PHENOMENON-DRIVEN INQUIRY AND SCIENCE TEACHER PROFESSIONAL DEVELOPMENT

by

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DEDICATION

Completing this action research required tremendous effort, time, and energy. I completed this while raising my young daughter who was three when I began the program. I, therefore would like to dedicate this to her. From the moment I was inspired to go back to school for what I truly love to the moment I completed this research, I wanted my daughter to witness me committed to a vision of passion and interest. This vision could only come through hard work and dedication. Selah, may you always know that with hard work, dedication, and passion, you can do anything.

This capstone is also dedicated to my father. He has encouraged me to pursue my dreams, embrace my challenges, and been an unwavering source of stability. My father has questioned this journey when I needed to reflect and moved out of the way at all the necessary obstacles for my growth. He is my rock in this world and I am ever more grateful to him.

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I am deeply grateful to my family for seeing my passions and supporting my dreams. Going back to school as a single mom has been a complex and challenging task and the support of my family has made it much more manageable. My family has paved the way for me to complete this degree and I am grateful beyond words for their unconditional love and devotion.

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ABSTRACT

The purpose of this Capstone Project was to understand how phenomenon-based inquiry affects teachers' practices. The study investigated if the use of phenomenon-based inquiry positively or negatively affected teachers' practices. It also asked how teachers feel about using phenomenon-based inquiry. The research followed three groups of online courses that consisted of educators learning more about the phenomenon-driven inquiry approach. The first study group consisted of students in a voluntary outreach course with Montana State University. The second and third study groups included graduate-level students in the MSSE course 501. The research compared the teachers' perceptions and experiences with phenomenon-driven inquiry and examined the effects this educational model had on their teaching and their students. The results indicated that teachers found the phenomenon-driven inquiry model helpful and effective in increasing student engagement.

CHAPTER ONE

BACKGROUND AND INTRODUCTION

Context of the Study

I have a background teaching elementary school with a focus on the natural sciences. I have taught pre-school through 8th grades in private school settings. In the public-school setting, I have been a home and hospital teacher and a substitute teacher for all grades. I have also taught academic intervention and special day classes in the primary grades. Outside of the classroom, I have worked as an environmental educator, Naturalist, and Interpreter for all ages in parks, museums, and zoos.

For the past couple of years, I have been teaching out of the classroom so that I may focus on my young child. My unique teaching situation led to the creation of an action research project that was not based on my group of students. John Graves, my Project Advisor in the Master of Science in Science Education Program at Montana State University suggested I research the effects of intentional professional development instruction of phenomenon-driven inquiry on teachers' practices. He suggested I use several of his online courses to conduct my research. I enthusiastically agreed that this would be a relevant and interesting study. I became intrigued by teaching with phenomenon in the MSSE 501 Teaching Inquiry course and was therefore eager to learn more about it and the experiences teachers had with it.

Focus Question

The focus question for this study was, How does phenomenon-based inquiry affect teachers' practices?

Sub-questions included the following:

1. Does the use of phenomenon-based inquiry positively or negatively affect teachers' practices?
2. How do teachers feel about using phenomenon-based inquiry?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Inquiry-based Teaching

The inquiry-based teaching model strives to enhance science education by teaching scientific concepts while also developing the skills needed to practice quality science. It is built on the foundation that learning should be driven from a student's curiosity to understand concepts or understand problems. It is a technique that asks students to participate in an exploration of the natural or material world. This exploration leads to asking authentic questions, making discoveries, and then testing these discoveries in the quest for understanding. In these ways, inquiry mirrors the real practice of doing science ("What Is Inquiry?"2016).

A learning environment based in inquiry looks different than a traditional classroom setting. A traditional setting holds the teacher at the center of the class. The teacher generates ideas, problems, and questions, then leads the class through a clear set of activities and expectations. In an inquiry-based setting, the teacher is a guide but the student is the explorer. The student is responsible for generating ideas, identifying problems, and developing questions. Inquiry-based lessons are based on experiences that are instructive while also providing opportunities for research and discussion (Vlassi & Karaliota, 2013). In an inquiry-based classroom, the teacher may direct students to uncover their own meanings through their own feelings, experiences, viewpoints, and values (Llewellyn, 2014). A traditional classroom focuses learning around content

mastery, the right answer, and preparation for what comes next. Inquiry-based learning is based on problem-solving, processing information, and interested more in how learning occurs (Llewellyn, 2014).

Teachers have always worked hard to effectively engage, inform, and inspire students. However, far too often, learning and school become a passive and mundane experience for students and can turn eager learners into reluctant learners by hammering out the love to learn (Madda, 2017). To encourage a love of learning and for educational systems to remain positive we need to focus on cultivating passion and interest in our students. We see positive results in our students when they are interested, engaged, and excited (Strauss, 2015). The inquiry-based learning model is successful because it promotes individuality, thought, and creativity. Beginning at young ages, students should participate in science that engages them in the development of ideas, theories, and the application of scientific practice. Teaching with inquiry allows teachers to offer students a richer understanding of science (National Research Council, 1996) and promote life-long learning.

One study that investigated 40 fifth grade students compared the effects of teaching the same content in a traditional learning environment to an inquiry-based model. This study illustrated a significant difference between the achievement levels of the two classrooms. The students who had been educated by inquiry-based instruction performed better and learned more than the students who had been educated by the traditional teaching methods (Abdi, 2014). Inquiry-based teaching models were found to promote student creativity, thought,

individuality, and engagement. Overall, inquiry made science more enjoyable and fun for teachers and students and thus learning became effective, long-lasting, and successful (Corder and Slykhuis, 2011).

Next Generation Science Standards

The inquiry-based national teaching standards are now adopted by the national teaching standards, Next Generation Science Standards (NGSS), as a methodology and the foundational approach to learning. Scientific inquiry revolves around a question that can be studied and perhaps answered through investigation (Three Dimensional Learning, n.d). The National Science Education Standards (NSES) advocate cooperative and inquiry-based classroom environments to meet the needs of today's students (Lunsford, 2002). Inquiry-based instruction can be defined as an educational model where students participate in engaging, open-ended, hands-on activities that are student-centered. This definition encompasses the main types of inquiry. Structured inquiry is when the teacher provides students with the problem, procedures, and materials to conduct a hands-on investigation, but does not tell them any expected outcomes. With guided inquiry, the teacher only gives students materials and a problem to investigate. Open inquiry is similar to guided inquiry but the student develops their own problem without the teacher providing a problem. An inquiry-based lesson begins with exploration, observation, and questions. It then moves into an investigation based on the developed questions. It ends with the opportunity for

learners to make meaning from their process by sharing their investigation results (Colburn, 2000).

In 2013 the National Research Council, which consists of scientists, education researchers, educators, and engineers from 26 states, published the NGSS. They are based on *A Framework for K-12 Science Education* and work towards preparing students in Kindergarten through 12th grade for the school years and beyond (Holthuis, Deutscher, Schultz, & Jamshidi, 2018). The goal of the standards is to provide schools and districts with a strong foundation in curriculum, instruction, and assessment. They include content that covers the life sciences, the physical sciences, the earth and space sciences, engineering, technology, and the application of science (Holthuis, Deutscher, Schultz, & Jamshidi, 2018).NGSS is not a curriculum, but standards. They do not come with any lesson plans, required texts, or assessments (Witte & Varsity Tutors, 2015).

The Science and Engineering Practices component of NGSS promotes students to engage in the same behaviors that scientists engage in while working. These practices include asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence and obtaining, evaluating, and communicating information. NGSS gives the structure for students to interact with science in a real-world way. The standards require students to not just understand the facts but understand how the scientists uncover the facts. Students need to know how to form a hypothesis, how data

plays a role in forming the hypothesis, how to test hypotheses, and how to interpret data. The goal of NGSS is that every student can apply STEM (Science, Technology, Engineering, and Math) principles to their lives (Witte & Varsity Tutors, 2015).

The long lists of facts that the former standards asked students to learn has been replaced with a set of Disciplinary Core Ideas. The Disciplinary Core Ideas include grades K-12 and are grouped into four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology, and applications of science. These ideas are the content that can be used to develop explanations and support arguments (NSTA, n.d.-a.). Students learn to make connections across the disciplines and deepen their conceptual understandings with Crosscutting Concepts. They link the different domains of science and include patterns, cause and effect, scale, proportion and quantity systems, and system models, energy and matter, structure and function, and stability and change (NSTA, n.d.-b). A classroom using NGSS would hear *how* and *why* questions, rather than only *what* questions. Students learn to value sense-making over *answer making* (Holthuis, Deutscher, Schultz, & Jamshidi, 2018).

NGSS is young in its development and implementation. Its future and long-term effects have yet to be known. Some districts opt-out of following the guidelines, while others have adopted them wholeheartedly. While the future of NGSS is unknown, it has brought new ways of thinking into the lives of learning communities across the country (Witte & Varsity Tutors, 2015).

Educators must captivate their audiences and maintain a high level of attention to promote optimal learning. Students learn best when engaged. Yet, traditional teaching

methods like memorization, recipe style labs, and lectures can decrease student engagement. In recent years, educational models have shifted away from traditional lectures, labs, and memorization. Educational research has illustrated that these forms of teaching are not effective (Bobrowsky, 2018).

Phenomenon-driven Inquiry

A phenomenon-driven inquiry teaching model can increase student engagement. The use of relevant scientific phenomena can engage students effectively. According to the Merriam-Webster Dictionary, a phenomenon is an observable fact or event (Definition of PHENOMENON, n.d.). Phenomena used in teaching is engaging, relatable, observable, and most often naturally occurring. Phenomena are complex in nature to allow for questioning, built on common experiences, and align with state standards. In the classroom, phenomena engage students and maintain student interest as they try to understand what's happening and provide a storyline for the lesson to follow (German, 2018). Phenomena can be objects (such as a newtons cradle), observable events (such as video of woodpeckers drilling holes into a tree), or discrepant events (such as jumping flames). Phenomenon-driven inquiry engages students to connect with the scientific content and creates successful learning (NGSS Phenomenon-The Wonder of Science, n.d.).

Many teachers already incorporate aspects of teaching with phenomena by using interesting hooks to engage their students. However, the phenomenon-based inquiry model is different. In a traditional classroom, the teacher would first teach the explanation of the concept. They might explain the background, assign

readings, or demonstrate a lab. During this teaching period, the teacher might show students something interesting or exciting. Following this explanation, students might do an exploration of the content. They could participate in the lab, do a project, or generate a written assignment. In a phenomenon-driven lesson, the teacher *begins* with an interesting or exciting hook. The exploration comes *before* the explanation. The storyline of the lesson begins with the captivating event (phenomena) and continues with elaboration and content. When teachers begin with phenomena, the students want to understand it, thus providing an anchor for the lesson to return to. Incorporating phenomenon driven inquiry into lessons can be simple. The best phenomena can be ordinary, everyday things. Students remain more engaged when the event is something they can relate to (German, 2018). When teaching with this method, the teacher's goal is to have students learn content but the student's goal is to figure out phenomena. The teacher works to get students to wonder what is happening (T.Willard, personal communication, November 12, 2019).

There are a growing number of resources for teachers to choose phenomena to use in the classroom. Teachers should also feel free to develop their own based on students' interests and experiences. An example of phenomena for teaching erosion and weathering could be showing students a crack in the sidewalk where a plant is growing through. When teaching a geologic timeline, a video of the Grand Canyon could be used. Introducing chemical reactions could be explored by making slime (NGSS Phenomenon-The Wonder of Science, n.d.).

A phenomenon-based inquiry is a model of teaching that is right at a teacher's fingertips. Using every day, relatable, relevant and captivating occurrences to drive the storyline of the lesson, deepen student engagement and learning.

CHAPTER 3

THE JOURNAL ARTICLE AS SUBMITTED TO SCIENCE & CHILDREN

Title: Phenomenon Driven Inquiry

Subtitle: Why does a water strider stand on the surface of the water?

Abstract

As the Next Generation Science Standards (NGSS) become more widely implemented, teachers are learning how to best adapt the standards into their classrooms. Phenomenon-driven inquiry is a key component to NGSS and many teachers turn to professional development for deeper understanding of this concept. In this article we review phenomenon-driven inquiry and the effects that this teaching model has on teachers' methods. We asked teachers currently enrolled in phenomenon-driven inquiry professional development courses to take part in the research. The participating teachers, who were learning about phenomenon-driven inquiry and how to adapt it into their current teaching, were asked to reflect on the effects it had on their students and themselves. Through this research we found phenomenon-driven inquiry to be an effective model that teachers plan to implement in their classes.

Subhead: Teachers Embrace Phenomenon-Driven Inquiry

As teachers, we all know the feeling of losing our students' interest. We know the look of glazed eyes, the sound of indifferent chatter and work that illustrates apathy. We know that our students will learn more if they are invested in the subject and dedicated to their learning. So how do we as teachers best engage our students? How do we transform glazed eyes into bright eyes, indifferent chatter into the hum of questioning conversation

and apathetic work into thoughtful, compelling creations? To achieve these goals, teachers are turning to inquiry and professional courses on inquiry for guidance.

We followed forty-seven teachers enrolled in professional and graduate-level education courses with a specific focus on phenomenon-driven inquiry. We wanted to know how direct instruction in phenomenon-driven inquiry affected their teaching. Teachers enrolled in these courses were invited to complete pre and post surveys as well as interviews. Institutional Review Board (IRB) approval was received for this research. The data gathered from these surveys and interviews were analyzed to understand the effects of phenomenon use on teachers' practices.

The inquiry-based teaching model strives to enhance science education by teaching scientific concepts while also helping students develop the skills needed to practice quality science. The inquiry model is built on the foundation that learning should be driven from a student's curiosity to understand concepts or understand problems. Beginning at young ages, students should participate in science that engages them in the development of ideas, theories and the application of scientific practice. Students who participate in an exploration of the natural or material world are often successful, because these explorations promote individuality, thought, and creativity. Exploration leads to asking authentic questions, making discoveries, and then testing these discoveries in the quest for understanding. In these ways, inquiry mirrors the real practice of doing science ("What Is Inquiry?," 2016). Teaching inquiry allows teachers to offer students a richer understanding of science (National Research Council, 1996) and promote life-long learning.

Subhead: Teachers Learn Phenomenon-Driven Inquiry: Why Phenomenon?

Educators must captivate their audiences and maintain a high level of attention to promote optimal learning. We see positive results in our students when they are interested, engaged and excited (Strauss, 2015). However, far too often, learning and school become a passive and mundane experience for students and can turn eager learners into reluctant learners by hammering out the love to learn (Madda, 2017). In recent years, educational models have shifted away from traditional lectures, labs, and memorization. Educational research has illustrated that these forms of teaching are not always effective (Bobrowsky, 2018).

A phenomenon-driven inquiry teaching model can increase student engagement, and the use of relevant scientific phenomena can engage students effectively. According to the Merriam-Webster Dictionary, a phenomenon is an observable fact or event (Definition of PHENOMENON, n.d.). In the classroom, the phenomena work to engage students, maintain student engagement as they try to understand what's happening and provide a storyline for the lesson to follow (German, 2018). Phenomena can be objects such as a Newton's cradle or Galileo's Thermometer; observable events such as video of woodpeckers drilling holes into a tree or why leaves turn colors in the fall; or any number of discrepant events that teachers currently use with their students.

Many teachers already incorporate aspects of teaching with phenomena by using interesting hooks to engage their students. However, the phenomenon-based inquiry model differs from previously relied upon anticipatory sets. In a traditional classroom, the teacher would first teach the explanation of the concept. They might explain the

background, assign readings, explain vocabulary or demonstrate a lab. During this teaching period, the teacher might show students something interesting or exciting. Following this explanation, students might do an exploration of the content. They could participate in the lab, do a project or generate a written assignment. In contrast, in a phenomenon-driven lesson, the teacher begins with a phenomenon. The exploration comes before the explanation. When teachers begin with phenomena, the students want to understand it, thus providing an anchor for the lesson Incorporating phenomenon-driven inquiry into lessons can be simple. The best phenomena are ordinary, everyday things, as students remain more engaged when the event is something they can relate to (German, 2018). When teaching with this method, the teacher's goal is to have students learn content, but the students' goal is to make sense of phenomena. The teacher works to get students to wonder what is happening (T.Willard, personal communication, November 12, 2019). The storyline of the lesson begins with the captivating event (anchor phenomena) and continues with elaboration (supporting phenomenon) and content (sense-making). The anchor phenomenon is the core of the units' learning goals. Anchor phenomena are described as naturally occurring events that build on every day or family experiences. In addition, they are too complex to be explained in a single lesson. They are observable and will engage students in a range of ideas in order to understand the concept. Finally, specific Science & Engineering Practices and Crosscutting are used by students to learn about the science behind the anchor phenomenon (https://www.ngssphenomena.com/about; STEM Teaching Tool #28; https://thewonderofscience.com/phenomenal).

Anchor phenomena are specific phenomena that begin the unit of study with questions. Students return to these questions throughout the unit as a way to drive their learning. Anchoring phenomenon contain complex science concepts, and to help students understand them, supporting phenomenon are used. Supporting phenomenon drive learning back to the anchoring phenomenon and guide students to a clear understanding of the anchoring phenomenon.

Teachers can choose from a growing number of resources on using phenomena in the classroom or develop their own based on students' interests and experiences. For example, a phenomena for teaching erosion and weathering could be showing students a crack in the sidewalk where a plant is growing through. When teaching a geologic timeline, a video of the Grand Canyon could be used. Introducing chemical reactions could be explored by making slime (NGSS Phenomenon-The Wonder of Science, n.d.).

Subhead: A Phenomenon Lesson: The Water Strider Phenomenon

Figure 1. Water Strider

The following lesson was used to develop an understanding of phenomenon-driven inquiry with the teachers in the study. The lesson was shared with the teachers in the research experiment and they then took the model to create their own phenomenon lesson to use with their students.

Subhead: Anchor Phenomenon: Water Strider

The anchor phenomenon is a water strider (Gerridae) standing on the surface of the water. Ideally this would be introduced to students in a natural setting such as a slow-moving stream or pond. If that's not possible, living striders in classroom or an image would suffice. After observing, students are challenged with answering the question as to how the water strider can stay on the surface of the water and not sink. Using science notebooks or journals, students can write initial answers to that question to drive further learning.

Subhead: Supporting phenomenon: Objects in water

Figure 2. Cup of water with water dome

Have a full cup of water available. Be sure there is the beginning formation of a dome of water bulging above the rim of the cup. Ask students if you can put any more water into the cup without it spilling over. Most will say no. Carefully add a bit more water. Keep doing this until the students are convinced you can't add any more water. Take an object like a marble or piece of clay and ask students what could happen if you put it in the cup. Most will reply it will overflow. Demonstrate. Repeat the process, but once students are convinced you can't get any more water into the cup, ask what would happen if you put a paperclip into the cup. Most students will say it will overflow. Carefully put the paperclip in the cup. It should not overflow. Ask the students how many more paperclips you can insert before the water overflows. Most will say 2 or 3. Continue

inserting paperclips. You should be able to insert several dozen. Direct students to ask questions and draw an initial model of the interaction between the water and the paperclips in their notebooks.

Subhead: Supporting phenomenon: Properties of water:

Figure 3. Water drop on wax paper

Allow students to explore drops of water on wax paper. Using a medicine dropper or pipette, students drop water from various heights, push water from small droplets into large bubbles, or pull water with the point of the dropper. Allow students to explore. Encourage students to record observations in their notebooks. Again, draw models that explain how the water is reacting with itself. Models should be building one on another.

Supporting phenomenon: How many drops of water can you fit on the head of a penny?

Figure 4. Water drop on penny

Ask students to predict how many drops of water from a pipette can fit on the head of a penny before spilling over. Try it. Allow students to explore. Encourage them to make observations, ask questions, draw additional models and revisit previous ones.

Subhead: Sense Making: Throughout the study, as appropriate and as students are beginning to develop understanding, teach the following principles.

Cohesion: Water sticks to itself.

Adhesion: Water sticks to other things.

Surface tension: Due to adhesion and cohesion, the surface of the water is like an elastic sheet.

Polarity of water: Adhesion, cohesion and surface tension work due to the polar nature of the water molecule. Water is made up of two hydrogen and one oxygen atoms. The hydrogen atoms are slightly positively charged, and the oxygen atom in slightly negatively charged. The oxygen atom of one molecule of water is attracted to one of the hydrogen atoms of a second water molecule and so on.

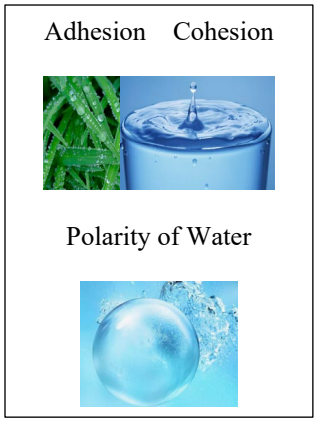

Figure 5. Adhesion, cohesion and polarity of water

Addressing the Anchor Phenomenon: When students are ready, return to the anchor phenomenon of the water strider. They should be able to answer the question of how a water strider can stand on the surface of the water. Using claim-evidence-reasoning statements or mini-posters, students can share their understanding of the phenomenon.

Subhead: Extension Phenomenon: Can you float a paperclip on the surface of the water?

Figure 6. Floating paperclip

This can be used as a formative assessment. Have students demonstrate this phenomenon and then write a minute paper about why it works.

Connecting to the Next Generation Science Standards (NGSS Lead States, 2013)

5-PS1-3: Matter and Its Interactions

www.nextgenscience.org/pe/5-ps1-3-matter-and-its-interactions

The chart below makes one set of connections between the instruction outlined in this article and the NGSS. Other valid connections are likely; however, space restriction prevent listing all possibilities. The materials, lessons and activities in the article are just one step toward reaching the performance expectations listed below

Performance Expectation	Connections to Classroom Activity Students:
5-PS1-3: Make observations and measurements to identify materials based on their properties	• are introduced to the properties of water, including adhesion, cohesion, surface tension
Science and Engineering Practices	
Asking Questions and Defining Problems	• observe the phenomenon of a water strider standing on the surface of the water and ask questions • observe other supporting phenomena and ask questions
Engaging in Argument from Evidence	• make claims, provide evidence and state their reasoning to explain the phenomena (2-PS1-4)

Disciplinary Core Idea	
PS1-A: Structure and Properties of Matter	
Different Properties are suited to different purposes	
Crosscutting Concept	
Cause and Effect	• make sense of causes that generate observable patterns (2-PS1-1) • conduct simple tests can be designed to gather evidence to support or refute student ideas about causes (2-PS1-2)
Connections to Nature of Science	
Science searches for cause and effect relationships to explain natural events	• observe and make sense of natural events (2-PS1-4)

Subhead: What Do Teachers Need To Use Phenomenon?

The impact of this particular professional development of teachers resulted in insight into what teachers think about phenomenon-driven inquiry and its effects. Eighty-two percent of the teachers used inquiry strategies when beginning the professional development courses, and 85% said they would continue using this model after the courses. The specific use of Science and Engineering Practices and Crosscutting Concepts increased by 25% at the end of the professional development. One hundred percent of the participating teachers wanted their students to be more engaged with lessons at the end of

the course, and 100% of them reported a direct increase in engagement when using phenomenon-driven inquiry. Given this positive impact on student engagement, it makes sense that there was a 37% increase in teachers' desire to incorporate phenomenon-driven inquiry into their regular lessons.

Teachers found the phenomenon-driven inquiry model helpful and effective. One teacher shared, "My students are going to love this change. Right now, I am starting small. I feel like the learning curve for me is steep, but worth it." To become effective at using this model, teachers need time to learn the model and should not be expected to excel at it right away. One teacher shared that she felt she was, "not good at it yet. I'm trying to think of more natural connections. I'm floating, how do I do this? I have little time for meaningful planning." With increasing daily challenges and ongoing demands, teachers need to be supported to learn this new way of teaching. As one teacher shared, "effectively teaching in this manner requires lots of prep time beforehand, and I see one of the biggest hindrances to teachers using this method being too little planning time during the school day."

Despite the challenges of learning a new teaching model, the time and effort needed to plan and the lack of support given for preparation, the teachers in this study felt that phenomenon-driven inquiry is worthwhile because it "builds knowledge from experience."

At a time when teachers have higher demands, students require increased engagement and the inquiry model becomes more widely used, the use of phenomenon-driven inquiry is a practical and positive step. With time to learn, plan and incorporate, teachers and

students can benefit from the phenomenon-driven model. As one teacher stated, “phenomenon-driven inquiry is great!”

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CHAPTER 4

CLAIMS, EVIDENCE, & REASONING

Claims From the Study

This study, which looked at the effects of phenomenon-driven inquiry on teachers' practices, holds value for understanding other teachers' practices as well as for myself as a teacher. Teachers in the study were trained in phenomenon-driven inquiry in professional-level coursework. They learned what phenomenon-driven inquiry is, its significance, and how to use it while teaching. The teachers were willing and eager to learn a new teaching technique. They widened their teaching lens to better serve their students.

Teachers were positive about general inquiry strategies and they found that the use of phenomenon-driven inquiry increased student engagement. Eighty-two percent of the teachers used inquiry strategies when beginning the professional development courses, and 85% said they would continue using this model after the courses. The specific use of Science and Engineering Practices and Crosscutting Concepts increased by 25% at the end of the professional development. One hundred percent of the participating teachers wanted their students to be more engaged with lessons at the end of the course, and 100% of them reported a direct increase in engagement when using phenomenon-driven inquiry. Given this positive impact on student engagement, it makes sense that there was a 37% increase in teachers' desire to incorporate phenomenon-driven inquiry into their regular lessons. While the teachers in this study were largely

knowledgeable and committed to inquiry use already, learning the phenomenon-driven inquiry approach improved this commitment. I believe that this 37% would have been greater if all the teachers had participated in the pre and post-surveys.

My research adds to the depth of knowledge already established on the Next Generation Science Standards, inquiry-based teaching, and phenomenon-driven inquiry. This study reinforced previous research that teachers find positive results in their students when they are engaged (Strauss, 2015). We have seen them become more engaged through the use of inquiry-based teaching. In my study, the teachers witnessed increased engagement when using phenomenon-driven inquiry. The teachers in my study were able to better captivate their students' interest by using phenomena in their lessons. This supports the existing research in favor of inquiry-based educational models (Abdi, 2014; Corder and Slykhuis, 2011).

Consideration for Future Research

A possible next step in continuing this study would be to conduct similar research for teachers learning the 5E's, another critical component of inquiry-based teaching. The 5E model includes five phases of a lesson. These phases include; engagement, exploration, explanation, elaboration, and evaluation. This study would follow teachers as they learn about what a 5E lesson entails and how to implement it in their own teaching. The research question might ask how the 5E model affects teachers' practices.

An additional study could be to continue to follow the teachers' implementation of phenomenon-driven inquiry into their classrooms in a longevity study. It would be valuable to see if they adopt phenomenon-driven inquiry as a regular part of their lessons.

It would also be valuable to see how much extra work the new teaching style requires and if they feel supported as they learn the new skill.

Impact of Action Research on the Author

This project, based on the action research model, has affected my own teaching practices in a few ways. First, I learned the value of teachers participating in professional development. I witnessed teachers learn a new skill, put it into practice, and then reflect on their experiences. I learned that continuing education courses and professional development is a critical part of maintaining an exemplary career as a teacher. I also deepened my own knowledge of phenomenon-driven inquiry. As I gathered data on teachers' experiences, I needed to understand this practice myself, especially while conducting interviews. Therefore, as a result of this study, I feel much more confident in my own abilities to teach using phenomenon-driven inquiry. A highly valuable part of this action research project was writing an article on the effects of phenomenon-driven inquiry on teachers' practices. This article highlighted the data as well as shared a phenomenon-driven inquiry lesson. The data identified an improvement in student engagement when teachers used phenomenon-driven inquiry and the teachers' desire to continue using phenomenon-driven inquiry. The article was shared with the educational community and will hopefully provide value to other educators. Through the data gathered, I saw that teachers were eager to incorporate phenomenon-driven inquiry into their teaching, even with the time it takes to become skilled in the new technique. This showed me that there is great importance in supporting teachers to learn new skills. With time and support, teachers want to adopt new strategies. This was my first professionally

submitted article and I learned a great deal about composition, research, and the process of submitting a manuscript. Perhaps the greatest effect that writing the article had on me was the act of sharing what I learned with others. As with teaching, where I learn the content more fully as I teach, writing this article brought me to a place of deeper understanding of phenomenon-driven inquiry.

Upon submission of my article, I received valuable feedback. While the article was rejected in its current state, I was encouraged to make changes and re-submit. The reviewers recommended I re-submit the article to the journal for high school teachers rather than elementary teachers. It is suggested that the disciplinary core ideas are at the high school level rather than at the elementary level. It was also recommended that I change the article to expand on the article to include three-dimensional teaching or learning to encourage understanding the "why" behind the anchoring phenomenon. I plan on incorporating these suggestions and re-submitting the article.

Overall, this action research project had a positive impact on the teachers who participated in the study and myself as a student and a teacher. I move on from this project with more knowledge, more confidence, and a stronger work ethic as a teacher and student.

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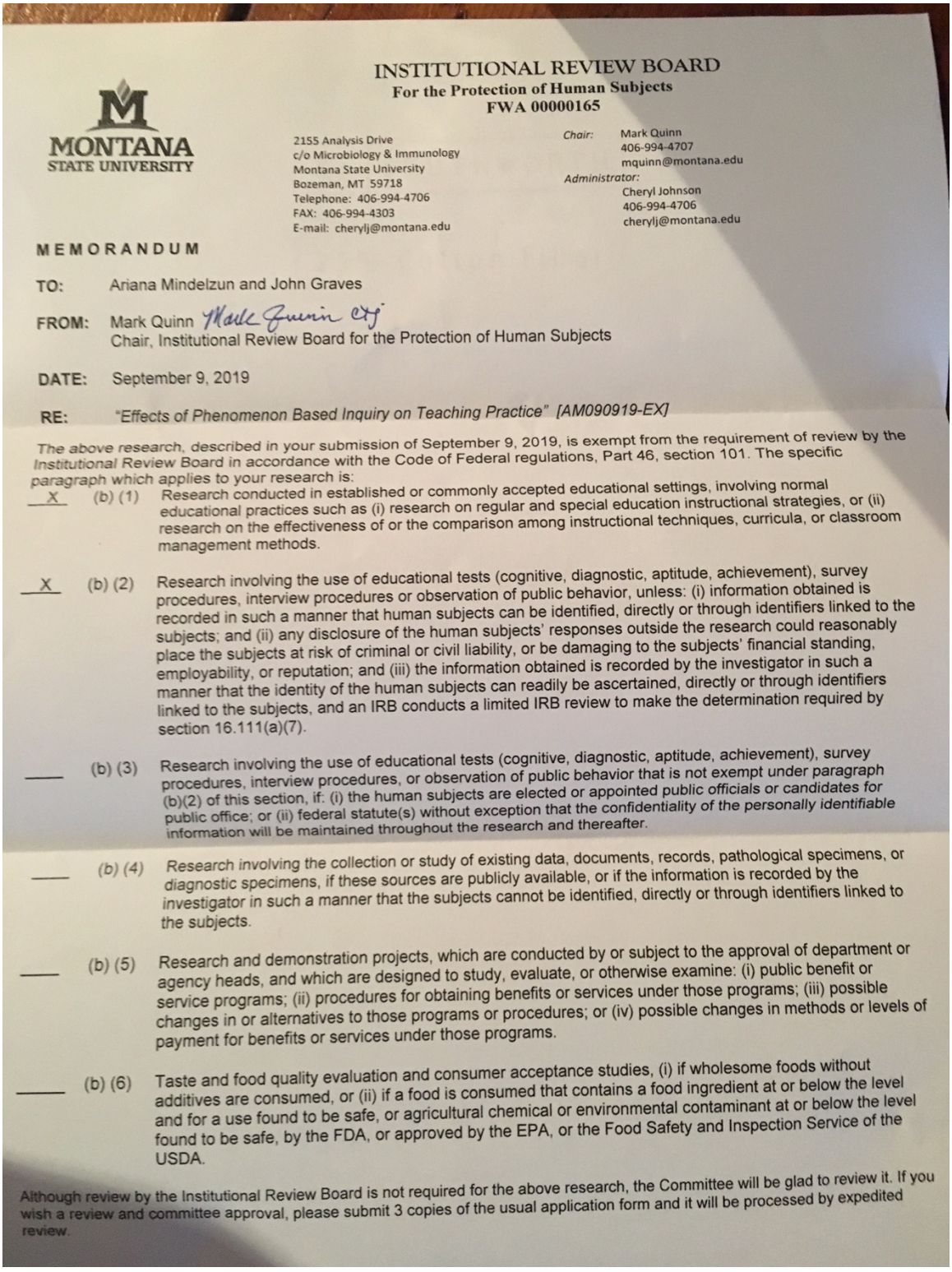
APPENDICES

APPENDIX A

IRB APPROVAL



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MEMORANDUM

TO: Ariana Mindelzun and John Graves

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

DATE: September 9, 2019

RE: *"Effects of Phenomenon Based Inquiry on Teaching Practice" [AM090919-EX]*

The above research, described in your submission of September 9, 2019, 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; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

____ (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 B

PHENOMENON USE PRE-SURVEY

Mark your response to each of these statements.

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. By answering these questions, you are giving consent to participate in study.

Statement	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
I am familiar with the phenomenon-driven inquiry educational model.				
I use phenomenon-driven inquiry in my teaching.				
I would like my students to be more engaged with lessons.				
I like the way I introduce my students to new units of study.				
I currently teach using inquiry strategies.				
I am familiar with NGSS science & engineering practices (SEPs) and crosscutting concepts (CC).				
I current teach specifically to SEPs and CCs.				

APPENDIX C

PHENOMENON USE POST SURVEY

Mark your response to each of these statements.

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. By answering these questions, you are giving consent to participate in study.

Statement	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
The Phenomenon-driven inquiry model will be easy for me to bring into my class.				
I enjoy using Phenomenon-driven inquiry in my teaching.				
My student's level of engagement has changed since using a phenomenon-driven inquiry model.				
My students are more engaged with lessons when I use anchoring phenomena.				
I plan to use a phenomenon-driven inquiry model in my class.				
I currently teach using inquiry strategies.				
I current teach specifically to SEPs and CCs.				

APPENDIX D

PHENOMENON USE POST INTERVIEW

Answer all questions honestly and thoroughly.
Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. By answering these questions, you are giving consent to participate in study.

1. Have you noticed a change in your student's level of engagement since using a phenomenon-driven inquiry?
2. Do you find a phenomenon-driven inquiry model confusing or clear? If confusing, what parts? Explain.
3. Describe a typical lesson you teach.
4. How has your teaching changed as a result of this course?
5. How has your understanding and use of NGSS's science & engineering practices and crosscutting concepts changed as a result of this course?
6. What interests you most about phenomenon-driven inquiry now that you've taken this course?
7. What was the most difficult thing about implementing phenomenon-driven inquiry in your teaching?
8. What else do you want me to know?