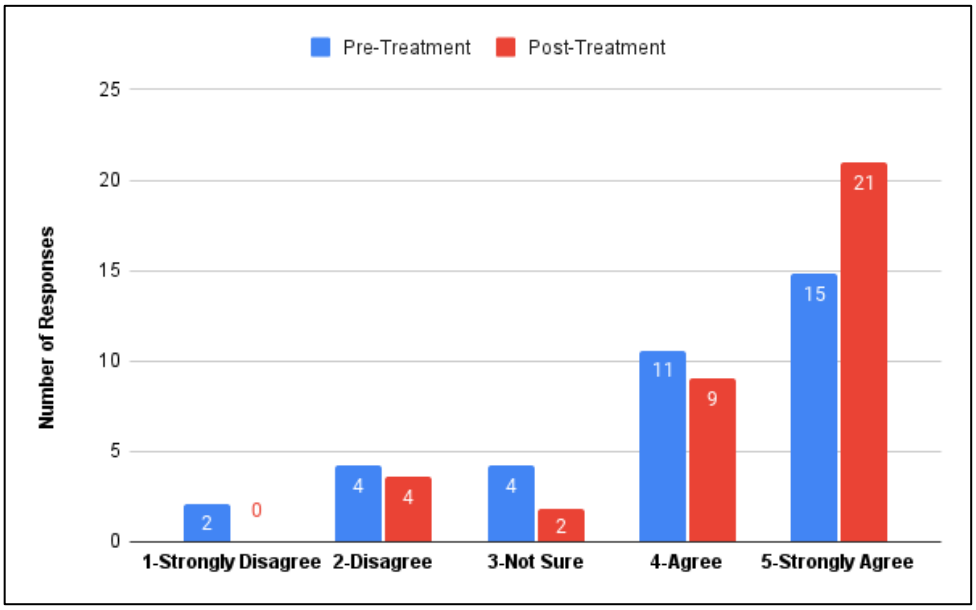

Figure 5. Graphical results of pre and post survey question indicating a strong preference for working alone over working with others regardless of the impact on their learning.

The question "When learning science online, I would rather work on my own than with others" resulted in an overwhelming favor of students preferring to work alone over working with others (Figure 5). This was in direct correlation with results from Figure 1 where students clearly preferred working alone over working with others regardless of online or in-person. Those in favor of working alone went from 72% (26) to 83% (30) by the end of the treatment. This change appeared to indicate that working in collaborative groups was a rather negative

experience for some students and solidified the opinions of the others. This was confirmed by multiple student responses when asked to explain: “Because most people don’t talk instead, they type in the chat and don’t interact with others” and “working with others doesn’t help me very much unless I know who I am work with well.” Another student claimed, “They sometimes distract me” while yet another stated, “I do assignments and tasks quicker and more accurate individually.” Multiple other students commented that they could work faster and more efficient on their own. One student even stated, “Doing things alone at your own pace feels good too.”

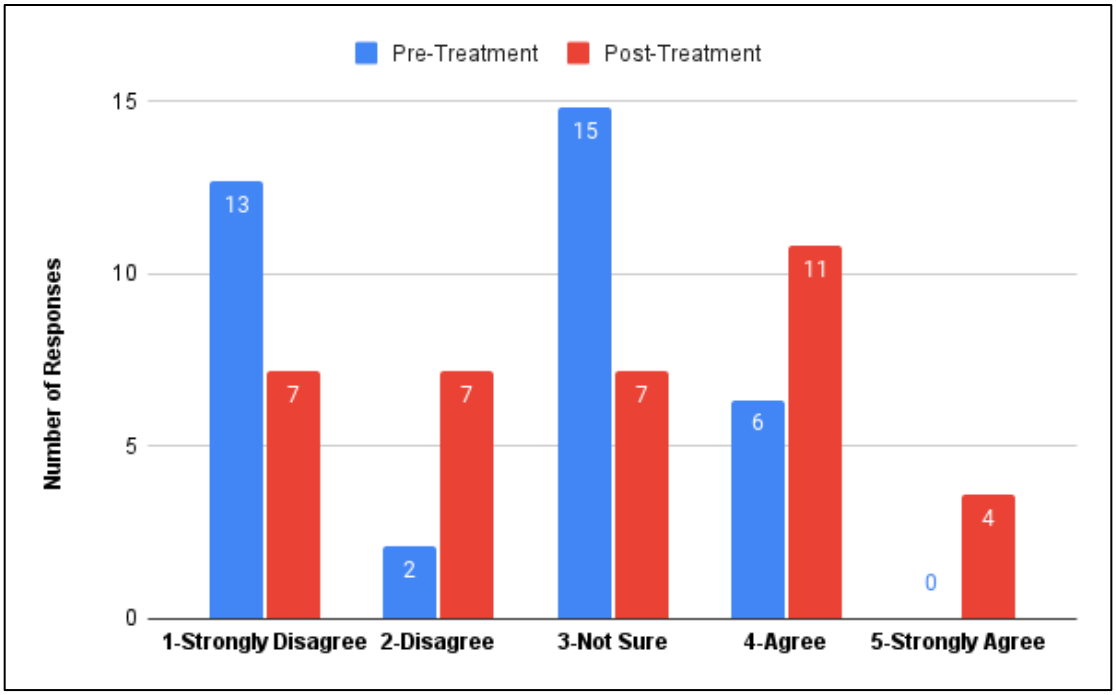

Figure 6. Graphical results of pre and post survey question: I feel that working with others helps to keep me engaged while learning science online. Results indicate that after the treatments, more students felt working with classmates helped keep them engaged.

The other question with noteworthy results was: “I feel that working with others helps to keep me engaged while learning science online.” These results provided some insight into the students’ perceptions regarding their engagement while learning online. As can be seen in Figure

6 above, there appears to be a marked increase in students' perceptions on working with others helping them to stay engaged with the class. At first glance, the results appear to be most striking in the Strongly Disagree category. However, upon combining both Disagree categories, there is only an overall net change of one student response. Although, it was worth noting that there was a marked reduction in students responding with Strongly Disagree. There was a 17% drop in Strongly Disagree responses. Even though it appeared those responses only shifted to Disagree, this still indicates students feeling at least a little more positive about working with others compared to the start of the year. The shift in responses from pre to post treatment that deserves attention is the Not Sure category. The Not Sure category dropped from 42% to 19%, resulting in a net drop of 23%, while the Agree increased from 17% to 31% and Strongly Agree increased from 0% to 11%, resulting in a net increase of 25%. This clearly indicates that students discovered working with others helped them stay engaged with their online class. When asked to explain their answer, a couple responses were, "I won't daydream as much" and "It's more fun to work with people; we are social beings after all."

The four student interviews revealed exceptional insights to what helped them be successful in learning science remotely throughout the year. The particular virtual collaborative strategy implemented did not seem to weigh heavily in what made any notable difference in students' engagement or learning. As can be expected, there was a strong dislike in general for any type of collaborative group learning work. All four interviewees expressed their concern regarding working in groups due to the lack of participation from some group members. This inevitably leaves other group members feeling as though they are forced to pull the weight of others while everyone receives the same credit or grade. During the interview when asked about

the preference of how groups are chosen, a student reflected on the pronounced difficulty in trying to form groups in the virtual setting by stating, "…it can be challenging and time consuming trying to reach out and communicate during the recruiting state – a lot of wait time for others to respond to your group invite. In person learning does not have this difficulty." This shed light on the importance of effective communication and continued to be a common theme throughout the interviews.

Another student confirmed this by saying, "I don't like being left with all the work when trying to work collaboratively." While another student responded, "Collaborative groups work well but only when all the group members actually contribute by doing their part and communicating well with everyone." According to her, "Group projects that were longer and more involved worked better because the students had time to get to know each other better and therefore communicate better. When there were group members that were more actively working and learning and more "with it" then it was more fun. Collaborative groups work well but only when all the group members actually contribute by doing their part and communicating well with everyone." Another student further added, "Once the group got to know each other better they knew better what each other liked so they could then deliver ideas that were more angled towards most of the group members and could eventually work something out."

This indicated that student success working collaboratively is highly dependent on two factors: the group members knowing each other well and effective communication and not so much on the specific collaborative strategy. Upon being asked what could make collaborative work better, another student replied with, "…need time to build relationships in small groups to get to know them so work can be more effective and productive." This was a concept that came

up in survey responses as well – students need to know each other well to be effective and productive group members. Students tend to be more engaged and invested in their learning when they are comfortable with each other and enjoying the learning together, which can only happen if they are able to effectively communicate. Cultivating and promoting this type of learning environment can be challenging in the best of circumstances let alone in a virtual science classroom. Clearly, just removing the group dependent grade in projects and implementing collaborative work alone is not enough for students to be engaged and invested enough to benefit from such learning strategies.

The effective communication between students within collaborative groups was not the only important communication component. Communication from teacher to students was another strong contributing factor to how engaged students were with the class and their learning. One student felt that she learned more this year even being remote than she did the year before, when she was in-person. She stated, "To me, communication is really big because being a remote learner, some teachers wouldn't communicate enough with the remote people, and it would just be harder for everyone. Communication was amazing and I was able to get answers to questions right away."

The importance of effective communication in students' learning also pertains to how content is delivered and in what context according to a student's statement: "Activities and homework assignments were very good…they helped me learn a lot more about the world around us…I liked the teaching technique because you tried connecting what we were learning to our world to see how it was used. Historically, we always wondered "why are we learning this? When you learn you are using all this stuff in everyday life then it really just makes sense, and

you want to learn more." Similar perspective from another interview was, "Learning science went well because the teacher was also virtual – communication is very important. However, even once you [teacher] were in person the last few weeks of school, I felt it went well due to the high level of communication from you…made it very easy to learn."

Teacher communication was essential in managing the virtual collaborative as well according to another interviewee's suggestion: "In breakout rooms, [teacher] checks in with each group asking how things are going and what is being worked on…but also checking in with each individual group member so they can report on who is not doing their part privately."

I believe such a high level of communication was achieved because I was teaching remote. Early on in my teacher journal I wrote, "Today was such a great day! I was able to talk to each of the students without interruptions and really connect with them. Even some of the remote students started turning their cameras on for the first time and contributing to the discussions." Without the "normal" classroom distractions and interruptions I felt hyper focused and prepared for each lesson. I found myself being more animated and sillier with the students to engage them compared to a regular day in the brick-and-mortar classroom. One day, I leaned in very close to the computer camera and said, "Hello? Hello? Anyone there?" This got a lot of giggles and cameras started coming on again followed by students asking and answering questions and even commenting on one another's responses. I reflected in my journal another occasion where I said, "Wow – all I hear is crickets – is anybody there?" Multiple students suddenly responded with, "Ms. Piatz, crickets would actually be quite noisy and annoying." This sparked another day of great engagement in the lesson. During a conversation with a colleague analyzing and discussing data, he stated that students seemed to respond well to my methods. He

hypothesized that my interactions with the students was similar to them watching a YouTube video.

The most profound realization was how I felt about teaching while being remote. One day I wrote, “I realized today that I am more patient and understanding as a remote teacher. I think of all my students as sweet and innocent without any feelings of frustration. It doesn’t matter how far behind they are or how late an assignment is, I am just happy to have them let me help them and talk to them.” When I am not the one having to deal with any classroom disruptions or behavior issues, I felt different. In my journal I reflected on a couple parent interactions. One, a parent wrote in and nominated me for the Ames Accolade Award for making her student’s science lessons always fun and engaging while learning remotely. Another parent had emailed a thank you saying, “I don’t know if my daughter will remember how magnetism works but we will always remember how kind you were…” This is when I realized that as much as we try to be objective as teachers, there is inevitably some level of implicit bias regarding how students behave in the classroom. Teaching remote removed all that negativity and I found myself happy and excited every minute of every day to teach the students and help them learn. The exhausting part of teaching stems from ongoing redirections and continual intervening of behavior issues in the classroom that can effectively stop teaching which inevitably stops the learning. There seemed to be an automatic connection between teacher and student when both were remote. They always had my undivided attention because I was not dealing with students in the classroom and having to split my time.

In speaking with other teachers in my building, this was confirmed. In meeting with other teachers on my team, meaning we share the same students, they did not have the same

experience with the remote students as I was describing. The remote students did not turn their cameras on and did not engage with the class and ask all the questions they did in my class. One co-worker stated, “I feel like I have to prioritize the students that are physically in the classroom, so I am not always available to the remote students.” Another co-worder claimed, “I don’t have time to be on my computer throughout class because I am constantly dealing with students in the classroom and having to wipe down tables at the end of class and be in the hallway between classes.”

CLAIM, EVIDENCE, REASONING

Claims From the Study

The need for effective communication between students as well as between teacher and students was significantly magnified in the virtual classroom. This was evident in the comparison between my experience teaching remotely to other teachers' experiences that were still teaching in the classroom even though we had the same students. When the students felt the teacher was available and attentive to them, they participated in all aspects of class including interacting with students that were in person via Google Meet. There were numerous student accounts of how important communication was to their online learning experience and success. Effective communication was needed not just in verbal instruction during live classes, but communication in the posted materials which took the form of text, audio, and video instructions. Students receiving immediate feedback and answers to questions from the teacher was another important communication component according to student responses. In fact, a parent emailed a thank you for her daughter feeling "seen and heard" in science class. The need for teacher flexibility in a virtual classroom along with consideration of parent's perspectives cannot be overstated (Currie-Rubin, 2019). According to research by Currie-Rubin (2019), "The online teacher needs to balance the focus on content and instruction with the broader needs of the whole child and thus the family and home environment" (p.121). Student engagement in an online classroom is critical to their overall success beyond just academics. How they feel about their environment which includes their classmates and their teacher, has a profound impact on the effort they exert in class coinciding directly with their engagement. I found it interesting that students still held a

strong preference for working alone while at the same time recognizing that working with others while they were online helped them stay more engaged. This phenomenon is most likely due to the specific difficulties that the virtual environment imposes. According to survey responses, many students found it frustrating when group members online would not participate in conversations or would type all responses instead of turning on the microphone and speaking. This left many students feeling they could work more efficiently and at a faster rate than when they were slowed down by long waits for group interactions. This leads me to believe that many of the students may prefer to work collaboratively with others online if everyone was doing their part and held to the same level of accountability. This is something that would need to be investigated further upon all the students returning to in-person learning.

The impact on my perspective as a science teacher from this study has been astounding. Regardless of the specific type of collaborative strategy implemented in the classroom, the key to student engagement is simply clear communication and relevance in what they are learning. During student interviews when students were asked about the different collaborative strategies, they did not seem to care much one way or another as to which strategy was implemented, only the communication piece was of great importance to them. This leads to me to conclude that the specifics of how a lesson is presented is not nearly as important as how well it is presented and communicated along with the level of support I can provide as the teacher.

The relevance students find in what they are learning has an equal profound impact on their engagement. When students can feel connected to what they are learning and can see the connection to their everyday lives, their engagement automatically increases, and they enjoy the class and embrace their learning experience. This was well stated during the student interviews

when a student even commented on how he and classmates had previously always wondered "why are we learning this". His interest was dramatically increased when he could easily make those real-world connections. This connection to their own lives along with the need for clear and consistent communication from the teacher trumped any research based collaborative instructional strategy. Although, teacher clarity, classroom environment, and teacher student relationships have long been documented as critical components to student engagement and learning. This does not change in a remote classroom. In fact, these attributes become remarkably more crucial in a remote classroom. Afterall, their connection to everything is contingent upon their connection and relationship with the teacher since there is no physical classroom with classmates.

Impact of Action Research on Author

Realizing the importance of communication to the students, I started implementing different day to day strategies in how I deliver instruction. I make a point to demonstrate how I think through ideas or concepts and provide personal examples when possible. When students are working in collaborative groups or independently, I make sure to talk to the students and engage in a conversation with them that includes their current task but also about their life or other classes. I can answer their questions or clarify instructions and procedures as needed which is particularly helpful for those students that don't like to ask in front of the whole class.

I also make sure to check in on each student individually every three weeks. I use a spreadsheet to keep track, so I don't miss anyone which allows for me to also document any notes. This has resulted in building relationships with students that wouldn't otherwise have happened. Parents have thanked me for being their student's "mom away from home". For the

first time, I am experiencing students emailing me additional information about topics we study or family photos that are related to what we are learning. This is a strong indication of a high level of engagement. I was forced to implement these strategies to keep connected with remote students during the pandemic, but these are practices that have been well appreciated by all students. I now take photos, with permission from students and parents, of students doing labs or being silly in class and post them up in the room. If students are excited to come into the classroom, then they are already engaged and easier to keep engaged throughout the class period.

The other communication piece that I took from the online experience was posting daily agendas with all pertinent information. The online students commented on how much they liked having everything easily accessible and how it helped them know what to be doing and stay engaged. Daily agendas posted in Google Classroom has been beneficial for absent students as well and provided a place for class questions to be posted when students are at home.

My perspective on how I feel about teaching has been forever changed. I was made critically aware of the negative impact classroom behaviors had on my day-to-day teaching and emotions. Now that I am aware of this, I will be purposeful and intentional with plans and procedures for classroom management as well. This can reduce ongoing classroom disruptions that could foster frustration in the teacher and other students effectively degrading the classroom culture which in turn negatively impacts the effective communication within the classroom. This single change when moving to remote learning and teaching had an acute impact on my overall attitude towards the students particularly when they needed help making up missing work.

In conclusion, students are engaged in class and have the best learning experiences when they feel they are receiving clear and thoughtful communication from their teacher as well as

their classmates. When students feel valued by their teachers, they are willing to take the necessary risks and ask questions and engage with whatever task or problem is presented to them. When students are given the opportunity to get to know their small group members well, then they can engage in more meaningful and productive conversations.

Having strong communication within collaborative groups is what makes students enjoy the learning experience and get the most out of it resulting in a desire to work together rather than independently. This requires the teacher to be readily available and checking in with the students; asking what each member is working on and helping sort out any difficulties. This combined with students understanding the relevance and importance in what they are doing, and learning is what increases their engagement regardless of the specific collaborative strategy that is implemented.

Regardless of how beneficial collaborative learning can be, a common thread throughout students' responses was the need for all group members to "do their share". Removing much of the joint group grade and implementing a larger portion on individual work was not enough for students to fully embrace the collaborative work. There is a need for students to be accountable for their portion of the work for the group to truly be successful and productive. Moving forward, I would like to implement regular progress reporting during collaborative projects. This would resemble something similar to how research groups at universities meet weekly to share their progress. The key would be for these progress reporting meetings to be done as a whole group or whole class with the intent to raise the bar for individual accountability while simultaneously providing an opportunity for feedback and ideas from peers. This would also provide a foundation for building an understanding of the value in peer review and the benefits of

collaboration and how it works in the real world. These “progress meetings” would be conducted using a platform such as Google Meet for remote learners with the requirement that cameras must be turned on and microphones must be used.

Future Research

Next steps for research include evaluating student growth in meeting the science learning objectives in an online environment. Careful and thoughtful consideration needs to be given to what is expected of student learning in remote classrooms versus brick-and-mortar to determine what content should be highlighted and what can be eliminated to provide the most relevant and practical science education that takes the most advantage of the flexibility available in virtual settings. Teaching science remotely to remote students was significantly different from traditional brick-and-mortar education.

Contrary to popular belief amongst educators I encounter, a virtual classroom may have the potential to exceed what can be learned in brick-and-mortar classrooms. This was indicated by responses from this study’s student interviews where one student commented that she learned more this year than the previous year in person. Another student stated how much he appreciated not having to ask, “Why are we learning this?” because I related the content to their everyday lives making the learning more fun and relevant. There was another online student that traveled a great deal throughout the school year and yet he always logged into class even while in the car. He would share with the class where he was and where he was heading and allow us all a view of the scenery. Such a personal experience would be difficult to replicate in a physical classroom and receive the same enthusiastic responses from classmates. Not to mention, had he been in

person, he would either have been forced to miss school altogether for his family trips or missed out on all those experiences.

This leads me to hypothesize that given an appropriate amount of time to prepare and having access to digital equipment and resources a teacher would need that an online science class has the potential to not just meet the same learning objectives as in person students but possibly exceed them. The time it takes to learn online versus in person could be of concern as well. However, one must consider the time gained from the elimination of distractions due to various classroom management issues, drills, and assemblies. Online school also avoids weather related school closures. Therefore, whatever time is lost during online learning due to unforeseen issues such as internet connectivity, can certainly be gained back due to the lack of so many other interruptions with proper planning.

The Iowa Core science standards, NGSS, designated for 7th grade include physical science, earth and space science, and life science topics for a total of 19 standards, with nearly half falling under the life sciences category at 9 standards. Energy is the common theme throughout the standards with the lion's share of the life sciences residing in ecosystems.

In a physical classroom, engaging in authentic inquiry-based learning that students can relate to their everyday lives, particularly regarding ecosystems, presents some challenges including but not limited to lack of appropriate and relevant outdoor space, limited time for taking students outside and the increasing resistance for allowing fieldtrips. This is where online learning can offer advantages. They are not constrained by 4 walls and a bell schedule. Students can simply step outside their front or back door. An online class can be made asynchronous at any time to allow for student investigations, or the entire class can be taken outside without the

need for permission slips. This allows for individualized learning to easily take place based on a student's interests or surroundings. This further allows the teacher to become the facilitator of learning rather than just a provider of facts.

The big ideas represented in our performance expectations that could be optimized for online learning include potential and kinetic energy; energy conservation and transformations; thermal energy; magnetic and electric forces; cyclic patterns of Earth-Sun-Moon System; flow of energy and cycling of matter through ecosystems; environmental and genetic factors that influence structure, function, and growth of organisms; characteristic animal behaviors and specialized plant structures that impact reproduction; organizing Earth's 4.6 billion year history using rock strata and geological time scale.

Considering the emphasis on 3-D learning with NGSS, as opposed to rote memorization of facts, this needs to be considered when choosing the performance expectations that would best exploit the unique flexibility and versatility of online learning. Students can choose an area around their house, neighborhood, or local park as a study site effectively individualizing every student's learning experience. An energy pyramid constructed from one study site could be vastly different from another student's site or the types and consequences of an impact on a local ecosystem can vary greatly from one student's surroundings to another. Motion in terms of potential and kinetic energy and the effect of gravity on projectile motion only needs a ball and table. Footballs and basketballs outside provide excellent data collection opportunities as well. Recording observations of the Sun's location throughout the day and year to learn about the relationship between seasons, sun angle, and day/night cycles. Getting students outside to observe and record the position of the sun relative to the moon to make connections to moon

phases and causes of eclipses. Learning how evidence from rock strata is used to organize Earth's history can be done by studying local geology in Iowa, bridging the gap between the classroom and their surroundings. Geological features of Iowa such as the exposed Precambrian bedrock that was once sandstone providing evidence of the ancient ocean that once covered Iowa or the phenomenon of the lack of dinosaur fossils found even though western Iowa's upper bedrock is late Cretaceous. Each student would be learning the same content and skills yet be able to apply it to different situations and sharing their specific findings with the whole class via digital platforms effectively elevating what would be feasible in a brick-and-mortar classroom.

Students' learning could be measured by tracking their growth through various units. Treatment units would be these non-traditional units designed specifically for online learning and the comparison would be the traditional units. A comparison of gains between the treatment units and traditional units based on learning targets would provide evidence of students' learning and growth to determine the effectiveness of learning science online.

REFERENCES CITED

Altiere, A. E. (2016) *The effects of cooperative learning structures on traditional instruction in a middle school science classroom.* (Professional paper submitted for Master of Science in Science Education in Bozeman, MT). https://scholarworks.montana.edu/xmlui/bitstream/handle/1/10029/AltiereA0816.pdf?sequence=5&isAllowed=y

Anderman, L. H., Midgley, C., & ERIC Clearinghouse on Elementary and Early Childhood Education, C. I. (1998). *Motivation and middle school students. ERIC Digest*.

Currie-Rubin, R. (2019). Understanding the roles of families in virtual learning. *Teaching Exceptional Children*.

Eisenbach, B. B. (2016). Considering the virtual classroom: A call to middle level education programs. *Middle Grades Review*, *2*(1), 1–7.

Engels, M., Miller, B., Squires, A., Jennewein, J. S., & Eitel, K. (2019). The confluence approach: Developing scientific literacy through project-based learning and place-based education in the context of NGSS. *Electronic Journal of Science Education*, *23*(3), 33–58.

Gemin, B., Pape, L., Vashaw, L., & Watson, J. (2015). *Keeping pace with K–12 digital learning: An annual review of policy and practice*. Evergreen Education Group. https://files.eric.ed.gov/fulltext/ED570125.pdf

Herold, B. (2017). Online classes for K–12 students: An overview. *Education Week*, Editorial Projects in Education Research Center. https://www.edweek.org/ew/issues/online-classes/index.html

Kiefer, S. M., Alley, K. M. & Ellerbrok, C. R. (2015) Teacher and peer support for young adolescents' motivation, engagement, and school belonging, *RMLE Online*, *38*(8), 1-18, https://doi.org/10.1080/19404476.2015.11641184

Kose, S., Sahin, A., Ergun, A., & Gezer, K. (2010). The effects of cooperative learning experience on eighth grade students' achievement and attitude toward science. *Education, 131*(1), 169-180.

Lin, E. (2006). Cooperative learning in the science classroom. *Science Teacher*, *73*(5), 34–39.

Morgan, H. (2015). Online instruction and virtual schools for middle and high school students: Twenty-first-century fads or progressive teaching methods for today's pupils?

Ryan, A. M., & Patrick, H. (2001). The classroom social environment and changes in

adolescents' motivation and engagement during middle school. *American Educational Research Journal, 38*(2), 437-460.

Swan, B., Coulombe-Quach, X.-L., Huang, A., Godek, J., Becker, D., & Zhou, Y. (2015). Meeting the needs of gifted and talented students: case study of a virtual learning lab in a rural middle school. *Journal of Advanced Academics*, *26*(4), 294–319

APPENDICES

APPENDIX A

STUDENT PRE AND POST TREATMENT ATTITUDE SURVEYS

Name: _____ Class Period: ____

Filling out the following survey is completely voluntary. Participation or non-participation will not affect students' grades in any way. Your honest responses are important and greatly appreciated.

Here are some questions about you as a student in science class. Please read each statement carefully. Choose the number that best describes what you think about these statements. There are no "right" or "wrong" answers. Your opinion is what is wanted. Some questions ask you to explain "why" you answered the way you did. Please answer as thoroughly as possible.

1 = STRONGLY DISAGREE
2 = DISAGREE
3 = NOT SURE
4 = AGREE
5 = STRONGLY AGREE

1. Learning science online this year will be hard.

   1 2 3 4 5

   Why did you answer the way you did in the above question?

2. I feet I will not have useful school resources while learning science online.

   1 2 3 4 5

   Why did you answer the way you did in the above question?

3. I believe I will be too distracted while learning science online.

   1 2 3 4 5

   Why did you answer the way you did in the above question?

4. I feel I can learn science online better if I am able to discuss assignments with classmates in small groups.

   1 2 3 4 5

   Why did you answer the way you did in the above question?

5. I feel more connected to my online science class when I can work with classmates.

   1 2 3 4 5

   Why did you answer the way you did in the above question?

6. When learning science online, I enjoy working independently.

   1 2 3 4 5

7. I feel better about learning science online when I can work in small groups.

   1 2 3 4 5

   Why did you answer the way you did in the above question?

8. When learning science online, I enjoy being able to work with others.

   1 2 3 4 5

9. When I work in small groups online, I feel that I can get more work completed compared to when I work alone.

   1 2 3 4 5

10. When I have to work individually during my online science class, I learn less compared to when I can work with others.

    1 2 3 4 5

    Can you give me an example?

11. I feel that I get distracted easily when I work with others during online learning.

    1 2 3 4 5

    Can you give me an example?

12. I feel that working with others helps to keep me engaged while learning science online.

    1 2 3 4 5

    Can you give me an example?

APPENDIX B

STUDENT INTERVIEW QUESTIONS

Participation is completely voluntary. Participation or non-participation will not affect students' grades in any way.

1. How has learning science online been going this year?
    a. Are you doing as well, better than, or worse than you expected? Why?
    b. What do you like about learning science online? Why?
    c. What have you not liked about learning science online? Why?

2. Do you prefer learning new science concepts asynchronously, on your own at your own pace, in small groups of 3-4, or whole class live instruction? Why?
    a. When do you prefer to work alone? Why?
    b. When do you prefer to work with others? Why?
    c. Does working with others in our online model help you learn?
        i. Why or Why not?
        ii. Can you give an example?

3. What is your opinion on working in small groups online as compared to individual learning online?
    a. Can you give me an example?

4. Are you more likely to participate in classroom discussions and activities when you are in small groups or during whole class live meetings?
    a. Why? Can you give me an example?

5. What can I do as your teacher to help make learning science online more effective? Why?
    a. Should students or the teacher choose the groups for collaborative work? Why?

6. Is there anything else you would like to share about learning science using collaborative learning strategies?
    a. Breakout Rooms
    b. Flip Grid
    c. Peer Review/Virtual Gallery Walks
    d. Group Projects & assignments

7. Is there anything that you think that YOU could do, or could have done differently to improve your learning experience?

8. Do you believe that learning online was better for you during collaborative learning tasks compared to independent learning?