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Science Interactive Notebooks: A Case Study On Learning In High School Students

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SCIENCE INTERACTIVE NOTEBOOKS:
A CASE STUDY ON LEARNING IN HIGH SCHOOL STUDENTS

by

Autumn A. Mollet

A capstone submitted in partial fulfillment of the requirements for the degree of Masters of Arts in Education: Natural Science and Environmental Education.

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CHAPTER ONE

Introduction

Science interactive notebooks are an influential tool in my classroom. Interactive notebooks allow students to record relevant information, such as lab directions, lecture notes, articles, and movie facts from class on the right hand page of their notebooks. Students then interact with that material on the left page using diagrams, concept maps, graphs, summaries, and other reflective tools (Molloy, Arno, Martin, & Robinson, 2012). This interaction with the fundamental information is different than traditional worksheets in that students are able to keep their work and refer to it throughout the year in one organized and convenient location. During the past school year as I have been using this method in my classroom, I have noticed an increase in student comprehension of scientific topics. I realized in order to use the science interactive notebooks most effectively, I would need to understand how they were affecting students’ learning, which led to my research question: *What is the effect of science interactive notebooks on high school biology students’ learning?*

In order to understand how students learn, we need to take a closer look at the way the brain works. Studying brain science can inform teachers as to the best ways to deliver material and increase student retention. Some of the techniques that can increase learning in students are creating models, making acronyms, providing real-life connections, and reviewing information. Science interactive notebooks provide the place
for these learning techniques to be recorded and examined. Then, the notebooks aid students when studying the material and help teachers to understand their students’ learning processes.

In this chapter, I present background information about my love for science and the story about why I became a science teacher. I then discuss how I started to utilize science interactive notebooks in my classroom. Then, I present an inspirational student’s story, and I discuss my plan to encourage more of my students to take ownership in the interactive notebooks and their own learning in the same way she did. I will also describe the unique opportunity I have in my classroom and how that led to the approach of my research on science interactive notebooks in my classroom.

**Background Information**

I was aware of a calling to teach from a very young age. I often came home from school and my room became a classroom for my stuffed animals, dolls, and to their lack of amusement, my younger siblings. It has always been in me to learn and help others to learn as well. I knew I would become a teacher for older students, but the subject area had always been leaning towards English or social studies. In high school, I had an amazing biology teacher who inspired in me the desire to pursue science as a part of my career. I had always been curious about the natural world. My family went camping in the Minnesota State Parks every summer, and I loved exploring the different places. We hiked and enjoyed the beauty of our surroundings. Sometimes we brought our horses and checked out the trails. It was such a different perspective from the back of a horse. I rode and wondered about the lives of the different trees and plants we would see. I often ponder why I never thought about turning that curiosity and love of nature into teaching. I
speculate that it had something to do with always having male science teachers and never being able to see myself in that role. I believe that having a strong female presence in a science setting allowed me to realize that it was okay for me to take interest in science, and I wanted to be that presence for other girls. So the decision was made, I was to become a high school biology teacher.

I graduated from college in May of 2011 and began the hunt for a job. It did not take long for me to obtain a position at the Area Learning Center in my hometown as the after-school science teacher where I taught biology, physical science, and forensic science after school to at-risk students. This experience gave me the opportunity to try new teaching techniques and to experiment with technology in order to best serve the student population. The following May, I interviewed and accepted a full-time position at a charter school in the Midwest where I am currently employed. My charter school has a focus of service learning, technology, and college readiness. As a part of the college readiness objective, we are an Advancement Via Individual Determination (AVID) school. AVID’s mission is to close the achievement gap by preparing all students for college readiness and success in a global society (AVID College & Career Readiness, 2017).

As an AVID school we offer an elective class to students who perform in the academic middle to prepare them for college. We also implement school wide AVID strategies to help everyone acquire skills to help them be successful throughout their school years and beyond. To aid in building understanding and learning about new skills, teachers are often sent to AVID Area Conferences. This is where my journey with science interactive notebooks began. At the AVID Conference in Tampa, Florida in June
2015, I sat through the Science Strand meetings and learned about this amazing way of learning. What I found so compelling about the notebooks was the way students were expected to interact with the information to find a deeper connection to what they were learning. The presenters had us role-play as students in various activities to show us possible lesson ideas. I was engaged and could see the potential of this type of learning in my classroom. I felt this method of recording new information and skills would give students a more authentic approach to science than the worksheets we were currently using.

Last year, I implemented science interactive notebooks in my biology class and saw some great progress. It challenged my students to think differently about science. Having these notebooks caused me to plan in another way for class by evaluating what the more challenging topics of each section were in order to give students more practice. Once I identified what they needed more practice with, I asked them to complete a left side activity to aid in increasing their comprehension of the information. Left side activities can include diagrams, compare and contrast activities, or practice with a new skill. In Figure 1 below, I have provided an example of notes and a left side activity we completed in class on graphs earlier in the school year with the objective to increase student proficiency in identifying the proper type of graphs to use in different data situations. This type of note taking and then practice allowed students to come away with a better understanding of the material.
My Student Inspiration

Teachers often think they are there to inspire their students, however, students are often inspirational to their teachers, too. In fact, I have a student who inspired me to continue to pursue the science interactive notebooks in my classroom and make them even more effective. From the start of the story she seemed an unlikely source of inspiration. She did not perform well on assignments and failed most of the tests. She was quiet in class and never asked for help. She struggled immensely and actually ended up failing the first semester of biology. Unfortunately, this was not anything new for her; she performed low in many classes and could have fallen through the cracks so easily. She managed to work hard enough to barely pass the second semester. So what makes her my inspiration then you ask? It was the experience she had and shared with me when she
repeated that first half of biology with me. The year that had not gone well for her was when I was still using mostly worksheets for student assessment in my classroom. She repeated the first semester of biology during my first year of implementing the science interactive notebooks. I would not have attached how much better she did in class the second time around to the notebooks, themselves, if she had not told me. I would have assumed that because she was exposed to the material again that she retained it better. However, I ask students to draw a lot of the concepts into their notebooks to help them understand the difficult topics that are hard to visualize, and I did notice that she was more engaged in class, and she was, in fact, an excellent artist. For example, when she was studying photosynthesis, an overall simple process that plants go through, I had them draw the process: the sunlight hitting the plant, the water coming up through the roots, the carbon dioxide going into the plant, the oxygen coming out of the plant, and the glucose being stored within the plant, so that students can visualize the process and remember what is happening.

Apparently this approach is what my student needed to succeed. She let me know in an email. Reading it actually brought me to tears. I was so happy there was something that connected with her and that she had taken the time to thank me and let me know.

Thank you so much for doing notes the way you have been this year they are such an eye opener! I love taking notes now. Although many students do not enjoy the diagrams and drawings they help me a lot as a visual learner. Not only is it easier to visualize it takes the information and lays it out for me to understand more easily. I've [sic] been
adding the method to my history class notes as well, I've 
[sic] started to tape in stories, T-charts, and ven-diagrams 
[sic] to my notebook. I'm actually proud of the work I do in 
these notebooks and enjoy reviewing them, this is helpful 
because I haven't ever been good at studying [sic]. (Student 
email, 2017)

The best part about it was that she was using the techniques I was using to teach her 
science in other classes. She even included a picture of her history notebook to show me. 
She was so proud of her work. It was amazing to me that something I had learned about 
and decided to try in my class had such a profound impact on her and her learning. She 
realized that it worked for her and used it. This is what makes her the inspiration for my 
study. She took what I taught her and applied it in other classes. She took control of her 
learning in a deeper way. I want all of my students to be able to take the tools I use to 
teach them science and use them elsewhere in the same way that this struggling student 
did.

Unique Opportunity

For the first time in my teaching career, I have a teacher candidate in my 
classroom. She is working on her Masters in Education and is with me for 13 weeks. In 
preparation of her teaching my class, which is already well established with their 
interactive notebooks, I have shown her my example notebook. I gave her some 
implementation tips such as making sure to give explicit instructions on what she wants 
and to provide feedback as students work. This will ensure they are doing and hopefully 
also learning what she intends while they are completing the activity. I also gave her
access to my interactive notebooks resources, and she is free to explore different techniques and activities. The focus will be on student learning. Approaching interactive notebooks in this way will allow my teacher candidate the chance to experience different uses for the interactive notebooks to see if they are something she will continue to use in the future. Her insight into the planning, student use, and grading of the interactive notebooks will be obtained and reported upon. Together we will discuss how students learned and what processes we thought worked the best overall.

The other great thing about having her teaching my classes for a few months is that it gives me the opportunity to sit back and observe my students. I will be able to record their reactions to the interactive notebooks and their learning experiences. It also frees up the time for me to interview my students and get their insights into the notebooks. I can ask them about specific feedback and find out how the interactive notebooks are impacting their learning from the student’s point of view. I would be able to do this during class work time without having anyone lose out on help they may need with the scientific material. This unique opportunity will give me more insight into the student perspective of interactive notebooks so that I can find out from them what is the most conducive to their learning.

Conclusion

Being able to organize information spatially within an interactive science notebook, students become aware of the knowledge and skills required to control their learning (Waldman & Crippen, 2009). Left side activities provide the students the opportunity to connect with the information at a deeper level than just note taking can. By interacting with the information in different ways students are able to attach the learning
together and evaluate the information for themselves. These types of varied learning experiences aid in student retention of the material.

In chapter two, the literature on science interactive notebooks, instructional strategies, and learning through brain science is reviewed. Then, chapter three explains the methods behind the qualitative research case study that will be conducted. Chapter four explains the study results, which include the journey of the teacher candidate and myself, the classroom observations, and students’ writings and interviews. Additionally, the case study and the themes discovered will be presented. Finally, in chapter five, the literature review and the research results from my teacher candidate, myself, and the students will be reflected upon. I will share limitations that were encountered within the study and will offer up some suggestions on further research that can be conducted to further study interactive notebooks within the classroom.
CHAPTER TWO

Literature Review

**Introduction**

In this chapter, I provide a literature review on science interactive notebooks, some instructional strategies, and the brain science behind learning. Within the science interactive notebook section, I discuss the research on interactive notebooks, examine the effectiveness of note taking, and present how the notebooks can be utilized for scientific inquiry. Additionally, I discuss how the standards in science can be met through interactive notebooks. During the literature review on instructional strategies, the subtopics of explicit teaching, active learning, and collaborative learning are addressed. The research aids in the understanding of what types of strategies can be incorporated into the scientific interactive notebooks to aid students in their learning. Within the last section, I discuss the brain science of learning and teaching. Understanding how the brain learns, processes, and retains information is crucial to my case study research: *What is the effect of science interactive notebooks on high school biology students’ learning?*

**Science Interactive Notebooks**

A science interactive notebook is a powerful instructional tool that can enhance a student's learning (Chesbro, 2006; Waldman & Crippen, 2009; Molloy et al., 2012; Young, 2003). The AVID style of interactive notebook has students put important class information such as lab directions, lecture notes, articles, and movie facts, which is called
the input, on the right page. Students are then expected to interact with that classroom information on the left page, called the output. Output can be completed through drawing diagrams, creating concept maps, graphing, writing summaries, and making foldables.

“The output can serve several different purposes in your classroom, including checking for understanding, activating prior knowledge, developing understanding over time, and assessing learning” (Molloy et al., 2012, p.40). Students are given a handout that describes the expectations of each side of the interactive notebooks for them to put into their notebooks to refer to throughout the year (See Figure 2). This notebook setup engages students to not only take down the information in the first place, but then reinforces the topic by completion of the left side task.

\begin{figure}[h]
    \centering
    \includegraphics[width=\textwidth]{interactive_notebook.png}
    \caption{Interactive Notebook Handout adapted by Sara Peloquin and Autumn Mollet}
\end{figure}
Scientific interactive notebooks provide organization, strengthen writing skills, reinforce collaboration in the classroom, and contribute to inquiry learning. All of these skills are important to enhancing learning in students. “Learning involves making new connections between clusters of neurons in different parts of the brain….The more connections you create, the better you can use what you learn and the longer it takes you to forget it” (Carter et al., 2009, p. 157). The goal of learning is that students retain what they learn; interactive notebooks create the new clusters that allow for longer retention.

In addition to retention, organizational skills are important to student success as information is most useful when it is organized (Waldman & Crippen, 2009). Learning can be a messy process, though. By using scientific interactive notebooks, students are allowed to record what they learn: the input; then apply the information into a final product: the output. Molloy, Arno, Martin, and Robinson (2012) describe the organizational aspect of interactive notebooks:

[Interactive notebooks] provide a vehicle to organize all notes, worksheets, problem sets, responses to videos, and lab investigations. The notebooks also provide students with a place to interact with the material, develop their understanding, and be involved in making decisions about their learning. (p. 2)

Students are more likely to transfer the learning to long-term memory when they have the opportunity to reflect on the new learning (Sousa, 2011). Not only is learning occurring more rapidly, but interactive notebooks can help develop student writing skills (Butler & Nesbit, 2008; Marcarelli, 2010). Writing within interactive notebooks serves
several purposes. One purpose is to take notes during lectures, readings, or videos, which allows students the ability to review important scientific concepts. Another is to write summaries and generate questions which gives students the opportunity to process notes and scientific text. Another purpose is to generate a record of scientific experiences as students are able to write down what they did, how they did it, and what happened because of it. Writing about their experience is especially useful as their thinking about scientific topics can be explained. “When notebooks focus on making sense of investigations, students modify, reflect on, and organize their knowledge to deepen their understanding” (Butler & Nesbit, 2008, p. 2). Having students record their experiences and then explain them through the use of post-lab and analysis questions requires them to process the experience. Deeper analysis allows students to take control of their learning while refining the information and engaging in self-reflection (Waldman & Crippen, 2009).

**Importance of note taking.** Note taking is a foundational skill for successful learning in the classroom. Actively recording information to recall and reference later involves thinking and learning. “When used effectively, notes can be the key to understanding material and learning science” (Molloy et al., 2012, p. 2). Note taking leads to important skills needed in the classroom.

Note-takers not only need to comprehend and write down personally flavoured information, but, before that, they also need to acquire and filter the incoming sources, organise and restructure existing knowledge structures and, most
importantly, they must store and integrate the freshly processed material. (Makany, Kemp & Dror, 2009, p. 2)

Note taking is an intricate activity that requires comprehension and selection of information while writing (Makany, Kemp, & Dror, 2009; Piolat, Olive, & Kellogg, 2005). The act of note taking allows students to process information at a deeper level, helps students encode information into memory, and also serves as an external memory aid for students (Titsworth, 2001).

Note taking is a craft that students need to learn, develop, and refine. Research has shown that teachers who provide written organizational lecture cues boost the note-taking abilities of their students and that insight into note taking raises achievement (Titsworth, 2001; Titsworth & Kiewra, 2004). Organizational cues can also be verbal signals used by teachers during the lecture that help students organize the material. The lecture cues given could include telling students to draw a line to separate main ideas, star or circle an essential concept, add or sketch an example into their notes, or summarizing the crucial material for them. Lecture cues allow students to take more detailed notes and to remember more information from the lecture (Titsworth, 2001). Not only do students need practice in note taking and in listening for lecture cues, but in order to get the most out of their notes, students need to take the time to review and study them. Taking notes during lectures makes a difference in test scores when they are reviewed before the exam (Kiewra, 1987). Additionally, if students revise and review their notes, they will have the most retention of the information presented during the lecture (Luo, Kiewra, & Samuelson, 2016). The way that science interactive notebooks are set-up to take notes on the right side and interact with the information on the left side provides students the
maximum potential for retention of the material. In my class before chapter tests, students go back and write summaries of each section of their notes. Writing summaries requires students to reread their notes and review the important information from each section. Kiewra (1987) states having students review their notes before the exam makes a difference in test scores. Science interactive notebooks can be kept all year long and reviewed to aid in recall of knowledge and higher test scores. Along with presenting a place to improve writing, to take notes, and to review material, science interactive notebooks lead to an opportunity for scientific inquiry within the classroom.

**Scientific inquiry.** “Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (National Research Council, 2000, p. 1). In the classroom, scientific inquiry learning provides the methods and activities that lead to the development of scientific knowledge. According to the National Science Education Standards (NSES), [Inquiry] involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (National Research Council, 1996, p. 23)
Inquiry refers to a learning process in which students are engaged, and more specifically, it is said to be an active learning process: “something that students do, not something that is done to them” (National Research Council, 1996, p. 2). Active learning allows students to participate in and be in charge of their own understanding. “Active processing allows students to review how and what they learned so that they can begin to take charge of their learning and the developments of their own personal meanings” (Caine & Caine, 1990, p. 68). If students are active in their own learning through inquiry, they will not only understand science content better, but will also be able to improve their scientific practices.

Inquiry learning experiences can include labs, activities, and group projects. In a study done at the University of Georgia, researchers demonstrated greater improvements in students’ science literacy and research skills using inquiry lab instruction (Gormally, Brickman, Hallar, & Armstrong, 2009). Interactive notebooks can provide different formats for documenting science. “Most current, high-level strategies for inquiry science are easily adapted to the pages of an interactive notebook” (Waldman & Crippen, 2009, p. 53). Within an academic setting, scientific inquiry learning can be achieved by having students design experiments to test hypotheses. When designing a lab, students need to research background information to determine the materials and procedures needed to collect the data. Students then practice their writing skills within their interactive notebooks by relaying the details of data collection that would be needed to replicate their lab. While conducting the lab, students utilize their interactive notebooks to gather data and record their method. Using interactive notebooks allows students to “model one of the most vital and enduring functions of scientists…recording information, figures, and
data” (Young, 2003, p. 44). After completion of the lab, students complete a left side by compiling the data into graphs and analyzing their findings within their notebooks to communicate the results. “Knowing how to collect and present data in the science classroom is an essential skill for all science students” (Molloy et al., 2012, p. 139). Scientific interactive notebooks are tools that allow students to conduct scientific inquiry effectively. Interactive notebooks also allow students to meet science standards through the ability to strengthen writing proficiency, scientific inquiry, and processing skills.

**Science standards.** Standards are important to the classroom as they guide the development of the educational objective for student learning. A standard is written by someone else, usually the state or another educational organization, about what students are expected to know about the content by the end of the program. Standards can be assessed in multiple ways: group activities, inquiry labs, writing exercises, and assessments all of which can be accomplished with the science interactive notebook. An objective is written by the teacher and is the daily goal of what students should know by the end of that class period. In my classroom I use the Minnesota state standards. These standards are further broken down into benchmarks which I then use to write my own classroom objectives. “The standards and benchmarks describe a connected body of science and engineering knowledge acquired through active participation in science experiences. These experiences include hands-on laboratory activities rooted in scientific inquiry and engineering design” (Science. MN Department of Education: Academic Standards, 2009, p. 1). The standards are not only about the scientific content, but also the practice of science, which lends itself to inquiry-based learning and higher-level thinking and is the basis of my research (see Appendix A).
Instructional Strategies

Organization, writing, collaboration, and inquiry are all meaningful aspects of a science interactive notebook. These skills are significant because they allow students to develop a retention of material. Instructional strategies are also important to student learning. The teacher needs to be aware of a few strategies that can also increase student knowledge, such as explicit teaching, active participation, and collaborative learning. These are easily moved into action within the science interactive notebooks.

Explicit teaching, such as those used in interactive notebooks (Waldman & Crippen, 2009), is thought to provide the best crossover of different areas of life for students (Halpern, 1999). Explicit instruction allows science classrooms to move beyond the point where students are just learning skills such as observing, inferring, and hypothesizing (Molloy et al., 2012). These basic scientific skills should be combined with scientific knowledge, literacy, reasoning, and critical thinking to provide a full understanding of science (Butler & Nesbit, 2008). Explicit instruction within interactive notebooks includes telling students why they are doing something along with how well they are doing it in order to prepare students to use these new skills in the classroom and beyond.

“Active learning is generally defined as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing” (Prince, 2004, p. 1). Having students participate in classroom activities that are designed around important learning outcomes and promote thoughtful engagement on the part of the student
promotes greater retention of material. Active learning can be seen in a classroom when students are engaging with the material within their interactive notebooks.

Collaborative learning refers to an instructional method in which students work together in small groups toward a common goal. These learning groups are effective (Sousa, 2011) because teaching others helps students learn the material better themselves. Part of the benefit of this approach to learning is that students make sure that all members of the group understand the material and work together. “…Collaboration enhances academic achievement, student attitudes, and student retention” (Prince, 2004, p. 5).

Students learn in different ways, so taking diverse approaches and using variety when teaching helps with retention (Sousa, 2011). Lectures, labs, collaboration exercises, and writing activities are all methods that can bring the diversity needed for all students to understand and retain the material. Once students have the knowledge of the content, they are able to engage and think about it differently.

**Explicit teaching.** Many students struggle with learning when necessary guidance and support are not provided. Explicit instruction is direct, student engaging, and success oriented. In order to be successful, students need to not only be taught new skills but also how to use them in other situations. According to Archer & Hughes (2011),

Explicit instruction is characterized by a series of supports or scaffolds, whereby students are guided through the learning process with clear statements about the purpose and rationale for learning the new skill, clear explanations and demonstrations of the instructional target, and
supported practice with feedback until independent mastery has been achieved. (p. 1)

At first the advantage of the skill should be explained. Then, its use in other situations must be explored. When students are taking notes giving them direct organizational cues, such as highlighting key concepts, is an example of explicit teaching. Another example of explicit instruction is using the interactive notebooks to teach students the use of a new graphic organizer. For example, direct instruction about how to use a Compare Contrast Organizer (see Figure 3) is a method of explicit instruction. “Many science concepts require comparing and contrasting at deeper levels. This organizer helps students see the similarities and differences in concepts in a more organized manner than in a Venn diagram” (Molloy et al., 2012, p. 231). Graphic organizers can help students organize information while reading, taking notes, or before writing about a topic (See Figure 3). Graphic organizers provide a visual representation of information and connections between ideas and can aid in learning complex science concepts (Molloy et al., 2012). Visual representation of information also addresses variations in learning styles among students. The use of graphic organizers is a skill that students can then take and apply in other subjects to aid them in learning the material.

Figure 3: Graphic Organizer (Molloy et al., 2012, p. 242)
Direct explanation of a new skill will provide students the opportunity to understand why the skill is important and how it can be used later. Explicit teaching has been shown to promote achievement for all students. “Teacher-led group instruction most likely has this positive impact on achievement because it increases such effective teaching elements as clear explanations, modeling, practice, feedback, and frequent responding” (Archer & Hughes, 2011, p.9). The ability for a teacher to give feedback about students’ thinking can strengthen their learning throughout the year (Butler & Nesbit, 2008; Mallozzi & Heibronner, 2013). If feedback is timely and clearly addresses the task or is specific to students’ performance it can redirect and enhance student learning (Mallozzi & Heibronner, 2013; Marcarelli, 2010). Not only can feedback have an impact on student learning, but it can aid the teacher as well. “As students receive more feedback and thus become more engaged in learning activities, their actions and self-assessments provide more feedback to teachers, who, in turn, make better decisions about instruction.” (Pollock, 2012, p. 4). This cycle that feedback can create can make the classroom a better environment for learning. Direct explanation of a new skill and feedback on its use are instrumental in students being able to use that skill effectively in the future.

Explicit instruction allows students to transfer what they have learned across disciplines. “...when [thinking] skills are explicitly taught for transfer, using multiple examples from several disciplines, students can learn to improve how they think in ways that transfer across academic domains” (Halpern, 1999, p. 70). If not explicitly taught, students are often unsuccessful in applying knowledge and skills learned in one context to other situations (Abrami et al., 2008; Perkins & Salomon, 1988). Explicit instruction
can increase the possibility that students will transfer their knowledge from one situation to another (Marin & Halpern, 2011; Perkins & Salomon, 1988). The ability to apply and transfer knowledge is crucial not only for high school success, but also success in the workplace, post-secondary education, and everyday life (Abrami et al., 2008; Marin & Halpern, 2011). “[Explicit instruction] is a viable means by which to educate students in ways with which to negotiate the complexities of modern life, both within the boundaries of school and beyond” (Marin & Halpern, 2011, p. 12). Explicit instruction is important when teaching new material to students. The interactive notebook will be used to introduce and practice these skills with the intent of students learning to use the notebooks effectively and applying that knowledge within different situations.

Active learning. Those who actively participate in the learning process learn more than those who do not. Students need to do more than just listen during class time. Less emphasis needs to be placed on transmitting information to students. In order for that to happen lectures need to include more student participation. “Introducing activity into lectures can significantly improve recall of information” (Prince, 2004, p. 4). This can be done a variety of ways; questioning, pausing, and discussions are a few.

Questioning allows a chance for students to participate and for the teacher to gauge student understanding of the topic. This technique also allows for re-teaching or addressing any misconceptions students may have about the topic. Pausing during lecture gives students time to look over what they have written. Teacher can then have the students discuss with others what they have written. Students can ask questions of the teacher or other students for clarification and then add details or examples into their notes. Discussions are one of the most common active learning strategies. In order for
discussions to be successful, teachers need to be comfortable with the topic and have a variety of questioning strategies to engage the participants. Discussion is preferable to lecture “if the objectives of a course are to promote long-term retention of information, to motivate students toward further learning, to allow students to apply information in new settings, or to develop students' thinking skills” (Bonwell & Eison, 1991, p. 6).

In active learning the focus is on developing students' skills. Students are involved in higher-order thinking and engaged in activities that allow them to explore their own attitudes and values. “They must read, write, discuss, or be engaged in solving problems. Most important, to be actively involved, students most engage in such higher-order thinking tasks as analysis, synthesis, and evaluation” (Bonwell & Eison, 1991, p. 5). The core elements of active learning have been defined as introducing activities into lectures and using activities to promote student engagement. “Considerable support exists for the core elements of active learning…[and]…extensive evidence supports the benefits of student engagement” (Prince, 2004, p. 4). Students working within their interactive notebooks to write, analyze, or work together would be identified as actively learning.

**Collaborative learning.** Students can learn by teaching others, which is why cooperative learning groups are so effective (Sousa, 2011). Interactive notebooks can be effective for encouraging collaboration as students work together on many activities and during labs to process the content and make connections to their classroom learning.

Collaboration, promotes students’ long-term retention of content material because they learn the ‘how’ as well as the ‘what’ of learning. High achievement for all students occurs in a science classroom environment in which they
are discussing and refining the learning process. (Molloy, et al. 2012, p. 179)

By working as a team, sharing their expertise, and evaluating procedures, students are more likely to learn the purpose behind scientific concepts. Providing time for students to discuss their learning allows them to receive feedback from others and generate new ideas (Marcarelli, 2010). Groups interpret the information, analyze, evaluate, and then explain it together. Group members speak together and clarify their reasoning to each other. They can assist each other in reviewing and adding information into their notebooks to answer questions and complete lab procedures. Active participation requires them to come together and evaluate the data until they reach consensus. “By involving others in our learning, we have the opportunity to revise our thinking and check our understanding in a safe environment” (Molloy et al., 2012, p. 205). The collaboration will cause them to analyze each other's thinking as well as their own thinking forcing students to be conscious of others’ opinions and experiences. Active participation, emotional stimulation, and socialization can enhance a student's learning (Sousa, 2011). The process of collaboration can be documented in the interactive notebook with the use of different colors as students add notes to enhance their original thinking.

The Brain Science of Learning

“The brain goes through physical and chemical changes when it stores new information as the result of learning. Storing gives rise to new neural pathways and strengthens existing pathways” (Sousa, 2011, p. 83). Learning is the process by which new knowledge and skills are acquired. Students learn in different ways and can develop
a preference for a learning style. There are visual, auditory, and kinesthetic learners (Sousa, 2011; Tileston, 2004), so taking a diverse approach and using variety when teaching can help all students in the classroom. Visual learners acquire knowledge better by seeing, auditory learners need to hear things, and kinesthetic learners use movement or touch to comprehend information. All learners can benefit from a combination of these styles, as multisensory activities during instruction improves student learning and retention (Sousa, 2011). Learning and retention are different. A student can learn something for a test and then forget it. Retention is the process where long-term memory protects learning so that it can be located, retrieved, and identified for later use (Sousa, 2011; Tileston, 2004).

Memory is the mechanism by which new knowledge and skills are retained for the future. It allows students to draw on experience and make predictions about upcoming events. To increase the likelihood that recently-taught information will be stored and retrieved, it must have meaning. “Meaning is not inherent in content, but rather is the result of how the students relate the content to their past learnings and experiences” (Sousa, 2011, p. 74). There are three ways that the brain constructs meaning: through relevance, emotion, or patterns and connections (Tileston, 2004). By providing a connection to the students’ lives, teachers are giving a purpose to the learning. These connections will cause the learner to be more likely to store the experience in their long-term memory for use later (Sousa, 2011). The brain is hardwired to look for patterns to aid in survival (Caine & Caine, 1990; Tileston, 2004), so providing students with opportunities to look for patterns in the learning can result in a deeper understanding of
the topic. Problem solving is a beneficial way for students to extract patterns in learning for themselves.

**Teaching with brain science.** “Teachers try to change the human brain every day. The more they know about how it learns, the more successful they can be” (Sousa, 2011, p. 4). Instructors who review information with their students at the beginning of class and who use closure at the end of class where students are allowed to process the information see an increase in learning retention (Caine & Caine, 1990; Sousa, 2011).

Because learning is cumulative and developmental, “good teaching builds upon skills and understanding over time” (Caine & Caine, 1990, p. 67) through rehearsal. Rehearsal is the continual reprocessing of information and is a critical component of moving information from working memory to long-term storage (Sousa, 2011). Whenever students retrieve material from long-term storage into working memory, they relearn it (Tileston, 2004). There are many types of rehearsal activities that teachers can use, reviewing and closure are just a few. Starting the class with a bell ringer for review or a writing activity as closure can all be done within the pages of an interactive notebook.

Not only is rehearsal vital to learning, but so is the meaning of the learning. An effective teacher will create a classroom environment for students that helps the brain make meaning of the learning (Tileston, 2004). There are a few ways that teachers can help students attach meaning to their learning. Teachers can provide models that are either concrete or symbolic (Sousa, 2011). Models will give students a much needed visual of the information. Educators can also create an artificial meaning for the material through mnemonic devices or acronyms as this allows students to remember a difficult concept more effectively.
Educators can also have students learn by doing. Students that are actively involved in a problem-solving or tactile activity are more likely to retain new material. Problem-solving allows students to interpret the material and analyze the situation for effective solutions. Interactive notebooks can provide a place for students to practice making inferences and solving problems. Inquiry labs can be a type of problem-solving activity that would enhance learning. In an inquiry lab, students are given materials and asked to investigate a problem. An example is in my biology class where I provide students with different materials for a bird beak, such as spoons, clothespins, and tweezers and the food type, usually beans, and the students have to design an experiment to test which beak type would be the best in different environments. The students should have time to collect evidence to support their answer to the problem (Marcarelli, 2011; Molloy et al., 2012). Time should be given for students to design the experiment and run different trials to collect and record the data in their notebooks to be analyzed. Students should then have an assignment to assemble this evidence together. Having to justify their reasoning and share their findings with others gives them a chance to explain and reflect upon their thinking. Interactive notebooks provide the place for students to write and reflect on their learning so that they can share it with others.

Instructors can also provide a connection to the learning through something the student already knows or real-life situations (Caine & Caine, 1990; Tileston, 2004). These connections mean that the students will be more likely to remember it because it has meaning to them. “Past experiences always influence new learning” (Sousa, 2011, p. 54). If teachers are unable to make connections to past learning situations, they can employ experiential learning activities including class demonstrations, projects, field
trips, and labs to enhance learning (Caine & Caine, 1990). In her review of the literature, Staib (2003) found that the use of case studies, group discussion, and student-instructor interaction are among the most effective means of enhancing student learning. Evaluation of the mock situation and critique of the analysis provides practice for real situations. Simulating real-world situations and providing opportunities to discuss the problems that arise within those scenarios can strengthen memory and learning (Marin & Halpern, 2011). Science easily lends itself to these types of case studies and group discussions. Science interactive notebooks can be used to write down student reflections or experiences, so many of these types of different learning connections can occur. Since the learning connections are recorded in the interactive notebook, students have the chance for feedback and can review their learning.

Conclusion

Science interactive notebooks will be a useful tool in aiding and assessing the learning of high school biology students. Interactive notebooks allow students the opportunity to take, review, and revise notes during and after lecture. As stated in the note taking and brain science literature reviews, reviewing notes is important to student understanding and retention of material. These notebooks are also a pivotal tool in inquiry (Chesbro, 2006; Waldman & Crippen, 2009) as they provide a place for students to record observations, inferences, make predictions, and think for themselves. Waldman and Crippen (2009) stated

Interactive notebooks can empower students for learning science because they require active engagement with course concepts incorporate self-reflection; allow students
to express their personal values, experiences, and feelings;
teach organizational skills; create pride in and ownership of
class work; and help students visualize and demonstrate
understanding as evidence of self-regulation. (p. 53)

Incorporating various instructional strategies can ensure that scientific notebooks are effective in helping students learn scientific content. Explicit instruction allows students to learn new skills that will be able to be used in the future either within other classrooms or in the workplace. Active learning moves students from listeners to participants in their education and engages them with activities and high level thinking. Collaborative learning can enhance the retention of new scientific material. By working with other students to refine thinking and answer questions, students can learn more about the material than they would if they worked alone.

Activities such as problem-solving and examination of real-life scenarios allow learners to take charge of their own comprehension of the material. It also allows students to perceive and deal with their own attitudes and biases and to enhance thinking skills and logic as they search for broader connections and implications to what they are learning (Caine & Caine, 1990). Providing students with opportunities to look for patterns in the material can result in a deeper understanding of the topic. Problem-solving activities allow students to extract patterns in the data and use it to learn. Including these techniques within the interactive notebooks allows students to learn the material on a deeper level. In chapter 3, I present the rationale behind conducting a qualitative case study and how it was designed. My target population and setting is described and the data collection and analysis processes are outlined.
CHAPTER THREE

Methods

Introduction

Science interactive notebooks are tools for science educators to contain and develop teaching strategies (Chesbro, 2006) while at the same time addressing the state science standards and the learning needs of students. Within an academic setting, science interactive notebooks can be utilized in a variety of ways. The interactive notebook provides students with a place to take notes and an opportunity to enhance their writing skills (Butler & Nesbit, 2008; Young, 2003). Interactive notebooks are essential to increase scientific literacy and visualize learning, especially through the use of graphic organizers (Molloy et al., 2012). They supply a location to practice the processes of scientific inquiry (Chesbro, 2006; Marcarelli, 2011; Molloy et al., 2012). Interactive notebooks can aid students in communication of their learning and ideas with others, which is important to the scientific process (Butler & Nesbit, 2008). They also provide students with an organizational tool that helps them to realize how much they have learned throughout the unit and ultimately the school year (Waldman & Crippen, 2009; Young, 2003). For teachers, the science interactive notebook is also an assessment of student learning (Young, 2003).

Science interactive notebooks are an effective device for the learning that students will need in order to succeed in the 21st century (Marcarelli, 2010). Problem-solving,
collaboration, and examination of real-life scenarios are activities that can enhance the essential deeper learning needed to succeed. Searching for patterns in the learning of new material can result in a deeper understanding of the topic (Caine & Caine, 1990), which makes problem-solving so integral to science. The ability to search and find an answer to a question solidifies the process of science for students. Collaboration within a group to review real-life scenarios can enhance student knowledge of scientific concepts. All of this information allowed me to design my case study around the question; What is the effect of science interactive notebooks on high school biology students’ learning?

In this chapter, I present the rationale for my qualitative research and case study approach. I then describe the target population and setting for my study. Next, the procedure I use to conduct my research, including the human subject research review specific to my situation, is outlined. The data for my study will be gathered through qualitative observation, interviews, and documents and the techniques used to acquire that data will be recounted within the section on data collection. In the data analysis section, I will report how the data will be validated, separated into common themes, and reflected upon.

**Rationale**

Students tend to struggle with important scientific concepts. In order to help students to gain a better understanding of biology concepts, I utilize science interactive notebooks in my classroom. I want to study the effects of student learning through the use of their interactive notebooks. As a teacher I notice a difference in retention, but I want to know if the students perceive the notebooks as an aid to their learning. By focusing on student and teacher perception, my research provides the constructivist worldview since I
want to construct meaning from student and teacher experiences. “Social constructivists believe that individuals seek understanding of the world in which they live and work” (Creswell, 2013, p.8). The basic creation of meaning comes from social interactions. This constructivist view works best with qualitative research as the researcher creates meaning from the data collected in the field. The “goal of the research is to rely as much as possible on the participant's view of the situation being studied” (Creswell, 2013, p.8).

“Qualitative researchers try to develop a complex picture of the problem or issue under study. This involves reporting multiple perspectives, identifying the many factors involved in a situation, and generally sketching the larger picture that emerges” (Creswell, 2013, p.186). In order to design my research, I took into account the research on science interactive notebooks and student learning. During my qualitative case study, I hope to understand how science interactive notebooks can affect biology students’ learning. I chose to perform a case study because this type of inquiry will provide an in-depth analysis of student learning within the science interactive notebooks. “Cases are bound by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time” (Creswell, 2013, p.14). Data collection will occur through observation, document examination, and interviews with students. In the upcoming section, I describe my setting and the target population of my study.

**Target Population & Setting**

The target population is 10th grade biology students. Most of the classes within our school have an assortment of students who come from a background of being either home, publicly, or privately-schooled. There is a very small number of diverse students
mixed in with a mostly white non-Hispanic population (See Figure 4). Students with disabilities make up 11.9% of the high school. Students that qualify for free and reduced lunch make up 17.3% of the total population.

![Percentage of Student Population Per Race](image)

*Figure 4: Data based on student population as of March 23, 2017*

My research was conducted in a formal education setting, specifically within one of my high school biology classes at a Midwestern public charter school. I chose one class to focus on, so that I could make more detailed observations and take the time to carefully read through all of the writing samples. The class was chosen based on class size, demographic variety, and learning style. This is my natural setting, and “qualitative researchers tend to collect data in the field at the site where participants experience the issue under study” (Creswell, 2013, p.185). I had the opportunity to act solely as a researcher in my classroom collecting the data since my teacher candidate was teaching. As an observer, I had the time for collection, and students were comfortable with me interviewing them. In order to ensure ethical handling of my students and the proper
collection of data, I describe the human subjects research next followed by the methods for the research.

**Human Subjects Research**

I obtained written permission from my school to conduct the research. I also received a signed informed consent from my teacher candidate to perform this research while she is in my classroom. She gave permission for me to observe and reflect on her techniques and to report those findings during the study. In order to proceed with my study, I submitted an application and my capstone to Hamline’s Institutional Review Board for approval. After I received approval from Hamline, I obtained parental permission for the class that I was using in the study through a letter sent home with students. Parents were allowed to address any concerns they had with me about the use of their students’ data within the study before giving permission. Student names were kept confidential and only the data collected was discussed within the capstone. In the next section, I will describe the methods I used to collect the data for my research.

**Methods**

While my teacher candidate was with me for part of spring semester, I was able to observe my students and record data about their experiences with the interactive notebooks and their learning. My observations and story of this time was a chief component of my research and helped to shape some of the techniques I will be using with the interactive notebooks in my classroom in the future. The feedback of my teacher candidate was a principal part of my research as well. My teacher candidate and I took the time to discuss her journey with the interactive notebooks. Together we came to conclusions about the important aspects of the interactive notebooks and how they, in
turn, affect student learning. Her feedback on her experience with the interactive notebooks was an important point in my research.

Another aspect of my research is student feedback. I chose one of my biology classes to follow closely for part of spring semester, which included time with my teacher candidate and time without. Once a week in May, I gave students writing prompts (See Data Collection, p. 42) to answer within their science interactive notebooks. I also left myself open to exploring further follow-up prompts (Creswell, 2013) that may arise based on prior student responses. This gave me the opportunity to explore ideas I may not have thought about ahead of time and allowed for deeper student reflection of learning.

For each of the writing prompts given, I digitally scanned the answers students recorded into the interactive notebooks, so that I have a copy of their responses. I also selected a student who need to clarify his response with a follow-up interview in order to learn more about his answers and get his personal narrative. I took notes during this interview to record the student answers. The questions asked in the interviews were based on the responses of the student to the writing prompts and were created after consulting with my teacher candidate to ensure validity.

These data collection methods of student observations, written responses, the collaboration between my teacher candidate and I, and the student feedback provided my research with the qualitative data needed to answer my research question: “What is the effect of science interactive notebooks on high school biology students’ learning?” A limitation to my conducted research within my own class is a bias I may bring to the study. One advantage I had was the benefit of being able to check with my teacher candidate when data is collected and analyzed. I also included any negative or discrepant
information that my research revealed, and in the following section, I outline the collection guidelines I followed to ensure my data was valid. Qualitative researchers need to document the procedures of their case studies and document as many steps of the procedures as possible to produce reliable data (Yin, 2014). This allows anyone reading my data to follow my thinking from start to finish. Other researchers would be able to trace my evidence from my initial question to the case study conclusion. In order to achieve accurate data records, I refer to sources often with my report, present the actual research, indicate under what conditions data was collected, and create consistent circumstances with the specific procedures and questions from my case study protocol. If I am able to record data in this fashion, the evidence from my case study would “exhibit heightened construct validity, increasing the overall quality of the case study” (Yin, 2014, p.127).

**Data Collection**

Recording field notes on the behavior and activities of the students within my classroom will make me an “observer as a participant” (Creswell, 2013, p.191) meaning that my role as a researcher will be known to my class. There are some advantages to this type of research such as firsthand experience with the students. I recorded information as it occurred and unusual behaviors were noticed while observing. Some limitations of this research included that I could not see everything that is happening within the classroom, students acted differently knowing they are being observed, and this method of data collection is time consuming.

I kept a journal throughout the experience for my observation field notes. Within my journal, I recorded the date and time of each observation. On observation days, I
checked to see if all students in the class were on task at five minute intervals. I watched for students to be focused on what they are supposed to be doing including note taking, working in their notebooks, group work, labs, and other teacher directed activities. I then marked down how many students were not on task using my Observation Protocol Chart (See Appendix B) during this check. During the time between checks, I watched 3-4 students to make detailed observations of what they are doing. These students were chosen randomly and were different each day. I also followed observational protocols by drawing a line within my notes to separate the descriptive notes of the students from my own reflective notes. These are some of the questions I reflected upon and referenced following my student observations:

- How did students respond to the activities in the interactive notebooks?
- How did they react when changes were made or suggested to what they are doing?
- How did they respond to the different left sides that are used? What did they seem to like or not like?
- Are they learning the information that they are intended to?

In order to answer the last question, I looked through students’ daily work to watch the development of thinking and learning and look for trends that may be illuminated. This allowed me to glimpse the learning of scientific content in the classroom. I also examined other private qualitative documents. A collection of the written responses within my students’ science interactive notebooks were obtained through the digital scanning of their notebooks into the computer. This allowed me to keep a record of the students’ writing samples to analyze. Some advantages of using
qualitative documents are that it provides written evidence which saves me the time in transcribing, and it enables me to obtain the authentic language and words of my students. Concerns with this approach involve the time it took to scan the notebooks into the computer and the fact that not all students are equally articulate and perceptive.

I used open-ended questions within writing prompts to gauge the students’ perspectives of the science interactive notebooks. These prompts were given once a week over a three-week period during the last month of school. Students were given time at the beginning of class to work on their written responses. In order to create these questions, I looked at what I wanted to learn from the study about how students are utilizing the interactive notebooks and what I could improve upon. In order to ensure reliability, I asked a paraprofessional, my teacher candidate, and my capstone committee to look over the questions to ensure they were asking for what I was looking for. These are the three writing prompts that I will give students in May (one a week):

Writing Prompt #1

What do you like about the interactive notebooks in science? Why? How does your interactive notebook help you learn? What specifically does it help you with? What is a weakness of the science interactive notebooks for you? Why? How does that affect your learning? What could the teacher change to make that better?

Writing Prompt #2

Without being told, have you used a skill that you learned in your science interactive notebooks in another class? If so, which one and why? If not, if you had to choose an activity to help you learn in another class, which one would you choose and why?
Writing Prompt #3

What interactive notebook activities have helped you the most to understand difficult scientific concepts? Please give examples and reference specific pages of your interactive notebook.

After reviewing the responses to the writing prompts, I selected any students that needed to orally clarify their answers because they were unclear or I need more insight into their thinking. The follow-up interview that was conducted was used to learn more about the student answer and to get their personal narrative. I took notes and recorded audio during this interview. The audio was used to aid in the transcription of the student responses and was not kept after the responses were recorded. The questions asked in the interview were guided by the response of student to the writing prompt using the emergent design approach.

The research process for qualitative researchers is emergent. This means that the initial plan for research cannot be tightly prescribed, and some or all phases of the process may shift or change after the researcher enters the field and begins to collect data. (Creswell, 2013, p.186)

During the interview, I followed some specific protocols. In my notes, I had a heading that included the date, time, and the name of the interviewer and the interviewee. I asked two to three questions about student’s written responses, and I kept the interview short and to the point. The interviews did not last more than five minutes. The interview was unstructured, open-ended, and occurred during class work time.
The flexibility of the interview allows me as the researcher to have control over the line of questioning. It also allows me to talk with students about their responses and get the thoughts behind their writing. Some drawbacks to this approach are that my presence as their teacher may bias their responses, that not all students are equally articulate, and that they may also be embarrassed to talk with me during class when others may overhear our conversations.

By using qualitative observations, documents, and interviews, I was able to have multiple data sources to review and analyze. This gave me a glimpse into my students’ perspective of their science interactive notebooks. These different sources of data were more informative than gathering just one set of figures. It allowed me a better overall picture of how the interactive notebooks affect their learning. In the next section of this chapter, I will discuss how I reviewed data, made sense of it, and organized it into emergent categories that appeared during the data analysis.

**Data Analysis**

The purpose of qualitative research is to learn what the participants, in this case my students and teacher candidate, think about the problem or issue. In order do this I need to explore the process of learning. As a result, the focus of my data collection is to analyze the data to find out how science interactive notebooks affect my students’ learning. Data analysis in qualitative research can proceed at the same time as other parts of the study are being developed, such as the data collection and the write-up of findings (Creswell, 2013). Using multiple sources for gathering data lends reliability and validity to my study by allowing me to triangulate my data. “The most important advantage presented by using multiple sources of evidence is the development of converging lines
of inquiry” (Yin, 2014, p.120). Being able to match up themes that emerge in more than one of my data sources allows for more supported evidence. “If themes are established on converging several sources of data or perspectives from participants, then this process can be claimed as adding to the validity of the study” (Creswell, 2013, p.201). “By developing convergent evidence, data triangulation helps to strengthen the construct validity of your case study” (Yin, 2014, p.121).

The first step after collecting the raw data is to organize it and prepare it for analysis. This included typing my field and interview notes and scanning in the students writing from their interactive notebooks, so that I could sort and arrange the data. I then read all the data to reflect on the overall meaning, so that I could start coding the data. Coding involves taking data collected during research and segmenting it into categories by topic with a term or abbreviation that allows you to assemble all the material about the topic together (Creswell, 2014). I hand coded the data collected during my case study related to topics that emerged during my research. This helped me provide a description of the students as well as generate themes for the study. “These themes are the ones that appear as major findings in qualitative studies…” (Creswell, 2013, p.199-200). By coding data and finding themes, I created a case study database of my research. “…The creation of a case study database markedly increases the reliability of your entire case study” (Yin, 2014, p.124). This allowed me to organize and preserve the data collected in order to better analyze and discuss later.

The final step is to interpret the qualitative research and decide what was learned from the study. In order to properly understand my research, I utilized both inductive and deductive reasoning.
Qualitative researchers build their patterns, categories, and themes from the bottom up by organizing the data into increasingly more abstract units of information… thus, while the process begins inductively, deductive thinking also plays an important role as the analysis moves forward. (Creswell, 2013, p. 186)

Allowing me to follow up on the general themes that emerge from my data sources to try to develop a complex picture of the learning of students within science interactive notebooks. To aid in reliability, I reflected on my role within the study and how my background and experiences shaped my interpretations of the research. In order to ensure validity in my analysis, I utilized my teacher candidate and fellow science educators as peer debriefers. My teacher candidate already assisted me with generating my writing prompts and aided me when creating my interview questions as well. My colleagues helped me to analyze the data I collected to ensure I noticed any discrepant information. They also helped to ensure that I covered all the various themes of the research. Finally, my debriefers asked questions about the study in order to help add validity to the research (Creswell, 2013).

**Conclusion**

Scientific interactive notebooks provide a mechanism for student organization, bolster writing skills, increase collaboration among students, and support inquiry learning within the classroom. The learning of scientific content can be hard for students to grasp and equally challenging for teachers to assess. Science interactive notebooks are useful in providing feedback about student learning to the teacher. I conducted a qualitative case
study by collecting data from observations, documents including student writing within their interactive notebooks, and student interviews. I followed data collections protocols to ensure reliability and validity within my study. Data analysis occurred during collection and afterwards in order to code data into convergent emerging themes. The data and the themes were discussed with peer reviewers in order to assure validity of the study. In chapter 4 the data collected from the qualitative study of observations, documents, and interviews based on the research question: What is the effect of science interactive notebooks on high school biology students’ learning? is discussed in detail.
CHAPTER FOUR

Results

Introduction

Science interactive notebooks are a tool used in my classes to help students to organize their thoughts and to aid in their learning. I wanted to find out how effective the interactive notebooks have been with the students. Within the qualitative case study, I conducted a variety of methods were used to gather data. The three methods used to collect data were observations, written documents, and narratives to help me to answer my research question *What is the effect of science interactive notebooks on high school biology students’ learning?*

I observed a class of tenth grade biology students, as my teacher candidate taught, in order to gauge how students were using the interactive notebooks during class. I also examined students replies to several writing prompts that they were given over a three-week period in May. I examined their interactive notebooks for other written evidence of their learning processes. My teacher candidate was interviewed for her insight into the interactive notebooks and her narrative is also included. Several themes emerged from the data:

- organization
- note taking
- creativity
• variation
• reference
• student engagement
• student affinity towards the interactive notebooks.

I start the chapter by stating the background information for my case study and then describing each of the emergent themes along with the data that was collected.

**Case Study Background**

The class I chose for the case study had 22 total students, with a fairly even distribution of 10 males to 12 females. Four students were on a 504 plan and one student was on an IEP. There was also one English Language Learner in the class as well. Consent forms for the case study were sent home with students on April 5, 2017. The permission slip was due April 10, 2017, so that I could start observing. Seventeen of the 22 total students turned in a signed consent form; 15 parents gave permission for their students to participate in the study, and two parents chose for their students not to be participants. Of the 15 students participating in the study, eight of them were male and seven were female.

All students in the class were observed when I was at the back of the room, but data was only recorded for those who had sent back positively signed consent forms. I was able to observe for five days due to spring break, Science MCA testing, and my teacher candidate leaving the classroom. The number of students actually observed each day changed due to student absences. During the five days of observation, the science interactive notebooks were used every day. Most of the time the notebooks were used in class for note taking and left-side activities. Individually, students were mostly seen
either highlighting or referencing the notebooks, which allowed me to note some general patterns within my observations.

Specifically, I used the Observation Protocol (Appendix B) to record how many students were off task every five minutes during class. I watched for students to be focused on what they are supposed to be doing including note taking, working in their notebooks, group work, labs, and other teacher directed activities. I defined off task as not following the general classroom procedures. If they were talking, but working on their assignments I did not count it as off task. If they were not following along with note taking or the lecture, then I counted it as off task. Along with this check each day that I was observing, I choose a few students to watch closely in order to record their individual actions. I ended up being able to monitor all fifteen of the participants at least once within the time frame.

The writing prompts were given in May over a three-week period. All students in the class were expected to engage in the writing prompts, but students with the positive signed consent forms are the only ones whose data is included in the report. I projected the writing prompts on my SMART Board and read the prompts to the class. Students were then able to ask any questions if clarification was needed and then they had ten minutes to write their responses to the questions. The writing prompt was left projected on the board for student to refer to as needed. These written documents were then looked at along with my observations for major themes that emerged.

**Organization**

The first theme that stood out in the data was organization. During observations students were diligent in following the notebook procedures. I watched as students wrote
in the essential questions and dated their notes. Notes were always on the right of the notebook and the entire class was on the correct page. Knowing the class expectations of the notebook framework allowed students to stay organized. Caleb responded, “I like that interactive notebooks are organized and clearly purposed. It is helpful to have all your materials in one place.” Another student wrote, “I like the notebooks because they are neat and orderly. Having all of your information collected in the notebooks makes it easy to interact with the material.” The interaction occurs when the notes are reinforced by completing a left side activity (see Figure 5).

![Figure 5: Student Example of the Interactive Notebook format.](image)

When students wrote their responses to writing prompt #1, 57% stated that the left sides, as shown above, helped them learn the most within the interactive notebooks (see Figure 6). Pat wrote, “The interactive notebook helps me learn because I’m writing things
down then doing an activity.” Joe said, “The left sides help apply/review what we talked about in class.” Chris responded that “interactive notebooks help me learn mostly through the left sides because the best way for me to learn is seeing an example and then doing it.” Some of the other ways students learned with the interactive notebooks were the visual aids, charts, examples, and having all the information in one place. Fred responded, “The notebook helps me learn by providing plenty of examples. It helps me figure out exactly how to do something.”

![Bar Chart: Students Report What Helps Them Learn Within INBs]

**Figure 6:** Data based on student responses to writing prompt #1 on May 11, 2017.

“Organizing contents provides schema or scaffolding structures to aid the brain in understanding science content” (Molloy et al., 2012, p.1). Having all the student work collected and located in one place makes it easy for students to reflect on their learning. It was surprising that the students realized that the interactive notebooks not only helped their organization, but their learning as well. In Figure 7, eight students responded that one of the things they liked the most about the science interactive notebooks is the
organization. Mary stated, “I liked that all the notes were organized because it helped my brain process all the information and it was easier to study.” Missy replied, “My interactive notebook helped me learn by helping me retain information better and have all the information organized.” Jen wrote, “I like that the INBs are always there as a resource for studying. It’s nice having all of the information on hand and organized, because that is something I tend to struggle with.”

<table>
<thead>
<tr>
<th>Students Report What They Like About INBs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nothing</td>
</tr>
<tr>
<td>All Information in One Place</td>
</tr>
<tr>
<td>Summarizes Information</td>
</tr>
<tr>
<td>Diagrams</td>
</tr>
<tr>
<td>Variety</td>
</tr>
<tr>
<td>Studying Reference</td>
</tr>
<tr>
<td>Notes</td>
</tr>
<tr>
<td>Organization</td>
</tr>
</tbody>
</table>

Figure 7: Data based on student responses to writing prompt #1 on May 11, 2017

When I asked my teacher candidate, Becky, if she thought the interactive notebooks were a useful learning tool for students, she responded “The notebooks help organize their thoughts and activities, provides them repeat exposure to the content, and uses memory enhancing tools such as color and images to help students learn and remember content. She did however add, “I think the usefulness of the notebooks depends greatly on the quality of task the students are asked to do in them.” Not just any activity counts as a quality left side. It cannot just be busy work, it needs to be something
that engages the students and either has them practicing a skill, like filling in a Punnett square, or has them thinking about the content at a higher level. The layout and organization of the interactive notebooks helps students to learn scientific content.

**Note Taking**

The next theme to emerge from the data was note taking. During my observations, I noticed that students were very focused on recording notes within their notebooks when the slides were up and listening to the teacher during lecture. Students also asked relevant questions that contributed to the learning of others about the immune system and specific diseases. Within the notebooks, students followed procedures well and were on task at a 90% participation rate during note taking. Missy was observed taking her notes differently than other students in the class. Due to her placement within the room, she felt most comfortable writing with her notebook in her lap as she was turned to the board. Most other students turned their heads or chairs to face the board.

Many students were efficient with their time when they were done taking notes and waiting for lecture. Mary used her waiting time to highlight her notes. Caleb was very good at summarizing the notes. He only recorded new items and did not write down everything from each slide. This made him finish writing notes into his notebooks before others, but he did not use the time to get off task. He waited patiently for the lecture to begin where sometimes he would add information into his notes depending on what was mentioned during lecture. Martha read through her interactive notebook and as soon as she realized there was a new slide up, she would go back to writing new notes within her notebook.
A number of my students developed a personal system for note-taking to make it work better for their learning and referencing later. Peter took the time while taking notes to draw in lines whenever different topics came up to break his notes into chunks. This will make it easier for him to find relevant information later. Amber used a technique that I now refer to as the four-color method. I saw her using it and asked her about it during work time in order to understand what she was using the various colors for. She does not like to use the same colors every day, but knows what a different color within her notes means. She uses one color for the essential question, another color for main topic ideas, a different color for definitions, and the final color is for examples. She says she likes it better than highlighting. The interactive notebooks allowed my students to not only take notes, but they were also able to develop their own systems within the notebook framework.

**Creativity**

The data showed that creativity was also a theme within the interactive notebooks. “Students take responsibility for their learning more clearly with interactive notebooks because they can see the relationship between what they recorded from lecture, lab, or reading and the products created from the information” (Molloy et al., 2012, p.39). When students are allowed to be creative they are able to retain the information better as they make the connections to the information for themselves. An example of creativity aiding learning is Amber’s four-color method. She took something that is required in the class, note-taking, and made it her own. By developing her own style, she is making her learning personal.
Many creative opportunities were given to students throughout the year; such as one pagers, diagrams, and choices on what kind of left side activity they wanted to complete to aid their learning. An example is that students needed to compare density dependent and density independent factors, but they could choose exactly how they wanted to do that. Many chose to use graphic organizers like Venn diagrams and T-charts, but one student drew images (See Figure 8). I asked my teacher candidate if she thought the left sides that were created by students were better than those given to students. “In general I think that left sides that are more open to student choice and creativity are better for learning retention because it requires the student to invest in learning something in order to complete the assignment.

![Student Example of Left Side Choice](image)

*Figure 8: Student Example of Left Side Choice*

One pagers (see Appendix D) were one of the creative activities that students felt helped them to understand difficult scientific concepts the best (see Figure 9). Mary
stated “The one pager really caused me to remember the vocabulary in that chapter and the different graphs.”

Fred responded, “The activities that helped me the most was the creation of the one pagers. Not only were they fun, but you also learned from them.” When students were asked what left side activity they would choose to use in another class to help them learn they also responded with one pagers. Mary responded, “I would use a one pager, even though I do not like doing them, because they incorporate pictures/visuals that help me remember the information easier.” Sara would also choose a one pager, “One pagers help me a lot, mostly because there is a lot of information in one spot and I do not have to go searching for a bunch of stuff.” The combination of organization and creativity that one pagers provide. helped students to understand scientific concepts.
Figure 10: Data based on student responses to writing prompt #3 on May 22, 2017.

My teacher candidate noticed that the students who did well on creative assignments were also the students who put in a great deal of time and effort into their notebooks on a regular basis and seemed to do better in class. The correlation between creativity, effort, and class performance is an interesting point to research further. In general students appreciated being able to individualize their learning within the interactive notebooks and maybe that is what actually led to the higher class performance. Jessica said,

My interactive notebook helps me learn because I can see the answers and knowledge really easily and it’s all in one plan for me to find. I also like how it can give me a little bit of creativity for the left sides of the notes.
Variation

Along with creativity, came the variation that is present within my students’ science interactive notebooks. The variation that an interactive notebook can provide in your classroom can be just the thing a student needs in order to learn. Right side activities like note taking and lectures help the auditory and linguistic learners. Many of the left side activities are completed by the students themselves catering to the intrapersonal students. Group work is accomplished during hands-on activities, like labs, which aids the interpersonal and kinesthetic learners. Analyzing and displaying the data from these activities appeals to the logical and mathematically-geared students. Graphic organizers, foldables, and diagrams help the visual learners. Jen wrote, “I like the variety with the notebooks as well. That’s definitely nice because having just notes in a notebook can be more difficult to study from than notes and diagrams and such.”

When asked what she liked about the interactive notebooks, my teacher candidate mentioned the variety that they provide to students.

It is a good tool for committing learning to memory and a good tool for teaching organization skills. The use of variety of activities in the notebook helps reach a wider variety of learners. Having all of the students’ work in one place is a convenient study tool.

Allowing variation and creativity makes the learning unique to each individual’s interactive notebook. There are similarities when one looks throughout the notebooks, but one can see the personalities of the students come through as well. Providing a variety of activities in the classroom engages more students in learning.
Reference

Another theme that emerged from the data was that interactive notebooks also provide a reference for students. There are some left side activities that students felt made better references than others. The two that were mentioned the most by students were diagrams and one pagers. Caleb wrote “The water cycle diagram was useful for me because it made me understand it better. It also made me focus on each detail rather than glossing over them. It was also a good reference.” Missy liked both one pagers and diagrams, “They have helped me understand difficult concepts.” Peter wrote,

One thing that has helped me outside of class is any one pager I have done. For example, they have helped me find better ways of summarizing a chapter or even study for the next test due to coloring, finding text, and drawing out things.

Left side activities are continuously referenced by students because the activities help them retain the information they are learning in class.

In order to reward students for their hard work on the left sides of the notebooks, my teacher candidate tried something new during the chapter test while I was observing. She let students use their interactive notebooks to be able to reference for the class period during the test. After the test, students were given a review packet of semester one to go through and write answers down for a discussion next week in preparation for the science MCAs. I was able to watch 14 participants to see if they took advantage of the opportunity of using their interactive notebook on the test. Specifically, I focused on Andy and Sarah. Andy left his interactive notebook open and referred to it as needed.
throughout the test and also on the review packet. Sarah did not use her interactive notebook on the test, but she did when she was working on the review packet. During the test a total of 10 out of the 14 participants referenced their interactive notebooks at least once. After the test, 12 out of the 14 used their notebooks to look up and review semester one concepts as they filled out the review packet.

**Student Engagement**

Interactive notebooks kept students engaged during most of the class time I observed. As seen in the Observational Protocol Chart (Appendix B), most students were engaged daily in the classroom activities. On Monday, April 10, 2017 the class was finishing up the first section of notes on the immune system, completing a left side on those notes, and then starting a new note section with the teacher candidate. During the class period there was 100% student engagement. Students were very focused on recording notes within their notebooks when the slides were up and listening to the teacher during lecture. All students worked on putting the left side paper into their interactive notebooks. They then participated in a class discussion about the left side activity and were filling in answers as it was discussed in class. Additionally, students were able to transition into the next section of notes quickly and smoothly when the teacher was ready for their attention.

On the second day, the class finished up lecture notes from the previous day with the teacher candidate, completed a left side on lymphocytes, and concluded with a group activity. Students were engaged and asking questions during the lecture. They were able to complete the left side activity by referencing the notes they had just taken. The group activity was a guided inquiry learning packet on the London cholera outbreak, modes of
transmission, and sources of pathogens. Student engagement for the entire block class period, 85 minutes, was above 75%

On day three class started with students assessing each other’s interactive left side activities within the notebook from the week before. When students were done they wrote in the essential question to begin the day’s notes. Students were very actively engaged in the lecture and asked many questions about different diseases. Class ended with students working on a left side activity. Eighty percent of students were engaged on day three and the block period on day four, where students were focused on completing various activities to review for the chapter test. On the fifth and final day of observation, 93% of students were engaged the entire class period during the chapter test on the human immune system.

The days that students were actively taking notes or completing left sides had the higher student engagement within the classroom. Any left side activity that required students to be creative and think seemed to be the most engaging to students. Along with my own observations, I asked Becky, my teacher candidate, about which left side activities within the interactive notebooks she thought engaged students more. She discussed the one pagers and chapter summaries: “These activities require the student to gather multiple pieces of information and spend time with the content.” She also thought that the foldables were helpful to students. “These allow students to pick and choose the information they want to include, which usually means that they are picking the most relevant info.” Finally, Becky mentioned that labs were helpful in engaging students, “I also like the data gathering labs that require students to graph data and analyze results and answer critical thinking type questions in the notebooks.” Note taking, creativity, and
variation within the notebooks keep students engaged and thus learning within the classroom.

**Student Affinity**

Another theme that stood out to me when evaluating the data was how much the students seemed to enjoy the interactive notebooks. Students could articulate that it helped them with organization and note taking. They repeatedly mentioned how the interactive notebooks allowed them to be creative. They talked about how having the diagrams and one pagers within the notes allowed them to understand difficult scientific concepts. Students discussed how variation in the types of activities we completed helped their learning. Jessica responded with why she really liked foldables, “I just like how simple it is and yet how creative you can make it. It is also something that you physically have to touch and move, which works well with how I learn.” Participants also wrote about how they used the left side activities as references and they discussed how the activities kept them engaged.

What surprised me even more was that 56% of the students say that they have used a skill that they have learned within the interactive notebooks in another class without being asked to. The second part of the writing prompt asked students what skill from the notebook they applied within that other class. One student used a T-chart. She said “I've used T-charts in other classes because I found they are useful when it comes to organizing things. I like the way they look, format-wise, because they are simple yet effective.” Two students wrote about how they used color to help them in other classes. One stated “I have learned to add color to my notes. I had a lot of stuff written down for lit and it helped me distinguish what was important to look at.” Peter added,
“Highlighting and coloring have helped me with my math notes.” In addition, students noted that the other tool that has helped them in other classes were graphs.

Students have been using skills that they have learned in science within other classes like; literature and math. They also have identified skills that could help them in history. I never explicitly told students that the skills they were learning in science within their interactive notebooks was something that could be applied in other classes, but many were doing that on their own. In order to increase this cross curriculum application next year, I plan on mentioning to students that what we are doing in their interactive notebooks could be useful in other classes. I believe that will get students thinking about what activities have helped them individually. That way they are able to identify what techniques help them most to learn and will then be even more likely to use it outside of science in order to practice independent thinking and learning skills for life. In order to help with bias in the case study, I also asked participants about weaknesses of the interactive notebooks in science. As seen in Figure 8, the answers on this were more widespread with the biggest issues being identified as too many notes, the fact that left sides need color, and that some left sides were too long or difficult. Chris wrote, “Sometimes if you have a lot of notes it is hard to study all of them, but the notebooks help me for the most part.” Fred responded, “A weakness of the notebooks would have to be the coloring part. I usually forget to do it.”
Figure 11: Data based on student responses to writing prompt #1 on May 11, 2017.

Caleb stated “A pitfall of interactive notebooks is the rhythm can become mundane and you begin to do things in a sloppy manner. This affects the things that we do often like writing the title and the dates.” This response leads me to the one interview I did for clarification. I asked Caleb what else was affected and he replied “the quality of my work.” I mentioned that I was thinking that for next year I would let students use their interactive notebooks on the tests. He replied that he felt that more students would take the time to complete things more thoroughly and would be less sloppy if they knew that they would be able to use their notebooks on the test. He suggested if I were to do this I needed to provide feedback within the interactive notebooks sooner and check for correct answers on left sides. When I said I was planning on changing that for next year, Caleb replied “That would be awesome!” By allowing students to use their interactive notebooks for reference on the chapter tests, it allows for me to ask more high level thinking questions. Engaging students beyond simple recall into more concept focused
questions. This prepares students better for the standardized testing like MCAs and ACTs. Overall students had more positive learning outcomes to attribute to the science interactive notebooks than negative.

Conclusion

Within the qualitative case study that I performed many themes emerged from the collected data. They included organization, note taking, creativity, variation, reference, student engagement, and student affinity towards the interactive notebooks. Interactive notebooks helped students improve their organizational skills. The framework of the interactive notebooks allows students to take information learned in class and apply it. This provides students an example to reference and use later in class. Many students communicated that having all of the class materials in one place allowed them to be better prepared for class. They also connected the organization to a better ability to learn.

Students wrote about how note taking went well with the left side activities, as it allowed them to take the information they were given in class during notes and interact with it. By drawing diagrams, making graphic organizers, and practicing skills they were able to have a better understanding of the information they were learning. Students were able to give a clear picture of the types of activities that they felt helped them to learn. About half of the students named one pagers as the left side activity that helped them learn the most and the one that they would choose to use in different classes to aid retention. The notebooks provide students with an opportunity to be creative as well. Choices regarding what to put onto left sides and how to arrange diagrams and one pagers allow student to personalize their interactive notebooks to reflect their individual learning.
A variety of different activities can be completed within the pages of the science interactive notebook allowing the teacher to accommodate multiple learning styles easily. A lab that is done with a group, is hands-on, and that is followed up with critical thinking questions and data analysis will aid interpersonal, kinesthetic, and logical learners. Auditory and linguistic learners will also benefit from discussing and recording the data with their lab partners. All of this leads to high student engagement within the classroom as the activities are appealing to multiple facets of learning at once. This also provides a reference for students and the teacher about what the student is learning in class.

Most students regard the interactive notebooks positively and acknowledge that the activities that are completed within them help them to retain information. Some students have used techniques that they learned within the interactive notebooks in other classes without being required to. They were able to determine which tools from the interactive notebook helped them learn and applied those tools to other situations in order to aid them. I will be more explicit about the benefits of what we are doing in class to allow more students to determine what helps them learn in order for them to apply those skills in other life situations. There were some perceived weaknesses to the notebooks. Things such as too many notes are a general complaint about science class. The comment about the routine becoming mundane and left sides being done sloppily will hopefully become alleviated with students being able to use interactive notebooks on their tests next year. They will realize the information will need to be there in order to reference, which will keep them on task. It is clear to me that the interactive notebooks have a positive effect on my high school students. In the next chapter I will discuss what I have learned
throughout the research process, explains the limitations of my study, and discuss what future research could be conducted.
CHAPTER FIVE

Conclusion

Introduction

Science interactive notebooks provide a place for my students to organize materials and engage with the content. By engaging with the content students are practicing and learning skills that can aid them in different situations. Within the process of researching interactive notebooks and their effect on students in my classroom, I have learned a great deal about myself and my teaching. Many of my research skills have been refined through the quest to answer my question: What is the effect of science interactive notebooks on high school biology students’ learning? There were some limitations that affected the case study, but there are revisions and expansions that could be conducted with future research projects.

Within this chapter I will revisit my inspirational student and how she impacted my desire to complete this case study. Discussion about what this project helped me to discover about myself, my research skills, and my teaching will follow. Afterwards, I analyze the various limitations that were encountered within the study. Finally, an explanation on how this case study and the research on interactive notebooks could be expanded upon in the future will be presented.
Inspirational Student

My study came about because of the impact my inspirational student had on me. Her email to me (see p.10) enhanced my perception of the interactive notebooks and what they could do for my students. Here was a struggling student who was not very good in logical classes, science and math, who found a way to connect those tough subjects to how she did learn. She is an artistic learner, so being able to draw the diagrams and complete the left sides within the interactive notebooks clicked with her. The part that I am so thankful for is that she took the time to let me know that this new technique I was trying in class is what allowed her to visualize the concepts and understand them.

Through this project I was able to reconnect with my inspirational student and check on how she was doing during her senior year. When I let her know that I was conducting a study on interactive notebooks and their effect on learning and that it was because of her, I saw her light up. It almost made me cry to see how that acknowledgment affected her. She explained to me how she is still using interactive notebook techniques she learned in my class to help her visualize concepts. She thanked me again for helping her figure out the skills she needed to learn. I let her know how much I had appreciated her emailing me and asked if I could use her email in this capstone. She gladly agreed, and I could tell she was proud to know that she could help me. Her email was a turning point in my teaching career. It was amazing to me how one decision I had made to try something new within my classroom had been the thing she needed in order to perceive content through her learning lens. As teachers we are told often how important our job is, but I did not fully comprehend that for myself until working with her.
My Learning

What I learned the most through this project was how much work, but also how rewarding research can be. The topic of scientific interactive notebooks was clear to me, but defining the aspect of the notebook I would research took some work. The direction the study took was what I had hoped for all along. I wanted a better understanding of how interactive notebooks were perceived by my students and how they affected their learning. The research on interactive notebooks also lead to an improvement in some of my skills.

The first skill impacted was my ability to research. For instance, during the literature review, I realized I had never investigated a topic so in depth before. I found it enjoyable and actually the easiest part of the project to write. Finding relevant articles and studies was the hardest part, but I found new techniques for finding credible sources, and I will use these techniques in the future and also pass them on to colleagues and students. My research writing has also improved through the multiple revisions that have been completed with the help of the feedback from my capstone committee. They have helped me to focus on the important aspects of what I want to say and word it in a way that is both understandable and professionally academic.

Through the case study, I was also able to refine my observation skills. As a teacher, this is invaluable. We become so focused, at times, on teaching the material to students that we do not often take the time to observe the impact of the different techniques we are using. By being able to take a step back from the teacher role and just observe, I got a clearer view of the influence interactive notebooks had within my
classroom. I could contemplate the effects that class procedures had on my students and their engagement.

My self-reflective techniques have also been enhanced by this project. This was a surprise to me. As a teacher I have always looked back at ways to improve my classes, throughout the days, months, and years. Teachers make changes throughout the day to their lessons in order to better connect and explain the content to their students. Additionally, I make changes every year to my classes to improve the lessons and my students’ involvement and learning. I made the change to incorporate the interactive notebooks within my class, but this research led me to complete these reflections at an even deeper depth. By reflecting solely on the interactive notebooks, I have seen their positive effects, but also the improvements that need to be made to achieve higher-level thinking. These changes are discussed within the next section.

**Teaching Discoveries**

The emergent themes from my research: organization, note taking, creativity, variation, reference, students engagement, and the student affinity to interactive notebooks helped me to understand how interactive notebooks were helping students learn within my classroom. Students appreciated the organization that interactive notebooks provided to them. Having all their notes and practice in one location was beneficial when students wanted to reference material. The variation that interactive notebooks provide also aided in different aspects of student learning as the notebooks can easily be adapted for diverse learning styles. One of the biggest things I learned from the data collected within the study was that the students appreciated the ability to be creative and that this creativity aided their learning and retention. My linear teaching style does
not always take into account the need for creativity when I am planning activities. As a result, I will make sure to allow for more creativeness within my students in the future in order to aid their different learning styles.

Much of what I learned about my teaching through the process of this capstone has to do with the effectiveness of the techniques I have been using to implement the science interactive notebooks within my classroom. As a researcher, I was able to step back and look at how the notebooks were being used, not only by the teacher, but by the students as well. Examination of the data helped to confirm that some of the procedures of the interactive notebooks work well, such as the organization and the set-up for the input and output of the information, which is consistent with the research (Molloy et al., 2012; Waldman & Crippen, 2009; Young, 2003). The left sides are beneficial to student learning. “The interactive notebook is a learning tool to strengthen student learning of content material through increased student participation” (Molloy et al., 2012, p.2). This is consistent with the brain science on learning as it is shown that students need time to practice the learning (Sousa, 2011; Tileston, 2004). Left sides are providing students with the practice they need to learn new content and increasing student engagement in the classroom.

I also learned that some procedures, like the way I have done most of the grading this year, were not as effective as I had hoped. When I asked my teacher candidate, Becky, what she would change from the way I currently use the interactive notebooks in my class, she responded, “I would try to include some way of assessing learning in the notebooks so that I have a good idea of where the class is at before they take the test.” The interactive notebooks in my class were only checked once a week. Checking the
notebooks only once a week does not allow me to give the students feedback while they are learning. I am unable to correct misconceptions or to help them if they are striving to understand something when I do not find out until a week after the lesson has occurred.

The weekly check was also misguided because it was mostly completed by peers. Peer grading is good for some things and would be helpful once in a while, but in order to provide meaningful feedback, I need to be checking things more often within the notebooks. Teacher feedback was mentioned in many of the articles and studies that I had reviewed before starting the study. Butler & Nesbit (2008) suggest that feedback should be more than just a score and should focus on the student’s level of knowledge and skill. Interactive notebooks allow teachers a chance to give targeted feedback as they see how students are improving and what skills they need to strengthen (Mallozzi & Heibronner, 2013; Molloy et al., 2012). The brain science research I looked at also mentioned feedback as being important. “Specific feedback offers suggestions and leads students to problem solve when things are not going well or when they reach an impasse in the learning” (Tileston, 2004, p.5). Specific feedback refers to addressing students’ strengths and weaknesses in order to guide the learning. Blanket statements like “nice work” do little to give the students direction. While reflecting on my teaching practices, I realize that providing students with quality feedback has been a weakness of mine, so I will be changing my grading procedures for next year.

In addition, I realized that I can do more explicit instruction within my classes. When introducing new procedures, I need to be more thorough in explaining the thinking behind it (Marin & Halpern, 2011). An example would be informing students they should date the pages in their interactive notebooks. In order to be taken seriously in the
scientific community, scientists must track all their data, and in doing so, dates are extremely important, as my research within the capstone reminded me. When teachers are introducing a new skill it requires time to practice so that it provides students with the opportunity to apply the knowledge later (Archer & Hughes, 2011; Marin & Halpern, 2011). This practice can come in the form of left sides. Most students stated that the left sides help them to learn more about difficult scientific concepts. Students are seeing the value of left sides and are even using some of the interactive notebooks skills they are using in science to help them in other classes. That surprised me as I was not sure how many students were actually using interactive notebook methods in other classes that did not require them. With more explicit instruction students will be even more likely to take techniques that have helped them learn in science and apply them when needed. If students understand the *why* behind performing a task within their notebook a certain way they are more likely to buy into the procedure and use it when needed.

**Limitations**

There were quite a few limitations to my study when I reflect back upon it. The first was the sample size. Choosing a larger class or watching more than one class could alleviate the sample size issue in future studies. The variation that occurred with the number of participants per day due to absences was also large. If I would have spent more time observing this may not have been as big of a limitation as it turned out to be. Spending only five days surveying also did not allow much time to observe variation within the classroom. Most of the observations were lecture based which is not typical of a week within my class during the rest of the year. Part of the reason for this occurrence was the time of the year the study ended up being completed as my observations had to
work around spring break, science MCAs, and my teacher candidate’s departure. If I would have completed my consent forms and college board acceptance procedure earlier I would have not had such a time crunch. Observations of more group activities and a lab that my teacher candidate conducted could have been included during the study which would represent what happens in the science classroom more accurately.

The biggest limiting factor of watching mostly lecture based days was that I was not able to observe much depth of thinking within my classroom. If there was an opportunity to watch just the few weeks that followed my teacher candidate’s departure I would have witnessed my students during oil spill STEM challenges. The first challenge was for students to examine the three types of oil spill clean-up which are containment, absorption, and dispersant. The next challenge had lab groups working together to design and test the best combination of these three techniques to see what worked most efficiently. The group then had to discuss strengths and weaknesses of their design and what they could do to improve it in the future. These types of activities lead to more critical thinking and high level learning that I wish I could have encountered during my study. Future research could alleviate this and provide a more balanced representation of what science interactive notebooks can do in a high school classroom.

**Future Research**

Knowing some of the limitations of the case study and the weakness of some of my procedures, future study of the science interactive notebooks in the high school classroom is needed. A long-term study on the effect of interactive notebooks on high school students would do a more complete job of gauging the effect interactive notebooks have on their scientific learning. Research could also be conducted on the effect of
explicit teaching on student understanding of interactive notebook techniques. Another area that could be addressed in the future is the effect of quality teacher feedback on student learning. Mallozzi & Heibronner (2013) discussed this in the conclusion of their study on the effect of teacher feedback within interactive notebooks:

Further research is warranted on how to structure teachers’ time and how to train them so that they are able to provide necessary and timely written teacher feedback with consideration for students to also be able to read, respond, and use ongoing feedback to impact their learning. (p.21)

Other research ideas involve looking at the effect of interactive notebooks in advanced science classes. This study year was also the first year that I used interactive notebooks within my Advanced Placement (AP) biology class. AP classes give students the ability to earn college credit for their high school course by passing an exam given in the beginning of May. The exam is scored on a scale from 1 to 5. In order to pass students must achieve a 3 or higher. The exam is focused on students being able to understand the scientific concepts enough to be able to predict what will happen if something about it changes, so it is a deeper level thinking than just simple recall of definitions or cycles. The class, itself, is very fast paced in order to be able to get through all of the possible material upon which the students may be tested. I decided to use interactive notebooks this year, so that I could help students comprehend the scientific information. The base knowledge would allow them to be able to critically think about the material, without a strong foundation of the concepts this is unlikely to happen. The pass rate for the AP exam this year with the use of the interactive notebooks was 72%.
The pass rate for the year before without the interactive notebooks was 40%. I am not able to draw cause and effect from these data, but I plan on keeping an eye on this for next year. I feel that a future study on how interactive notebooks affect the success rate of AP students would be a good follow-up to this data.

**Conclusion**

My inspirational student helped me to realize that the interactive notebooks were a beneficial approach to learning. The majority of students within my research also believed that the interactive notebooks improved their organization and aided in their learning. There are certain procedures that I can change within my classroom to make their learning within interactive notebooks even more significant. Providing more frequent and meaningful feedback to students is one of these changes. With more explicit instruction, more students will be able to recognize what helps them to learn and be able to apply those techniques within other situations.

A few significant limitations affected the outcome of this study. The biggest being the brevity of the study. The length affected the types of activities that were observed and lead to a narrow scope of observational data, but the written documents provided significant data into what students thought about interactive notebooks and how the notebooks assisted their learning. By looking at the limitations within this capstone a more effective experimental design could be developed to study the effect that interactive notebooks have on the learning of high school students.

Through this capstone I was able to enhance my observational and experimental design skills to become a better researcher. I was also challenged to improve my writing skills by completing a literature review and communicating my case study results clearly.
My self-reflection techniques were also refined throughout the case study. Being able to decide upon the most successful instructional strategies within the classroom makes me not only a more effective teacher, but also a more competent researcher. What I have learned throughout this process will not only improve myself, but the classroom experience for my students to come.

When I first started out using science interactive notebooks within my classroom I felt that they were just another tool in an enormous basket of things a teacher could do. I never imagined the impact that my choice of introducing interactive notebooks would have on my students and their learning. With the help of my inspirational student and this study, I realize how important these notebooks are within the science classroom. They allow students to learn organization skills, to be creative, to have the opportunity to perform scientific research, and to display and reference their learning. The decision to start using science interactive notebooks was made on a whim, but the impact they have made on my teaching and my students will remain a crucial turning point in my teaching career.
REFERENCES


*Science Scope, 29*(7), 30-34.


*Instructional Science, 16*(3), 233-249.


Appendix A

Minnesota State Standards

According to the Minnesota Department of Education (MDE), these are the most current Minnesota high school science state standards and benchmarks that can be covered in general within interactive notebooks. The first standard addresses the strand of nature of science and engineering and the substrand refers to the practice of science.

Standard: Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world. \textbf{9.1.1.2.3} Benchmark: Identify the critical assumptions and logic used in a line of reasoning to judge the validity of a claim (2009, p. 28).

The next standards connect to the strand of the nature of science and engineering and the substrands focus on the interactions among science, technology, engineering, mathematics, and society.

Standard: Science and engineering operate in the context of society and both influence and are influenced by this context. \textbf{9.1.3.3.2} Benchmark: Communicate, justify, and defend the procedures and results of a scientific inquiry or engineering design project using verbal, graphic, quantitative, virtual, or written means (2009, p. 30).
Standard: Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding. 9.1.3.4.3 Benchmark: Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results. 9.1.3.4.4 Benchmark: Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve the data collection and analysis (2009, p. 31).
Appendix B

Observation Protocol Chart for Case Study

Students Found to be Off Task

<table>
<thead>
<tr>
<th>Date Observed</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
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Observation Protocol Chart for Case Study

Students Found to be Off Task

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<td>14</td>
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</table>
Appendix C

Student Consent to Participate Form

Dear Parent/Guardian:

I am working on my Masters in Natural Science and Environmental Education through Hamline University. In order to complete the program, I am writing a capstone. My capstone involves studying the interactive notebooks that we have been using in biology class all school year. I would like to research how they affect student learning in your child’s class.

In order to collect data for this research I will be observing your student through the end of this school year. I am requesting permission to collect, copy, and include writing samples from your child’s notebook in my capstone. Writing samples would be in response to a few different writing prompts that will allow me to understand how the students feel about the use of the notebooks in science class. Responses will not be graded; they will just be for research purposes.

Based on student responses to these prompts, I may choose students to interview further. The interviews will be so that I can fully understand their feeling and thoughts as writing doesn’t always capture the whole story. These interviews will only be a few minutes long.
and would occur during class work time. I will be writing down the students’ responses and recording them for audio for anything I may miss. Once I have down the student responses the audio will be deleted. The student’s written or spoken responses will not be used against them in any way as I would like feedback both positive and negative to better understand how the interactive notebooks are working for them.

No student names will appear in any submitted materials and materials will be kept confidential at all times. These submitted materials will be a part of my completed and published Masters work. If you have any questions or would like to request a copy of my completed work, please contact me.

The attached form will be used to document your permission. If you choose to not allow your child’s work to be included in my capstone he or she will still have the same instructional activities on the same learning goals as all other students in the class. Thank you for this opportunity to learn to be a better teacher.

Sincerely,

Hamline Institutional Review Board

Mrs. Mollet
amollet@spectrumhighschool.org

Matthew Olson, Chair
mholson@hamline.edu
CONSENT by Parent or Guardian of students under 18 years old

I am the parent/legal guardian of the child named below. I understand the use of my child’s work samples and interview responses for the Capstone as described in the letter above.

____ I DO give permission for my child to be observed and samples of their written work to be included in the capstone as described above.

____ I DO NOT give permission for my child to be observed and samples of their written work to be included in the capstone as described above.

____ I DO give permission for my child to be interviewed and their responses recorded in the capstone as described above.

____ I DO NOT give permission for my child to be interviewed and their responses recorded in the capstone as described above.

Student’s Name: ______________________

Signature of Parent or Guardian: __________________________

Date: __________________
Appendix D

One Pager Guidelines and Examples

**One Pager**

A One Pager is a creative response to your learning experience. It allows you to respond imaginatively while being brief and concise in making connections between words and images. Your One Pager should reflect your personal thinking about the topic.

**Follow this format for your One-Pager:**

- Use unlined white paper
- Title the One Pager appropriately to reflect the content
- Use Color! The more visually appealing the better!
- Have a reason for placing things by each other
- Write two quotes from the reading or activity
- Use three visual images to create a central focus
- Write the main idea of the reading
- Place 5 essential vocab words/phrases around the images.
- Write two Costa’s level two or three questions and answer them.
- Put a symbolic colored border around the edge of the page

Minimal white space should be left – fill it with images and words
Student Examples of One Pagers