WHEN CURIOSITY DRIVES SCIENTIFIC DISCOVERY

by

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ABSTRACT

Through establishing a learning environment that encourages curiosity and enables student discovery through the learning process, students developed their own research and lab investigations. Observational data, student interviews, surveys, and a teacher reflective journal were used to collect data, which was processed using qualitative analysis strategies. The results strongly indicate that allowing students to develop their own learning pathway leads to greater student engagement and increased learning, ultimately improving the learning atmosphere in the classroom.

INTRODUCTION AND BACKGROUND

The students in my fifth-grade class are ten and eleven-year-olds at Hawthorne Elementary in Bozeman, Montana. Hawthorne Elementary is a K-5 neighborhood school located in the heart of the city. There are approximately 336 students enrolled at Hawthorne. The majority of the students are middle class and white. According to Great Schools, Hawthorne's population of students consists of 92 % white, 4 % Hispanic, and the remaining 4% are Asian, Black, and/or American Indian. Seventy-seven percent of the students at Hawthorne are ineligible for free or reduced lunch, 20 % qualify for free lunch and 3% qualify for reduced lunch.

Although Hawthorne is a public school, its involvement in the arts gives it a different feel than other public schools in the district. We are blessed with a great number of parents, eager to volunteer in the many art-focused events throughout the year, as well as STEAM (Science, Technology, Engineering, Arts, and Mathematics) night, family math game night, and more. We develop strong connections with local artists and our proximity to downtown allows us to keep our finger on the pulse of community events. These unique qualities present the opportunity for students, parents, and staff to be open for new instructional practices and methodologies. In general, the students at Hawthorne are academically motivated and well supported at home.

Last year, I decided to shift my instructional practice in science and began focusing on designing hands-on lessons that allowed my students to explore and learn on their own as we moved through each unit in science. Toward the end of the year, I began encouraging students to create their own lab investigations. When tasked to develop and design their own experiments, I saw my classroom undergo a noticeable change. The changes I saw in student engagement, student learning, and my perspectives on education all contributed to the development of my AR plan.

I have been working with this age group for ten years. Throughout these years, my role as an educator has shifted a number of times. Currently, I teach all subjects, including: math, science, social studies, reading, writing, and art, to one classroom of students. Throughout these years, I have yet to see a science curriculum that encourages creativity, connects to local real-world problems, and empowers students to develop their own investigations. The result is too many disengaged learners.

Science education needs to be dynamic and student driven, connect to real-world problems, and inspire curiosity. I view my classroom as an extension of life, where I expect all students to take responsibility for themselves and their own education. The purpose of this study was to examine the effects of providing my fifth-grade students with the opportunity to learn through research or experimental investigations that were entirely student designed. By promoting academic independence and allowing for meaningful learning to take place, I have created opportunities to examine my research questions.

Focus question:

1. How does allowing students to design their own investigations in an elementary science classroom affect student engagement?

Sub questions:

2. How does allowing students to design their own investigations affect attitudes about learning?
3. How does allowing students to design their own investigations impact me as a classroom teacher?

CONCEPTUAL FRAMEWORK

Before I launched into my investigation, I explored the research that others had done in similar fields to help prepare myself for developing my research plan. In particular, I was curious about hands-on learning/project-based learning, student engagement, journaling in science, and how hands-on/project-based learning impacted the educator.

From the online journal School Science and Mathematics, I uncovered an article which promotes the use of hands-on materials to improve science education in the classroom. The belief that science should be experienced has always been the cornerstone of my practices as a science teacher (Harty, Kloosterman, & Matkin, 1989).

Sometime ago, I broke away from our district-supplied Full Option Science System kits because of their inherent tendency to provide too much structure. Although they implement a variety of hands-on lessons, they lacked the ability for children to experience science in an individual way. Through this curriculum, all students are working on the same investigations; which produce the same outcomes.

This article reemphasizes the value in teaching science using a hands-on approach so that students feel like they are discovering information for the first time. I want my students to be excited about learning and connected to what they are studying. Providing them with the opportunity to design their own investigations has allowed them to take ownership for their learning and potentially feel like they are pioneers in science.

In another article I discovered, research was conducted on the effects of project-based learning on a group of sixth-graders. The authors created both an experimental and control group to test and compare pre and post tests for a unit on electricity. The group of students that was learning through project-based learning (experimental group) outperformed the students that were receiving the district's standard science education (Ergul & Kargin, 2014).

After reading through the article I asked myself the question, how could I use this research to help guide me as I continue to develop my AR? There was no question I would be using a hands-on approach to teaching science with my students. Project based learning is being encouraged throughout our district cross circularly. This article was inspiring and supported my current practices.

The article also provided me with valuable insight on how to plan and structure my research. In particular, the authors did a fine job of determining all variables before determining their two groups. However, their only measurement tool was testing. As I continued to move in the direction of planning my AR, I became certain that measuring growth by comparing student work samples throughout the course of my investigation would be extremely valuable, but it would not provide enough data to support the answers I needed for my research questions. I decided to include surveys, observational data, student interviews, and a teacher-reflective journal to gather the data that I needed.

Since my primary research question is focused on assessing engagement, it was imperative that I define what engagement is and how it could be observed. I found a fantastic and very informative article that helped me understand how student engagement is defined and how it can be measured (Heddy, Lombardi, & Sinatra, 2015). The authors of this article began by explaining that engagement can be split-up into four categories: behavioral, cognitive, emotional, and agentic. Although these groupings overlap, there are differences in each area. For example, agentic engagement occurs when a student is proactive during instruction and contributes to the instruction by requesting particular teaching or material. Behavioral engagement is a measure of a student's effort, persistence, and physical displays of maintaining attention.

At first, setting out to measure engagement with my students was a challenge. However, this article provided the framework to help define the types of engagement I could be looking for. I did not set out expecting all students to display agentic engagement but did expect all or most students to be behaviorally and emotionally engaged. Later on, as I moved through my Action Research plan I used the information from this article to determine how to measure engagement.

I discovered another article in which the author investigates how using a flipped classroom model of instruction impacts engagement and offers views of the nature of science (Clay, 2013). I chose this particular article because like Clay, my AR plan seeks to increase student engagement.

When examining his data, I felt a little bit overwhelmed. Although he included a few tables to display his data, I felt that the majority of his analysis was delivered through sharing percentages. The graphs and tables were mainly included at the end of the article rather than within the data and analysis section. Reading through this article I began to consider my formatting choices for my future capstone and decided that I would display my tables, graphs, and data to support my written analysis within my paper.

Taking the time to read through AR papers provided perspective on the process, formatting, and content (McWhorter, 2013). Since I use science journals daily in my classroom, I was curious to see how she was using them with her students and what the effects were of requiring her students to use them on fieldtrips. Also, I was interested to see what methods of data collection she used to support her claims.

In the data and analysis section of her paper I was immediately drawn to her survey questions (Figure 1). I really liked the questions that McWhorter asks in her student survey. In particular, questions 2, 3, 5, and 6, these questions seem to target student engagement. Since a significant focus of my AR project was on assessing and measuring student's levels of engagement in science, examining an AR Project like this one was extremely helpful in planning my own. The act of creating a student survey that asks students questions that help reveal engagement and learning required a significant amount of foresight and planning.

(1) I spend a lot of time with my family when I'm not at school.
(2) I like to draw in a journal/notebook in my free time.
(3) I like to do science experiments at home.
(4) I look for answers to my science questions online.
(5) I enjoy my science classroom.
(6) I feel comfortable about asking questions in my science classroom.
(7) I find using a science journal in the classroom is helpful.
(8)I look forward to writing notes in my science journal every time I go to science class.
(9) When I am indoors I feel less stressed.
(10) My teacher is enthusiastic about teaching me science.
Figure 1. Survey questions from McWhorter's AR paper, (*N*=100) (McWhorter, 2013).

We have been using science journals this year more than ever in the past. We use them to collect data for math, sketch detailed drawings, record observations, document feelings and thoughts, and record valuable vocabulary and concepts. I am certain that most of the children appreciate their science journals and are proud of the work they have done. Digging into the extensive research which has been done on using science notebooks in the classroom, an article from The National Science Teachers Association provided valuable insight into my planning (Young, 2002).

Young explains that science journals provide the opportunity to, "strengthen student learning of curriculum through increased student participation." Since a large percentage of my project is centered on creating independent learners, the use of notebooks seems like an essential tool for building academic independence. Since the students designed their own investigations, which centered around their own questions, science notebooks provided an excellent platform to creatively explore ideas, organize thoughts, and interact with the curriculum.

Before I began collecting data for this action research project, I anticipated some potential challenges with my AR plan. One challenge that continued to surface was the question of whether or not my students would always be able to come up with their own investigations. Reading through another article, I was reminded of this challenge (Colley, 2014). In the study, the author teaches one fourth and two fifth grade classrooms using "responsive teaching." Responsive teaching is when the teacher adjusts their teaching and instruction based on the activities, discussion, curiosity, and discovering of the group. Following a teaching model like this allowed me to be more flexible and prepared to deviate from my intended teaching plan.

Before this article, I had not heard of the term “responsive teaching.” In fact, I continued to explore the idea and uncovered a number of other websites, which offered a wealth of associated knowledge and excellent starting points for designing lessons.

During the literary review, I discovered a fantastic article in which the author describes his instructional concerns and explores his teaching practices as a high school physics teacher (Hammer, 1997). In his classroom, he allows students to explore ideas through discovery learning.

Starting off the article, he shares an anecdotal story about allowing students to invent an explanation by designing, testing, and replicating an experiment as they come to their own conclusion. However, their conclusion is incorrect. He continues on to discuss the difficulty in allowing students to develop their own scientific thinking and at the same time providing them with accurate content. He refers to this as “a tension among objectives.” I too, felt this tension among objectives as a teacher and throughout this project. As I read on in the article, Hammer addressed another concern of mine. “How much time should you devote to inquiry-oriented activities, at the expense of coverage?” (Hammer, 1997, pg. 485). There are so many concepts to teach, in all subjects. Allowing students to explore and design their own investigations takes time. On the other hand, teaching from a science book without involving hands-on learning time allows for excellent coverage of concepts, but does not entirely captivate students and encourage them to take ownership of their science education. This article was extremely useful in guiding my AR development.

METHODOLOGY

Preparing Students for Investigations

Currently, the units of study for our fifth-grade curriculum include: Ecology, Geology and Light and Color (Table 1). The Bozeman School District provides FOSS kits, which contain a variety of hands-on learning activities and teacher driven lesson plans. Generally, my practice has been to use the consumable materials provided in these kits to design my own investigations to instruct the students.

Table 1
Timeline of Units in Science

Unit	Tentative Dates
Ecology	October-January
Geology	February- March
Color and Light	April-June

This year, I altered my practice to allow for greater student involvement. My year-long plan began with using the month of September as a time to prepare my students for the greater academic independence that was to come later in the year. Most of this time was spent developing curiosity, refining observational skills, improving questioning techniques, defining journaling procedures, and understanding what it means to be "scientific." I introduced the students to my year-long plan in science, which included informing them of their involvement as designers of investigations. We discussed what an investigation is, why we investigate, and how we investigate. This was a very important time that helped lay a solid foundation for my students to write their own investigations later in the year.

Part of this year-long plan included launching each unit of study with an introduction to pertinent vocabulary, scientific processes, and relevant historical connections. Throughout this introductory week, I encouraged students to be observant and record questions they had relating to the material we were studying. We discussed not just the importance of asking questions in science but also determining what to do with these questions. It took some time for the class to understand that not all questions can be investigated. Some questions can lead to quick answers found through simple logic or group discussion. Some can be found through a quick internet search, while other questions require more time and effort to answer. The questions that do not have simple answers became the starting point of this AR project.

I needed the students to come up with questions for this AR project that not only connected to our unit of study but could also lead to one of two places. The question they planned to investigate needed to lead to either a research investigation or an experimental investigation. It was also imperative to my study that the students developed solid questions that they genuinely wanted to answer.

The research conducted for this action research project took place from October 2017 through January 2018. The unit of study for this time period was Ecology.

Scaffolding Through Mini-Lessons

Following my week long introductory lesson, I delivered one or two science mini-lessons each week in response to the needs of the class or individual students. Knowing specifically what all my students were working on gave me a variety of options for my mini-lessons. The fact that most students in the room were working on different research topics made it difficult at times to prepare lessons. Therefore, I only presented information to the whole group that would help support their research and shared advice to individual students when it did not apply to the whole group.

Here are some examples of mini-lessons presented during this collection period: developing data tables, planning observations, the importance of research- Alexander Fleming's discovery of Penicillin, the art of writing a compelling introduction, inserting graphs, developing your hypothesis, and drawing conclusions (to name a few).

Lab Leaders, Lab Assistants, and Research Presentations

This year, I allowed students to work alone or with partners on their investigations. Since I allowed the students to pursue answers to questions of both a researchable and experimental nature, there were two types of investigation outcomes. I tried my best to include all students in both methods of investigations by creating a system which helped expose students in the room to each other's investigations. Students that developed experimental investigations were placed in positions as lab leaders and students who did not develop experimental investigations were assigned to the lab leaders as lab assistants. Therefore, not all students were required to design their own experimental lab.

As for the researchable investigations, those students were required to follow a specific rubric which included a sharing component to their project. This sharing component required them to present their findings to the class or to a small group. If you examine the rubric, it is clear that these students were required to track not only their research but also their thought process throughout their investigation (Appendix A).

Approving Experimental Investigations

To help manage my classroom I created an approval process for the experimental investigations. In order for an investigation to begin, it had to be approved by me. Together as a class, we outlined what an investigation should look like and how an investigation should be designed. I then created a rubric that aligned with what surfaced in our discussion (Appendix B). Once students designed their plan, they were instructed to submit it to me. I went through it using my rubric and provided feedback which included suggested edits and required changes.

For each investigation that was submitted, I encouraged students to design investigations that took no more than three weeks to complete. My expectation was that the investigations would improve over time. To allow for more investigations to circulate throughout the study period, I gradually raised the bar on my expectations for their investigations.

Many of the investigations that the students designed centered around growing plants, since our first unit was Ecology. Student groups developed a variety of experiments including; how light impacts plant growth, how the depth a seed is planted affects growth, and temperatures role in plant growth.

Research and Data Collection Methods

I incorporated a variety of instruments to help synthesize the data collected (Table 2.)

Table 2

Research Questions and Data Collection Methods

Research Question	Observation	Student Interviews	Student Survey	Reflective Journal
#1	X	X	X	X
#2		X	X	
#3				X

Focus Question: How does allowing students to design their own investigations in an elementary science classroom affect student engagement?

Since my primary research question was centered on assessing student engagement, I chose to use all my data collection methods to collect data to answer this question. Through the use of my instruments I was able to capture a wide range of information as it surfaced to assist in measuring student engagement.

The instruments I designed to measure student engagement were; an observational tally sheet, which was used while students were working on investigations, student interview questions, a student survey, and sections from my teacher reflective journal.

Question 2: How does allowing students to design their own investigations affect attitudes about learning?

Student interviews and surveys helped provide opportunities to investigate changes in attitudes about learning.

Question 3: How does allowing students to design their own investigations impact me as a classroom teacher?

Through the use of a reflective teacher journal I gathered data to help learn more about how this AR project impacted me. Within the journal, I recorded specific information regarding what was happening in my classroom, as well as how the study impacted me. I also include information from the student survey.

Table 3 below outlines the data collection schedule as corresponded with each instrument and technique.

Table 3
Data Collection Schedule

Instrument	Technique	Occurrence
Observations	Observed and recorded student behavior and discussion during science periods.	Observations took place when permitted on multiple days throughout the collection period.
Student Interviews	A small cross-sample of students was selected and interviewed.	Four students were interviewed in early December at the end of the treatment period.
Student Survey	Questions were administered and collected through Googleforms	Once at the start and once at the end of the collection period
Reflective Journal	Journal entries shared insights into the day, observations, plans for mini-lessons, feelings regarding teaching.	Recorded in audio and written journal multiple times a week throughout the treatment period.

To ensure that my instruments were valid and reliable, I consulted my professional peer group within the Masters of Science in Science Education program through Montana State University and also shared this plan with my advising team. This study received exemption from the Montana State's Institutional Review Board and compliance for working with human subjects was maintained (Appendix C).

DATA AND ANALYSIS

Student Engagement

As the information was collected from each of the measurement tools, it was sorted accordingly to reveal themes associated with student engagement, student attitudes about learning, and the overall impacts this study had on me as the classroom teacher. Since the primary research question focused on student engagement, this section will begin with the analysis of the data pertaining to student engagement.

An interview was conducted to help reveal information on student engagement and also their views on learning throughout the treatment period. The four students that participated in this interview were a stratified sampling. One student was from my gifted population, one was an identified struggling learner, one had appeared engaged and eager to learn throughout the treatment period, and the last student was quieter and seemed less engaged and potentially less intent on learning during the treatment period.

During the student interview, a variety of questions were presented to the students. Many of these questions related to student engagement. To begin the interview, students were asked if they liked school. All students shared that they like school. Next, the students were asked, “What in particular are you enjoying about school?” All four students said that they liked science and agreed that it was their favorite subject. When asked, “What do you enjoy about science?” one student responded with, “I like making investigations and figuring out answers to my own questions.” Several students nodded their heads in agreement while another student mentioned that she enjoys the independence that science class provides.

Throughout the observational sessions, students were observed working independently on their projects, even when working with partners. During this time, the students appeared focused and approached their tasks with responsibility. During one observation, I overheard one student suggest, “Let’s work alone for a while and then share what we find later. I think then we could get more done.”

The student survey asked, “Do you like the idea of students creating their own investigations or would you prefer that I create them for you?” At the start of the study, 72% of the students said that they liked the idea of students designing their own investigations. At the end of the study, that percentage increased to 89%. One student reported; “My partner and I have been working on this project really hard and we have spent as much time as we can working on it, even at home.” The survey also revealed that at the start of the treatment period, 33% of the students felt science was their favorite subject. At the end of the treatment period that percentage increased to 45%. Responses and observations like these indicate that the students were engaged in science because the work they did during the treatment period was meaningful to them. Furthermore, it suggests that providing students with the opportunity to participate in independent and self-designed projects leads to an increase in student engagement.

Within my classroom, there were a wide range of learners, all showing differing levels of engagement. Throughout this action research project, I paid close attention to my population of students that is most frequently disengaged. In the interview, I asked the group, “Do you think that there are students in this class that are more engaged in science than in other classes?” One interviewee brought up a student who had been viewed by me during multiple observation periods working extremely hard. The interviewee described this student as, “much more engaged than she normally is.” Another student shared, “Yeah, she normally doesn’t do much unless you help her, but she seems to be working really hard on her investigation." Similarly, the third interviewee reported that another student, who tends to struggle to produce work, "does a lot of work on his own and even helps others out." For both of these statements, all the students in the interview group agreed.

During multiple observations, I witnessed students that generally take five minutes or more to get on task, start working in less than a minute. I saw students that are easily distracted and struggle to maintain their attention and work diligently throughout thirty-minute periods. In fact, the student that was mentioned during the interview as "much more engaged than she normally is" had a rather significant breakthrough early on in the study. During our second work period in science, she decided to stop using the "voice to type" feature on her computer because it was slowing her down. Prior to this moment, she did the majority of her writing using this tool, hindered by its inaccuracy. Incidentally, this student soon phased out the "voice to type" tool as a necessary component to her writing for the remainder of the year.

Other students who generally struggle to engage showed remarkable growth throughout the treatment period. One particular group of students, two of whom are on Individual Education Programs, decided to work together on their first investigation. This was the first time that this group of boys had decided to work together. At the very beginning, they struggled to communicate and get on task. At first glance, they appeared to be "fooling around." However, as I continued to observe them, I noticed that they were confused. This confusion was displayed by wandering to other groups to observe what they were doing, bickering over who would type on the computer, and asking to use the bathroom or get a drink of water. After I provided them with another set of instructions, the students quickly got on task. Five minutes later, they were observed building their plan and discussing ideas, all wearing very serious looks on their faces.

In the survey, the students were asked to what degree they agreed with the statement, "I have a hard time paying attention in science." Table 4 displays the student responses to this question from the start to the end of the treatment period.

Table 4
I have a hard time paying attention in science (N=28)

	Strongly Disagree	Disagree	Agree	Strongly Agree
Start of the Treatment Period	40 %	36 %	24 %	0 %
End of the Treatment Period	44 %	36 %	20 %	0 %

Through the triangulation of observational data, the student interview, and the student survey there is clear evidence to support the claim that the work the students were involved in throughout the treatment period increased engagement for students who ordinarily struggle to engage in their work.

Attitudes About Learning

Student attitudes about learning are closely linked to student engagement. In my experience, students who maintain positive attitudes about learning tend to find deeper engagement. Since student engagement increased throughout the treatment period, I expected that student attitudes about learning would also improve. Data collected throughout the treatment period provided clear evidence to show that student attitudes about learning improved through allowing students to design their own investigations.

During one observation period, I noted the comments students made when they were told we were going to take a five-minute break. Four groups of students said that they wanted to work through the break and the majority of the students exhaled, making a sound which clearly indicated that they did not want to stop working. Similarly, throughout the treatment period students asked to stay in to work through recess. It is common for certain groups of higher-achieving students to request to continue working through recess. However, the groups that wanted to stay in and work on science were not only the high-achieving students who were previously disengaged in learning.

During my second observational period, I recorded two out of the four students who requested to stay in and work were on IEP's for writing. During another recess period, I counted eight students who wanted to stay in, four of whom were struggling learners. During this time, I saw students outlining and planning their investigations. One student was observed taking notes on what his partners were reading. This particular student generally struggles to write in class without teacher prompting.

As the students continued to work on their investigations, their discussions with peers became more scientific. Around the classroom I noted students discussing variables, ways to display data, the need for evidence, and even challenging each other on whether their investigation was scientific enough. Throughout the study, groups were observed referencing the rubric and discussing the importance of certain criteria. During one observational period, I observed 100% of the groups examine the rubric at least once during a thirty-minute work period. Since the students were designing their own investigations, there was a need for them to venture off into side-research projects to better understand concepts to make better sense of their investigation. Numerous times, students approached me asking for help understanding unfamiliar vocabulary words, processes, or concepts. During an observational period on November 7th, a student asked me, “What is humidity?” I suggested that his group takes a moment to look up the word. Five minutes later, I observed the group members discussing the meaning of the word.

This theme that the students’ curiosity was driving their learning became apparent at the beginning of the study and continued throughout. Within my teacher reflective journal and numerous classroom observation sessions, the students were observed learning due to their own curiosity, but they were also seeking new scientific understandings out of necessity.

One group was observed researching photosynthesis to understand the needs of plants in order to better prepare for their investigation. Another group, who was investigating temperatures role in bacterial growth, had to restart their investigation after two weeks because the agar was drying out too fast. It was amazing to watch this group of students analyze their process and determine where they went wrong. During class time, they were observed researching agar thickness and humidity to better prepare petri dishes to restart their investigation. When it came time for them to create new petri dishes, they were now able to mix and pour them without my assistance. In my journal I shared my excitement for this group’s academic drive and desire to learn independently. “It is wonderful to see the students rebound from this upset. All of the petri dishes which were placed on the heating pad dried out! I was equally surprised. However, it was very encouraging to see them open their computers and solve the problem for themselves.”

The idea of having students take responsibility for their learning, was reemphasized later in the student interview. I asked the group if they felt like they were learning this year in science? One student stated, “We are teaching ourselves and learning from our mistakes.” Later in the interview, I asked the group what was motivating them to learn? A student responded with, “I like how in the investigations, we know what we have to do and what to get accomplished. We don’t need to be told what to do and we get to work on our own ideas and are in control of what we do.” Responses like this revealed that the learning opportunities provided through this action research project helped students develop more positive opinions of their potential as learners.

When questioned in the survey if they felt excited about learning each day in science, the student responses again aligned with the idea that this study improved their overall opinion of learning in science. Table 5 displays the data from this question.

Table 5
I feel excited about learning each day in science (N=28)

	Never	Sometimes	Often	Very Often
Start of Treatment Period	0 %	11 %	41 %	48 %
End of Treatment Period	0%	10 %	36 %	54 %

This data clearly shows that a greater percentage of students reported an increase in excitement for learning from the start to the end of the treatment period. When asked to share what excites them about learning in science one student responded by saying, “I feel like there is a different quality of learning in figuring out stuff on your own.” Another student added, “You get to share your ideas and work in groups. It feels really good when you are done because you are proud of what you accomplished.”

Not only were students excited about learning in science but they also felt like they were learning. Table 6 displays the percentages for their responses to a survey question asking if they felt like they were learning this year in science. The responses from the start to the end of the treatment period revealed that more students in the class strongly agreed with this statement over time.

Table 6
I feel like I am learning this year in science (N=28)

	Strongly Disagree	Disagree	Agree	Strongly Agree
Start of Treatment Period	0 %	0 %	38 %	62 %
End of Treatment Period	0 %	0 %	29 %	71 %

Impacts on Educator

Choosing to examine the impact this study has had on me, provided valuable insights that allowed me to improve my practices as an educator. Within my reflective journal I found numerous passages that shared my excitement for the work the students were engaging in. On October 26th, I stated, "I am enjoying this whole process. Although it seems chaotic and overwhelming at times to have so many different projects going on at once, I am eager to read student work, discuss investigations, challenge their methods, and learn with my students along the way." Similarly, another journal entry from later in the treatment period shared, "Students are engaging in research that seems far beyond my learning objectives. There is a lot happening in the classroom and it is difficult to track. However, most investigations are leading to very intriguing results."

The feedback I received from my data collection instruments provided me with continued encouragement and added to the excitement of teaching science. When it was time to collect data, I was eager and curious to read student responses or make observations. After collecting information from the first student survey, I recorded in my journal, "Today I conducted the student survey. Immediately after collecting responses I asked the class to silent read for the last five minutes before recess, to give me time to look over their responses."

Although I only included one question in the student survey to reveal student opinions on my level of excitement for teaching science, the results helped support the theme that allowing students to design their own investigations was exciting and engaging for me. Table 7 displays this data.

Table 7
My teacher appears excited about teaching science (N=28)

	Strongly Disagree	Disagree	Agree	Strongly Agree
Start of Treatment Period	0 %	0 %	11 %	89 %
End of Treatment Period	0 %	0 %	3.6 %	96.4 %

At the start of the treatment period it was already evident that my students felt I was excited about teaching science. By the end of the treatment period, a greater percentage of the students strongly agreed with this statement. This revealed the student's perception of my enthusiasm for teaching science matched my own feelings recorded in my reflective journal.

Throughout the treatment period and beyond, I was constantly thinking about this project. I would wake up in the middle of the night and record ideas. During my free time, I found myself tending to gently steer casual conservations with friends and family in the direction of my research project. Through the use of a voice recorder and a written journal, I was able to collect important observations and ideas as they would arise. I was constantly thinking of ways to improve and to help my students by seeking advice and opinions of others.

Not all aspects of this project were so easy. Preparing a variety of mini-lessons in response to student needs was challenging. At times, I had to be flexible in my teaching and sometimes lessons did not work out as well as I would have liked. Also, due to the diversity of investigations, I ended up finding myself creating mini-lessons that targeted smaller percentages of my student population. On November tenth, my journal reflected this challenge. “Creating mini-lessons that are relevant for all or even the majority of the students in the class is difficult.”

Even though I tended to keep the lessons brief, time seemed to be a persistent challenge that surfaced in my journal responses. “It is hard to keep up with the mini lessons and I also wonder if it is the best use of time. The whole process of creating and implementing an investigation takes a lot of time. I have so many other responsibilities as their teacher.” The amount of time that is allotted for science education in my classroom is limited. Not being able to meet every day or even three days a week was a persistent challenge. Again, this is reflected in my journal through responses like this, “These investigations are so consuming that in order to get them done in a timely manner, I would need to be meeting with these kids for at least an hour a day.”

INTERPRETATION AND CONCLUSION

Student Engagement

Providing my class with the opportunity to design their own investigations allowed the students to engage in research and hands-on-learning that led to greater independence and the production of more meaningful work. When I initially set out to begin this study, I wanted my students to feel like pioneers in the world of science. My expectation was that by allowing my students to choose their own questions to research and investigate, they would become more connected to their work, leading to increased engagement and improved attitudes about learning.

Student responses during the survey and interview provided valuable data to show that student engagement improved over time because the work was authentic and important to the students. At the beginning of the study, 72% (N=28) of students liked the idea of creating their own investigations. By the end of the study, that percentage increased to 89%. Similarly, 33% of students identified science as their favorite subject at the start of the treatment period. This percentage increased to 45% at the end of the study. Student quotes during both the interview and survey shared valuable information to help solidify the claim that not only had engagement increased, but more specifically, it improved because the work the students were doing was meaningful. Observational data helped triangulate this claim by providing consistent data that nearly all my students were engaged during work periods.

While examining the data associated with engagement, another important theme emerged. Allowing students to design their own investigations improved engagement for the commonly disconnected and distracted population of students in my classroom. During observational sessions, I observed a number of students who generally struggle to begin tasks, stay focused, and follow through, display remarkable engagement throughout work periods. I witnessed sudden breakthroughs in productivity, use of tools, and management of time. The student interview supported this claim by providing insightful quotes from multiple students suggesting that certain students were working harder than ever on their investigations.

Attitudes About Learning

There was a strong correlation between student attitudes about learning and student engagement. Since student engagement increased throughout the treatment period, naturally, the students developed more positive attitudes about learning. This was expressed during the interview, student survey and observational data. Sorting through the data, a number of themes emerged associated with student attitudes about learning.

At Hawthorne Elementary, my fifth-graders still get recess twice a day and it is a time that is highly valued. However, there are only a few groups of students who are willing to give up recess to work on assignments, silent read, or work on homework. There are also a large number of students who are a lot less willing to give up their recess. During the treatment period, it wasn't surprising to see that a number of students wanted to continue working on their investigation through recess. After all, the students were engaged and curious as they worked through their investigations. However, I began to see a new group of students requesting to stay inside. A number of struggling learners both on IEP's and not on IEP's began to fill my backroom multiple times a week. During observational periods, I would hear strong discussion, excitement, and discovery. The students were engaged and creating quality learning time during their recess block. Although I did not interview this group to determine their attitudes about learning, it was obvious through observations that they were now more confident and empowered as learners.

Observational data provided valuable insight into the improvement of student discussion. Over time, discussions became more scientific and poignant. I observed students using terminology and language absorbed through independent research or presented through mini-lessons. Students were using language that suggested they were more confident in themselves as learners.

Impact on Educator

Teaching the same material, year after year, provides the opportunity for educators to refine their craft. Lessons evolve and improve to become often vastly different over time. This year, my action research project required me to carve a new instructional path. By allowing students to take more of an active role in their science education, it became necessary that I learned to implement new instruction strategies, introduce new discussion topics, and scrap or alter previously used lessons. As a result, I felt more like a pioneer myself since each day was filled with new opportunities to learn alongside my students. My journal entries revealed this theme very clearly, with passages that shared my excitement for learning new concepts to further enrich my life and my pursuit of knowledge.

At times, the changes in the curriculum and adjustments to my teaching methods presented challenges. Within my journal, my notes relating to this difficulty were revealed. Fortunately, the data I collected along the way helped to reassure me that the kids were engaged and learning. Furthermore, the variety of learning taking place within the classroom ensured me that it was worth it.

Being prepared to teach a wide variety of mini-lessons required extra time for curriculum development. Some days, I would arrive prepared and eager to share new ideas only to realize that the lesson I had arranged was insufficient, too challenging, or not applicable to the entire group. Journal entries from throughout the treatment revealed this common theme.

Similarly, there was a feeling throughout the study that there was never enough time. Currently, I teach all subjects, which includes; math, reading, writing, social studies, and science. Therefore, it was common during the treatment period for me to only have science three days a week. As a result, I felt an unnecessary pressure throughout the study that there was not enough time. This was reflected throughout my journal.

Although there never seemed to be enough time, it was evident that the time we spent working on investigations was appreciated by the students. They were eager to get started and continue with their projects throughout the study. There were also days when individual groups or students struggled to be productive or encountered hurdles in their studies which were difficult to get through. Large science projects that require weeks of time to complete are not common in the elementary classroom. Prior to this study, my students had little to no experience in designing and executing projects of this nature. Some groups need a lot of support completing their final reports, while other groups went on to develop iMovies to share their research with their families and peers.

Fortunately, teaching specific science content is not a major priority in the Bozeman School District in the elementary setting. Throughout the past six years that I have been teaching in Bozeman, I have witnessed the overhaul of our reading, writing, and math curriculums. Meanwhile, advancements in our science and social studies curriculum have taken a backseat. Therefore, stepping away from the traditional science classroom which focuses more on content, was an option for me. Although I was able to cover most of what I generally teach from year-to-year, I was forced to leave out a number of lessons to make room for these investigations. However, the experiences and scientific understandings which resulted from this study were much more valuable to the education of my students than added content knowledge. I am certain that these investigations will leave a much longer-lasting impression.

VALUE

I have been teaching science for ten years. Throughout this time, my practices and my perspectives on education have evolved or changed in numerous ways, for a variety of reasons. I consider myself a highly reflective person in all aspects of my life and I am always looking for ways to enhance my instruction and improve my classroom. This action research project provided the perfect platform to alter and strategically analyze my work as an educator.

At the start of each year, I always explain to my students that their experience in fifth-grade will be unique and different from what they have heard from previous students. The changes I make are generally minute and include adjustments in curriculum, the introduction of new projects, and the inclusion of studies relevant to current events. These changes provide enough space to make each year distinct and significant for both the students and myself. Furthermore, modifications like these come with little risk, since I am always covering the same topics, just in different ways.

Meanwhile, greater adjustments which have the potential to have a larger impact on my students and I, often rest for years, waiting for the right time to be put into action. The concept of allowing and encouraging students to be in charge of their education has been on my mind for years. Being a part of the MSSE program was essential in providing me with the support, techniques, and methodologies to feel comfortable in allowing my students to learn with greater independence.

Creating an independent learning environment should be a goal in every fifth-grade classroom. The qualitative data and evidence that I gathered throughout this study revealed how important it is for this age group to be involved in independent, meaningful work. This is an age in which they begin to feel more autonomous and develop their own opinions, interests, and beliefs for possibly the first time. It can be a fragile and confusing phase in life, as they challenge the norms, question adults, lose their identity, or lose hope in themselves. It can also be an exciting time, as they begin to understand their own significance and define who they are. By allowing my students to let curiosity drive their learning, while giving them the necessary tools and the know-how to work on their own investigations, I provided more than just an engaging learning opportunity. In honoring their needs and respecting this important developmental phase, I believe that this action research project helped prepare my students for greater independence that is demanded in next few years to come.

My plan for the future and suggestion to other teachers is to establish a learning environment that blends the traditional science classroom with one that provides more space for student exploration, inquiry, and academic freedom. In doing so, this will ensure that time and content are properly preserved, while creativity and curiosity are nurtured. Furthermore, students will feel like they are doing unique and meaningful work, which will lead to deeper engagement and increased feelings of success as learners.

Within my teacher-reflective journal, passages revealed that opening the door for the students to research whatever they wanted, created conflicts with time. My first suggestion is to create a timeline of events, so that content is properly covered and investigations are completed in a timely manner.

My next suggestion is, create clear expectations of what needs to be accomplished as a minimum and make it even more clear that the sky is the limit. Building a rubric with the student's input is a highly effective way to eliminate misconceptions, set clear expectations, and improve student buy-in. Doing this will help your students who struggle to complete work know what is expected of them, while higher achieving students can push their work to another level and reach their fullest potential.

Lastly, be prepared to be flexible and deviate from your plan. There is a certain amount of unpredictability that comes with allowing students to design their own investigations. For example, you may discover that some lessons are no longer as important and will need to be replaced, altered, or completely scrapped. When this happens, be open with your students and share your teaching process with them. This will will help make their work feel significant. They may even begin to see that what you choose to teach is a reflection of what they are learning and what they need, which can be very empowering.

Reflecting on how this action research project impacted me, I am even more excited about my future in teaching. I learned a great deal about myself as an educator and a person and how I can best utilize my skills to improve my practice. I also identified some of the areas where I tend to struggle and found new ways to work toward improvement. Most importantly, I was reminded of how curious fifth-graders are and how capable they can be when they are genuinely engaged and motivated to learn.

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APPENDICES

APPENDIX A

OBSERVATIONAL TALLY

Observational Tally

Engaged	**Tally**	**Not Engaged**	**Tally**
Student is independently on-task		Student is independently off-task	
Students are working together on-task		Student is disengaged with another student	

APPENDIX B

RUBRIC: PLANNING AN EXPERIMENTAL INVESTIGATION

Rubric- Planning an Experimental Investigation

_____ **Research Question:** Identify your research question.

3 points	**2 points**	**1 point**
- Student clearly identifies research question. - Student explains how their investigation provides a plan to answer the question.	- Student clearly identifies research question. - Student struggles to explain how their investigation provides a plan to answer the question.	- Student does not identify the research question and does not explain how their investigation provides a plan to answer the question.

_____ **Statement of Purpose:** Explain why you are conducting this experiment?

3 points	**2 points**	**1 point**
- Student clearly articulates why an investigation is the appropriate tool for answering their question. - Student provides background information on where they got the idea for their investigation.	<u>Student completes both below but answers lack clarity.</u> - Student articulates why an investigation is the appropriate tool for answering their question. - Student provides background information on where they got the idea for their investigation.	- Student struggles to explain why they decided to conduct an investigation to answer their question. - Student struggles to provide background information on where they got the idea for their investigation.

_____ **Research and Development of Ideas:** Record what you know and need to know

3 points	**2 points**	**1 point**
- Student has written down what they know and identified what they need to know. - Ideas are organized and complete.	- Student has written down what they know and identified what they need to know. - Ideas are disorganized and/or incomplete.	- Student has struggled to identify what they know and need to know. - Work is disorganized and incomplete.

_____ **Hypothesis:** What do you expect the outcome of your investigation to reveal and why?

3 points	**2 points**	**1 point**
- Hypothesis is stated and their reasoning is clearly supported.	- Hypothesis is stated but student struggles to provide supportive reasoning.	- Hypothesis is stated but student does not provide any supportive reasoning.

_____ **Plan/Procedure:** Record your step by step plan.

3 points	2 points	1 points
- Student provides a detailed plan that clearly outlines how the investigation should be conducted. Student has payed close attention to detail, investigation can be consistently replicated.	- Student provides a plan that outlines how the investigation should be conducted. However, plan contains inconsistencies and/or lacks clarity and may be difficult for students to replicate.	- Student plan lacks detail. It may be difficult to follow and will produce inconsistent replication.

_____ **Timeline of Investigation**

1 points	0 points
-Student provides timeline of investigation	- Students does not provide timeline of investigation.

_____ **Materials List:** What materials are needed to conduct your investigation?

2 points	1 point	0 points
-Student provides complete materials list	Materials list is incomplete.	No materials list

_____ **Organization:** You must create ways for your team of scientists to sort and organize data. Tables are great for quickly gathering and sorting information. Creating the table prior to starting the investigation helps you know what you will be measuring and where those measurements will go.

3 points	2 points	1 point
- Student includes at least two well designed tools for students to organize the collected data.	- Student includes either one well designed tool for students to organize their data or student includes two tools, but they are underdeveloped.	- Student includes only one tool that is underdeveloped.

APPENDIX C

INSTITUTIONAL REVIEW BOARD

MONTANA STATE UNIVERSITY

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
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MEMORANDUM

TO: Clinton Pike and Walt Woolbaugh

FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 27, 2017

RE: *"When Curiosity Drives Learning"* [CP112717-EX]

The above research, described in your submission of November 21, 2017, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

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

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

___ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

___ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

___ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

___ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX D

STUDENT SURVEY

Student Survey
1= Strongly Disagree, 2= Disagree, 3= Agree, 4= Strongly Agree

1. I like the idea of students creating their own investigations.

2. I have a hard time paying attention in science.

3. I feel excited about learning each day in science.

4. Science class makes me curious to find answers to questions that I have.

5. I see other students who usually have a difficult time working, working hard during science.

6. I feel like I am learning this year in science.

7. I work on science assignments outside of school because I am excited to work on investigations.

8. I am curious to find out what others discover from their investigations.

9. My teacher appears excited about teaching science.

10. I feel like I am getting better at writing investigations (research or experimental investigations).

APPENDIX E

SCIENCE RESEARCH INVESTIGATION RUBRIC

Name ________________________________ **Date**____________________

Science Research Investigation Rubric

_____ **Research Question:** Identify your research question and explain how you plan to answer it.

3 points	**2 points**	**1 point**
- Student clearly identifies research question. - Student explains how their investigation provides a plan to answer the question.	- Student clearly identifies research question. - Student struggles to explain how their investigation provides a plan to answer the question.	- Student does not identify the research question and does not explain how their investigation provides a plan to answer the question.

_____ **Statement of Purpose:** Explain why you are conducting this experiment and where the idea came from.

3 points	**2 points**	**1 point**
- Student clearly articulates why an investigation is the appropriate tool for answering their question. - Student provides background information on where they got the idea for their investigation.	<u>Student completes both below but answers lack clarity.</u> - Student articulates why an investigation is the appropriate tool for answering their question. - Student provides background information on where they got the idea for their investigation.	- Student struggles to explain why they decided to conduct an investigation to answer their question. - Student struggles to provide background information on where they got the idea for their investigation.

_____ **Research and Development of Ideas:** Record what you know and need to know

3 points	**2 points**	**1 point**
- Student has written down what they know and identified what they need to know. - Ideas are organized and complete.	- Student has written down what they know and identified what they need to know. - Ideas are disorganized and/or incomplete.	- Student has struggled to identify what they know and need to know. - Work is disorganized and incomplete.

_____ **Hypothesis:** What do you expect the outcome of your investigation to reveal and why?

3 points	**2 points**	**1 point**

- Hypothesis is stated and their reasoning is clearly supported.	- Hypothesis is stated but student struggles to provide supportive reasoning.	- Hypothesis is stated but student does not provide any supportive reasoning.

______ **Research Plan/Procedure:** Record your step by step plan.

3 points	**2 points**	**1 points**
- Student provides a detailed plan that clearly outlines their research plan. Student has payed close attention to detail. This plan should help guide them as they begin their research.	- Student provides a plan that outlines their research plan. However, the plan contains inconsistencies and/or lacks clarity and is not a clear guide that prepares the student for research.	- Student plan lacks detail. It may be difficult to follow.

______ **Research**

3 points	**2 points**	**1 point**
- Student clearly answers their research question, providing evidence and proof to support their answer.	- Student answers their research question but provides little evidence and proof to support their answer.	- Student attempts to answer their research question but provides little to no evidence or proof to support their answer.

______ **Presentation**

3 points	**2 points**	**1 point**
- Student organizes and prepares information in a logical way to properly present their findings. - Presentation is neat, creative, and easy to read.	- Presentation lacks organization OR Presentation is not neat, lacks creativity or it is difficult to read.	- Presentation is disorganized and the student does not properly present their findings.

______ **Spelling and Grammar**

3 points	**2 points**	**1 point**
- Assignment contains no spelling or grammatical errors.	- Assignment contains some spelling or grammatical errors (7 or less).	- Assignment contains many spelling or grammatical errors (8 or more).

______ **Timeline of Investigation:** How long should the investigation take?

0 points	**1 point**
- Student did not provide timeline of investigation.	- Student did provide timeline of investigation.

APPENDIX F

INTERVIEW QUESTIONS

Interview Questions:

Are you enjoying school this year?

What in particular are you enjoying about school, academically?

What do you enjoy about science?

Do you ever get bored in science class?

Why or why not?

Do you think that there are students in this class who are more engaged in science than in other classes?

Did you spend time after school and/or time on the weekends working on your science investigation?

Why or why not?

Do you feel motivated to learn in science? Curious?

What are some things that you like about science this year? Dislike?

On a scale of 1-10, 1 being a little and 10 being a whole lot, how much do you feel you are learning this year in science?

Do you think there are students in the room who are not learning in science?

How could I improve science this year?