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Inquiry-Based Learning and Higher-Order Thinking Skills in High School Science

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Inquiry-Based Learning and Higher-Order Thinking Skills in High School Science

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Introduction

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Think back to your ninth grade Physical Science class. Do you remember any specific topics or things you learned? Like me, you probably don't remember anything about ninth grade, let alone what you learned in science class. Chances are also high that, like me, your teachers used Powerpoint slides and lectures to teach new topics and ideas. Traditionally the order of a science unit is as follows: introduction of a new topic via lecture and slides, practice said topic with worksheets and book problems, complete a lab or activity by following the procedure, and then a unit/topic test. While this order does create predictable routines and schedules for the students, it is not the most effective way for students to deeply understand the topic they are studying. When following a traditional way of teaching, many students memorize the information for the test but don't deeply understand or retain the information.

As a science geek and chemistry major through college, I can attest to the fact that this is the sad reality of how science classes are structured. Students often prioritize knowing and memorizing the information that they will be tested on over actually understanding the information. Students are also often unmotivated or excited to learn about science because the pure amount of information they have to remember overwhelms them. I feel, as a science teacher, that the most important part of my job is to get students excited about science and teach them how they can see science all around them in the world. This had led me to my research question of: *How does the* *incorporation of inquiry-based learning and student choice increase student understanding in a high school science class?*

While completing my undergrad at Hamline, we were taught a lot about discovery-based and student-centered learning and how using strategies such as those can change the way students learn in the classroom. It gives the students control and allows them to explore science topics, discover new ideas, problem solve, and then reflect. One big way that I learned to incorporate discovery-based learning is by switching up the traditional order of a unit. Instead of starting with a lecture, students start off a unit by completing a lab or activity where they *discover* the idea or topic. Since students aren't aware of the topic already, they are more excited to see what happens during the lab and actually end up remembering more about the topic because they are experiencing it first hand. After the discovery step teachers can utilize a short presentation to clarify and explain what the students experienced.

With the Minnesota state science standards changing to the Next Generation Science Standards (NGSS), science classrooms will shift to a more student-centered approach which aligns with discovery-based learning. Even though I have already begun to incorporate discovery and inquiry-based learning into my classroom, I still have room to improve and create an engaging environment for all students.

Throughout this chapter I will discuss my research question, background and purpose of my capstone project and also dive into how my personal and professional experience have helped me develop my research question.

Background

During my first ever education class at Hamline, I remember being introduced to the idea of discovery and inquiry-based learning and feeling wholeheartedly overwhelmed. The technical terms and concepts went right over my head and instantly made me question if I really knew what I was doing. However, once we dove into those topics, I realized that I had actually experienced this kind of teaching in a classroom setting and it made more sense. Once I could see that I was familiar with the idea of a student centered classroom and strategies to increase student engagement, the idea of *discovery* or *inquiry-based* learning came pretty easy. Using activities such as discovery labs and giving students some choice in their learning are simple ways to incorporate discovery-based learning into a science classroom.

Personal Experience

Looking back on my own high school experience, I would fully qualify myself as a science geek. I took a double load of science classes my last two years even though I had already exceeded the graduation requirement. When I continued into college it only made sense for me to gravitate towards a science major. I settled on chemistry because I loved how it was involved in every aspect of my life. As a college freshman, I was torn because since I was a little girl I had always loved teaching and imagined myself as a teacher when I grew up. When I made the realization that I could become a chemistry teacher and pass on the same passion for science that I had, it was a dream come true and I went on to receive a Bachelor of Arts in both Chemistry and Education from Hamline University. Since I have taken so many science classes, I have sat through more lectures than I would like to count. However, as an education major, we learned that lectures aren't a very effective way to teach which put me in a weird and puzzling position. I noticed myself looking back on my past and current experiences as a student in science classrooms and analyzing them. I could easily identify which of my past classes and teachers utilized discovery-based learning and found myself constantly critiquing my current professors and teachers on how they could increase student engagement and deepen their students' understanding of the material by using different teaching methods. As I was looking back, many times my high school science classes were not taught through a discovery-based lens and I wondered if there was any connection between that and not remembering much of the science content I learned. Many of my teachers used a traditional way of teaching: it pushed me to memorize material for the test and many times I didn't actually fully understand the material. Now that I am a teacher, I strive to help my students actually understand what we are learning and not simply memorize information for the sake of a test. I believe that using a discovery-based style of teaching will do just that.

Conclusion

In conclusion, I am going to study how the use of discovery-based learning can deepen students' understanding of a topic, specifically by starting a unit with an interactive lab or activity to show students the science first hand. I want to flip the order of a traditional science lesson and not use lectures and slides as the primary mode of teaching. I created a website that will help teach educators about inquiry-based learning and provide resources that can be used to help start the implementation of inquiry-based learning into their classrooms. I believe that having students engage in science to learn science helps them to fully understand the material rather than memorizing facts and rules. In Chapter Two there will be a literature review that focuses on incorporating discovery and inquiry based learning in the classroom.

CHAPTER TWO

Literature Review

Chapter Overview

One of the main reasons I became an educator was to get students excited to learn about new things. I wanted to instill a sense of curiosity and teach them how exciting it is to learn new things in the world around them. In science, especially, there are so many amazing things that happen around them that I wanted my students to be able to understand. Unfortunately, many science classrooms are designed around memorization and lectures, rather than prioritizing the students' learning and understanding. When in a class that uses a traditional teaching style, students tend to only memorize information for a test and then shortly after forget the content because they have nothing to tie the information to. A common way to prioritize and deepen students' understanding of the material is by incorporating an inquiry-based learning and discovery-based learning in the classroom. By using inquiry and discovery based learning, students "discover" the topic and content, rather than being fed that same information off of a presentation slide. This technique deepens the students' understanding and also urges them to be curious about the topics they are learning about. This literature review will review research around the question: *How does the incorporation of inquiry-based learning and student choice increase student understanding in a High School Science class?*

Inquiry-Based Learning

Inquiry-based learning "adopts an investigative approach to teaching and learning where students are provided with opportunities to investigate a problem, search for possible solutions, make observations, ask questions, test out ideas, and think creatively and use their intuition" (Bulba, 2015, para 3). The use of inquiry-based learning could greatly impact and change a student's science experience in the classroom. This teaching strategy shifts towards a student-centered classroom and emphasizes the students' role in their learning process.

According to Bulba (2015), inquiry-based teaching isn't simply moving away from the front of the class. To incorporate inquiry-based teaching into your classroom, you must spark students' interest in a topic and give them opportunities to investigate, either individually or collaboratively. However, even though the focus is on students leading their own learning and investigation, the teacher must still be present and active in the classroom and lesson in order to guide students and ask questions. Students can often lead themselves astray, so a teacher must be close by to keep students on track and provide feedback (Bulba, 2015, para 7).

For inquiry-based learning to be successful, a teacher must understand the importance of presenting problems to students in a way that will challenge their current conceptual understandings. This will force the students to reconcile their thinking and construct new understandings (Bulba, 2015, para 4).

According to Hmelo-Silver (2004), inquiry-based learning helps students become active learners because it situates learning in real-world problems and makes students responsible for their learning. It helps learners develop strategies and construct knowledge at the same time. Inquiry-based learning has always been an interest of educators because "of its emphasis on active, transferable learning and its potential for motivating students" (Hmelo-Silver, 2004, p. 236). Inquiry-based learning stems from a family of approaches that include anchored instruction and project-based science. This family of strategies rely on the teacher to help guide the learning process but differ on the type and role of the problem, the problem-solving process, and the specific tools that are used. The goal of inquiry-based learning is to provide students with a guided experience in learning through solving complex, real-world problems. This goal is achieved by engaging students in scientific inquiry cycles by designing experiments, making predictions, making observations, and then constructing explanations of why their prediction was correct or not. Using inquiry-based learning means that students are actively constructing knowledge in collaborative groups. For this to happen, the teacher must take a step aside, giving the lead to the students, and simply be there to guide the learning process. The teacher must still be active in the lesson with open-ended questions to help make students thinking visible and keep all students engaged and involved in the group. While there still may be some direct instruction from the teacher, specifically when students need information on activities or clarification on a topic, the students are primarily responsible for their own learning. Putting that responsibility on students teaches them reflective and critical thinking skills and helps them become self-directed learners.

Why Use Inquiry-Based Learning

Student interest in science, especially with young girls, is declining and science educators around the nation are continuing to investigate strategies to engage girls in science. One strategy is to emphasize inquiry-based learning which has been redefined by a set of eight science and engineering practices in the Next Generations Science Standards. These practices reflect what scientists do in the real world as they engage in the scientific inquiry process such as asking questions, planning and carrying out investigations, analyzing and interpreting data, engaging in arguments by using evidence and evaluating and communicating information (Kim, 2016).

While there are many benefits of inquiry-based learning such as deeper learning and understanding, there has also been research done that supports a change in student attitude towards science, an impact on problem-solving skills and an impact on a sense of community in the classroom. Ferreira and Trudel (2012) completed a research study that looked into those benefits. They looked at 48 students from three high school chemistry classes and they used a mixed-method research design. Results were based off of student surveys, journal entries, approaches to solving a problem, and teacher classroom observations. It is important to point out that all of the participants were all male and attended a Jesuit Catholic school where the school population is 69% Caucasian, 20% African-American, 3% bi-racial, 3% Asian, 4% Middle Eastern and less than 1% Hispanic. To quantitatively measure changes in student attitudes toward science, they used a pre and post five point Likert-type survey questionnaire that contained 22 statements. Sample questions included: "I enjoy science;" "science helps a person think logically;" and "I am interested in studying science in college" (Ferreira & Trudel, 2012, p. 24). To measure any changes in problem-solving skills, students were asked to solve a problem before and after the implementation of inquiry-based learning and they also kept daily journals to record their thoughts, ideas, strategies, calculations, observations, and any data related to the inquiry-based learning process. The teacher also kept a journal to record any observations related to student engagement in problem-solving activities and changes in overall classroom atmosphere.

The results of this study show that there is a significant difference between the means of the pre- and post-survey on students' attitude towards science. When compared, the pre-survey had a mean of 3.46 and the post-survey had a mean of 3.66. These results indicate that the use of inquiry-based learning had a significant impact on the students' attitudes towards science

As for the impact of inquiry-based learning on student problem solving skills, they determined a change by computing a positive or negative change in the percentage of students who implemented each problem solving action. The problem solving actions they looked at include: suggesting preliminary reasons and solutions, listing the preliminary known facts, identifying learning issues, suggesting research ideas and resources, adding new facts, exploring new issues, and brainstorming more solutions, and finally suggesting the best possible solution based on the facts collected. The results of this study show that a greater number of students performed the six different problem-solving actions after the implementation of inquiry-based learning.

Finally, the impact of inquiry-based learning on the student perceptions of the learning environment was found by looking at eight items on the student survey. When looking at the pre-and post survey, a greater number of students agreed that science would interest them more if they could choose science concepts or problems that were relevant to them, if they had more control in their learning, if they had a greater role in the learning process, and that they enjoyed learning science when working in a group with peers (Ferreira & Trudel, 2012, p. 27). An analysis of student journal entries found two major themes: greater interaction among peers when inquiry-based learning was used and a greater sense of control on their own learning. Along with these themes, inquiry-based learning also helped facilitate learning.

What Inquiry-Based Learning Looks Like

Shifting from a traditional teaching method to an inquiry-based method can be hard for some educators. Despite the difficulty, Hugerat and Kortam (2014) made the argument that the main goal of a science teacher is to provide the students with the necessary tools to deal with learning materials as an independent learner. Using an inquiry-based teaching model in the classroom will teach students how to problem solve, formulate questions, make observations, and justify their arguments that will be essential in their lives moving forward as a citizen. Inquiry-based learning will look differently in various classrooms. Some easy and common ways to incorporate inquiry is through laboratory experiments, reading and analysis of articles, case studies from the history of science, and making observations in the field. To assess the incorporation of inquiry-based learning, educators can look for some or all of the following student outcomes: students should appreciate the diverse ways in which scientists conduct their work, have knowledge and ability to ask testable questions, make hypotheses, be able to confirm or reject a hypothesis, construct and defend a model or argument, consider multiple explanations, and gain an understanding of the tentativeness of science (Hugerat & Kortam, 2014). The most important thing to remember when utilizing inquiry-based learning is that it involves teaching students the process and skills used by scientists to learn about the world and it helps students apply those skills that are involved in learning science.

The History of Inquiry

The idea of inquiry has a long history, dating back 1910 where John Dewey's ideas stressed the importance of inquiry in education (Hickman, 1997). Inquiry was one of the core concepts of Dewey's philosophy. Dewey argued and believed that children learn best by doing things and trying ideas out, not by memorizing facts and lessons to repeat back to their teachers. Dewey addressed the technical aspects of inquiry in many of his works, specifically in *How We Think* (1910), which he wrote to directly address teachers and *The Theory of Inquiry* (1938). According to Hickman, it was in those works where Dewey gave the most clear definition of inquiry, that is inquiry is a controlled transformation of an unclear situation into one that is determinate. He believed that inquiry should be used anytime something was unclear or out of balance, in any situations ranging from trivial to life-threatening. Once we see or take note of a problematic situation, we must identify the problem, develop possible solutions, determine which tools are needed for such solutions, and then test out all of the solutions against the original conditions that sparked the inquiry. In some cases, this process can become more complicated. Throughout the process, we often change our minds about what Dewey calls 'ends-in-view' and what types of tools are needed to achieve them. According to Dewey (as cited in Hickman), inquiry is an observable behavioral process that is as natural as walking, chewing, or breathing, therefore, inquiry is not a mysterious thing that goes on inside the head. Regardless, these techniques of inquiry should be a primary part of early childhood education and continuously used as students grow older into adults. It is essential as they continue to grow and make improvements to their problem solving skills that are instilled in creating lifelong learners.

The goal of inquiry is more than a simple return to a status quo. Inquiry should result in growth and an enhancement of the meaning of an experience. Unfortunately, many times we resolve problematic situations that hinder growth, rather than promoting it. This is especially true in schools, because oftentimes educators focus on how much information a student can remember and how they perform on a test, rather than focusing on the process of that student building and experiencing knowledge and growth.

The Effectiveness of Inquiry-Based Learning

While there are many theories that support the benefits of inquiry-based learning, the implementation of it into classrooms is equally as important. There have been many case studies done, at multiple age levels from elementary all the way up to the college level, that show the benefits of an inquiry-based classroom. While some case studies use different terminology for inquiry-based learning, such as project-based or problem-based, they all utilize the same strategies to engage students and have them work through an inquiry lens.

Hung et al. (2012) completed a case study that focused on a project-based digital storytelling approach with the goal of improving students' learning motivation, problem-solving competence, and learning achievement. Their problem-based strategies involve problem solving, data collection, discussions, and writing a final report presentation and they include all these strategies into a collaborative project. Hung et al. state that these strategies "aim to cultivate the capability of active and self-regulated learning of students who are the supporters as well as the learners in the process of interacting with teachers" (p. 369). Project-based learning is very similar to inquiry-based learning in that they both focus on cooperation between students, cultivating problem solving skills, sharing, discussing, and supporting student opinions, and promoting learning achievement. This study focused on 117 fifth graders in southern Taiwan where they compared two experimental classes and two control classes. Each group consisted of 60 students (35 males and 25 females) and 57 students (31 males and 26 females) respectively. The experimental group took place in project-based learning while the control group experienced conventional learning. They used multiple tools to assess students, including a science learning motivation scale, a problem-solving competence scale, a science achievement test, and student interviews. Over 16 weeks each group had identical learning contents except for the difference in instruction and an analysis was completed as the term of the study. All final results were based off of the students' post test scores in each category that was looked into. The final analysis shows that the experimental group had enhanced the students' science learning motivation, with a mean score of 4.10 compared to the 3.69 of the control group. It also had the same effect on problem-solving competence, with a mean of 4.16 in the experimental group compared to a mean of 3.77 in the control group, meaning that the project-based learning enhanced the problem-solving competence of the students. Finally, the same result occurred when focusing on the students' science learning achievement. The experimental group had a mean score of 88.05 and the control group having a mean score of 85.49 showing that project-based learning also enhanced the students' science learning achievement. A few conclusions were also drawn from the students' interviews, including that they enjoyed the project-based learning activities and found them very helpful for their learning. In the end, the experimental results and feedback from the students conform to what researchers have stated, that project-based learning engages learnings and helps them improve their learning achievement.

Goos (2004) completed a case study that focused on learning mathematics in a classroom community of inquiry and examines the teacher's role in creating a classroom culture that focuses on inquiry. Goos believes that all classrooms are communities of practice, but they differ in kinds of learning practices that become accepted by both the students and teacher. She uses the example of math classrooms that use a traditional, textbook dominated approach. In that scenario, effective student participation would be listening and watching the teacher demonstrate math procedures and then practicing what was demonstrated by completing textbook problems. This teaching style fosters and prioritizes memorization and reproduction or procedures which contrasts to more open approaches such as discussion and collaboration. Goos points out that the when inquiry is used the students don't "rely on the teacher as an unquestioned authority, [but] students in these classrooms are expected to propose and defend mathematical ideas and conjectures and to respond thoughtfully to the mathematical arguments of their peers" (p. 259). This case study was conducted at an independent secondary school in the Australian State of Queensland and focuses on grades 11 and 12. For data collection, there was an emphasis on interpreting learning in complex social settings rather than on experimental manipulation and control of variables. Data collection included classroom observations, which was supplemented by video and audiotape recordings of teacher-student and student-student interactions, and interviews with teachers and students. The student interviews were conducted via individual, group, and whole-class to investigate the students' views about learning mathematics. While there was no numerical data collected to prove that an inquiry-based classroom culture helps students learn mathematics, the authors did draw that conclusion based off of the interviews and classroom observations. Goos mentioned that a small number of students resisted the teacher's efforts to move toward critical engagement and avoided constructive interaction with their peers, but overall, the study found many positive examples of learning as a result of the community of inquiry and noticed many differences in the nature and extent that the students participated. As the study went on, students more often made connections between everyday and scientific concepts in multiple settings in the classroom.

Higher Order Thinking Skills. In a traditional setting, many teachers assessed students on memorization of scientific facts and summarization of certain topics neither of which require knowledge of the subject's deeper ideas and concepts. When using inquiry-based teaching, assessments transition from those of memorization to those of deeper knowledge that nurture higher order thinking skills (Hugerat & Kortam, 2014, p. 447). One of the main objectives of inquiry-based teaching is to help students develop higher order thinking and cognitive skills at all levels. This allows the student to become more independent and a more creative learner, adapt to problem solving, and be more capable of using scientific content in everyday contexts (Hugerat & Kortam, 2014, p. 448). Some common characteristics of higher order thinking overlap with those of inquiry-based teaching. Zohar and Dori (2003) identified the following examples of higher order thinking in inquiry-based science education: formulating a research question, planning experiments, controlling variables, drawing inferences, making and justifying arguments, identifying hidden assumptions, and identifying reliable sources of information (as cited in Hugerat & Kortam, 2014, p. 448).

Next Generation Science Standards

The Next Generation Science Standards (NGSS) were released in 2013 and were designed to improve science education for all students and prepare them for college, careers, and citizenship (NGSS, 2013). The NGSS framework was designed and written by a committee of scientists, science educators, education researchers, and state leaders from across the country. Their aim was to develop standards around a few core ideas and create a sharper focus on equity and diversity in science education (DeBarger et al., 2015, p. 46). The development process of the NGSS included 26 states, 41 writers, and hundreds of science teachers, scientists, engineers, and education researchers who gave feedback on drafts. Eleven states, which amounts to approximately 26% of the US student population, have already adopted the NGSS with many likely to follow (DeBarger et al., 2015, p. 46).

The NGSS were designed to operate differently than past standards. In the past, standards have separated the content from the process of learning but the NGSS were developed to help students learn science as both a discipline and a set of practices for developing new knowledge. To do so, students use crosscutting concepts that connect science and engineering to deepen their understanding of the core concepts (DeBarger et al., 2015, p. 45). The reasoning behind the new set of standards was to create a new set of research-based and up-to-date science standards for K-12. While these standards are the base of what K-12 science should follow, they also give some flexibility to the educators to design learning experiences that will fit their students' interests. The NGSS are made up of three dimensions: Crosscutting Concepts, Science and Engineering Practices, and Disciplinary Core Ideas. These three dimensions are combined to form each standard to help students build a cohesive understanding of science throughout their time in school (NGSS, 2013, para 1).

With the new NGSS, students will have lots of opportunities to work hands-on with science concepts to increase their understanding. By incorporating hands-on activities, students will also develop problem solving skills and critical thinking skills. The ultimate goals are to promote depth of breadth, ensure greater coherence across grade levels, and help students understand the cross-cutting nature that span across the different science disciplines (NGSS, 2013).

Science and Engineering Practices

The Next Generation Science Standards stem from real world procedures in science and engineering. The goal of creating these standards was to reflect the strategies that scientists and engineers use in the real world and bring them into the classroom to teach to students. Science and Engineering Practices (SEPs) are very similar in that they are practices that describe the behaviors that scientists and engineers engage in. The SEPs focus on investigation and building models and theories about the world, similarly to the NGSS.

Implementation. A big hurdle to jump before implementing the NGSS is the need to provide and distribute curriculum materials to teachers and students across the country. Whether an educator adopts, adapts, or designs their own curriculum materials, the materials themselves matter to help students achieve the standards because high-quality materials provide models for how to help students meet challenging learning goals in standards, and they provide tools to help teachers improve their practice (Davis & Krajcik, 2005). Materials also include any tools needed for students to actually do science, such as lab equipment, must also be accessible to all students in all schools (DeBarger et al., 2015, p. 46).

Implementation doesn't stop after the distribution of materials. After standards are introduced into schools, educators must continuously adapt and change their day-to-day practices. Educational leaders need to track and view data to see the change happening and to help design better supports for implementation (DeBarger et al., 2015, p. 47). Higher-ups in education must monitor opportunity in schools to learn if there is "adequate time allotted to science instruction, access to high-quality curriculum materials and necessary equipment for investigations, and access for all teachers to professional development" (DeBarger et al., 2015, p. 48). Multiple organizations, including leaders in states and districts, professional organizations for science teachers, intermediary organizations, and business groups are helping to implement the vision of the NGSS framework. All of these groups are working towards developing resources for teachers and educational leaders (DeBarger et al., 2015, p. 49).

Challenges. There are a few challenges to the implementation of the NGSS. The first is that many schools do not have access to the curriculum materials needed to align with the NGSS framework vision. It is especially hard for schools that serve low-income students and student groups that are under-represented in science and engineering to access these materials (DeBarger et al., 2015, p. 46). Secondly, implementing NGSS into schools will require a big shift in teaching strategies and styles and will require a lot of professional development. Few teachers actually engage students with the practices that are essential to the framework, such as developing and using models, constructing explanations, and engaging in arguments from evidence. On top of that, a small number of assessments connect to the three-dimensional performance expectations of the NGSS. Lastly, many students are not exposed to affluent science instruction in elementary school which interferes with their ability to build a rich understanding of science throughout their K-12 career (DeBarger et al., 2015, p. 46).

Assessments

An assessment is a measurement or evaluation of a students' learning based on a combination of observation and evidence of knowledge to identify if a student has reached a certain proficiency. This section will explore the idea of proficiency and how to accurately and fairly assess students in a classroom where inquiry-based teaching is utilized.

There is a major gap between students' knowledge of science facts, which is typically assessed through achievement tests, and their understanding of how their knowledge can be applied through scientific reasoning, argumentation, and inquiry (Pellegrino, 2013, p. 320). We have seen a change in what we expect students to know and what we think science education should look like but have yet to see a change in how we assess science knowledge. The Next Generation Science Standards (NGSS) are designed around the three frameworks: core disciplinary ideas, Scientific and engineering reasoning and cross-cutting concepts. When put together, they define what it means to know and understand science and all three are essential aspects of knowledge and understanding (Pellegrino, 2013, p.320). With the NGSS, proficiency is now being defined with performance expectations that mix between science practices, cross-cutting concepts, and core content knowledge. This poses a challenge of how to evaluate and assess students' proficiency that relates to the vision of the NGSS and doesn't inhibit teaching and learning in the classroom (Pellegrino, 2013, p. 320). Since assessments are used as reflections of learning for scientists, educators, policy-makers, and parents, the assessments that are used in the classroom should represent the proficiencies that we want our students to have. Some would argue that assessments needed to effectively assess science learning have “yet to be created and that design and implementation challenges are substantial” (Pellegrino, 2013, p. 320). In the meantime, assessments should be designed by educators around the “performance expectations about what students at various levels of educational experience should know and be able to do” (Pellegrino, 2013, p. 320). However, it is also essential to point out that proficiency develops over time and increases as a result of logical systems of curriculum, instruction, and assessment. To effectively assess, educators should define the outcomes of their instruction, which will better guide them to forms of assessment that can help them know whether their students are understanding the desired objectives (Pellegrino, 2013, p. 320). This can also help teachers figure out how to better support and assist their students through their learning.

The U.S. National Research Council (NRC) uses a progression to describe student proficiency within the three intertwined domains across K-12. This framework identifies specific grade-band end-point targets for grades two, five, eight,, and 12 for each component of the core ideas (Pellegrino, 2013, p. 320). The NGSS builds on the NRC’s suggestions and also includes a table that defines what practice might include and what students are expected to do with each cross-cutting concept in each grade level (Pellegrino, 2013, p. 320). According to Pellegrino (2013), using this new perspective will help determine where a student lies on a spectrum or sequence of a given core idea rather than simply measuring if a student has knowledge of certain grade-level content. This type of assessment design better fits an inquiry-based classroom because it considers that all students learn differently and learn at different paces. The use of a spectrum allows for the long progression of knowledge and understanding and doesn't measure a student's knowledge straight against the decided grade level achievement.

Conclusion

In conclusion, there is a lot of research to support the idea that inquiry-based learning can lead to more proficient problem solving skills, more critical thinking, higher-order thinking skills, and a deeper understanding of the content. In order for this teaching strategy to be most effective in classrooms, the teacher must move away from standing in the front of the room with a traditional teaching style and become more of a facilitator to the students. Using this strategy along with the Next Generation Science Standards (2013) will help teachers create a skills-focused curriculum and will engage students and help them connect science to their everyday lives. By allowing students to explore science, do hands-on activities and work through problems, they are mimicking how scientists work and function in everyday life. While there are still some challenges with distributing curriculum materials and resources, educators should still focus and implement inquiry-based learning wherever and whenever possible in the classroom. Utilizing strategies, like inquiry-based learning, will change our students' experiences in the classroom and will improve student interest in science. Students become more engaged and interested because teachers connect academic content to natural phenomena and other topics that are relevant in our students' lives. All of this research has led me to my research question: *How does the incorporation of inquiry-based learning and student* *choice increase student understanding in a High School Science class?* I want to see how educating teachers on this strategy and implementation into the classroom will change the level of understanding with the students.

In Chapter Three, I will discuss the methods I will use to create and design my website. The website will be used as a resource for teachers to both learn about inquiry-based learning and find examples and resources that can be incorporated into the classroom. The following chapter goes through the organization and layout, audience and setting, and framework used to design my website.

CHAPTER THREE

Project Description

Chapter Overview

The goal of this project was to answer the question *How does the incorporation of inquiry-based learning and student choice increase student understanding in a high school science class?* I worked to create an online resource to help educate teachers on their topic and move toward answering this question. This chapter will provide some background information on the layout and format of the website, the intended audience, and the resources provided on the website.

Project Overview

As a first year teacher, I have encountered many times where I was searching online for resources to use to make my class more engaging and interesting for students, especially moving between learning models because of COVID. With that main thought in mind, I decided that a website resource for inquiry-based learning activities and best practices would be the best way to bring knowledge to both new and seasoned educators. Before I made my way into the classroom last fall, my district and school provided me with a vast amount of resources and professional development sessions and they continue to throughout this school year. As I was thinking about all of the sessions and resources I have attended or used this year, I asked myself which I enjoyed and used the most. The conclusion I came to was that I enjoyed online resources that I could come back to continuously to utilize. In such a technological age, especially with the amount of online learning students and educators have been doing in the last year, I felt that an online resource would be best fitting. There are a lot of websites geared towards educators already, but I haven't come across one that has a plethora of information or ideas surrounding inquiry-based learning.

The website provides educators with links and explanations to inquiry-based learning, example activities, strategies, tools, and other links to help teachers implement inquiry-based learning into their classroom and curriculum. In my experience, the biggest hurdle with inquiry-based learning is simply getting incorporated into the classroom and the teacher becoming comfortable with it. The list of example activities and implementation strategies will be helpful to those that struggle with finding ways to use it in the classroom. I hope that my website can help provide educators a simple, research based tool to become successful in implementing inquiry-based learning into their classroom and curriculum.

Framework

User experience. This is the first time I have designed a website. The process of laying out and designing a website can be a very complex and daunting process. There are many website development platforms that are available for use but there are multiple considerations I looked at before deciding on one. Since the process of designing a website is already so complex, I wanted a platform that would simplify the process, have helpful tips and tricks, provide templates, and be cost effective. Based on those considerations, I chose the platform Wix to design my website. Wix was easy to navigate and they provided helpful videos and tips from the first creation of the website. It was very easy to start off with a template and work through designing and adding things to the website. It was very user friendly and did not require prior knowledge on creating or designing a website.

A big consideration I had to keep in mind was the user experience. Making the website easy to navigate, understand, and organized in a way to help the user find the information they are looking for was very important during the design process. I often referred to websites that I was attracted to and were easy to navigate as inspiration for my website. I opted to make my website as simple as possible to help make it clear where information is and to make it as user friendly and of ease as possible.

Layout considerations. As I was building my website, I often found myself concerned about the layout and organization of the website. I wanted to make sure that any user could navigate the website with ease and efficiency and be able to find the information they were looking for. At the start of my project, I looked at many different websites to get a grasp on the layout I wanted to use, and found that I wanted a simple layout. I wanted to create a layout that would be efficient for the user and avoid any frustration while browsing the website. I reorganized the website a couple of times and ended with an organization and layout that I believe to be efficient and visually pleasing. I didn't want to overcrowd each of the pages on my website, so I often opted to create more individual pages to be able to simplify each page. I did this because I personally get overwhelmed when I am browsing a website that has a plethora of information on one page and it is hard for me to sort through and make sense of all of the information.

I ended with a simple layout and design, with easy to read text. I kept the pages consistent with layout and color schemes, while also having some differences to keep the look of the pages a little bit different and appealing.

Content. My website includes five main sections that can be accessed from the home page and navigation bar. The sections include: *About, What is it?, Benefits,* *Classroom Incorporation, and Resources*. On the home page, there is a short description of each section with a 'Learn More' button for users to click on. All of these pages are also accessible from the navigation bar, with the *What is it?* and *Benefits* sections shown as their own tab on the bar, and the remaining pages *Classroom Incorporation, Resources*, and *About* under the 'more' tab. It was important to me to include both background on what inquiry-based learning is and how it is beneficial in the classroom as well as examples and resources for other educators and users to use. Any users need to be able to build a background knowledge and see examples of how it can be incorporated into a classroom to get a well rounded view of inquiry-based learning. On the home page, I added a couple of quotes that I think summarize and describe inquiry-based learning really well and also will hopefully grab the attention of any user who is unsure if they want to continue on through my website.

Audience and Setting

Since it is my first year teaching I only have reference to one type of student and teacher body. I do, however, have in mind a similar audience so I will use my current school as my projected audience. I work at a public high school with a high population of African American, Asian, and Muslim students. The school has a high need as far as language learners and special education and I happen to teach multiple co-taught EL classes. The school has a student population of around 2,000 with about 125 staff members. Our science department is average sized, with 15 teachers, and the district does provide us with many opportunities to further our science and teacher education through conferences and training. We have a huge support system when it comes to navigating through our first year and how to best teach our students science.

Even though this resource website was designed with science educators in mind, any content teacher could utilize the resources and information provided on the website. These resources could be beneficial to other content teachers, as they could apply this to their own content, but the majority of the resources will focus on a science classroom. This website is focused on how to pivot traditional teaching methods to more student and inquiry-based teaching which will engage students to a greater extent and deepen their understanding of the content. While moving toward the Next Generation Science Standards, it is important to keep in mind the population of our school. The majority of our students have struggles in their life, including taking care of siblings, money troubles, mental health issues, and many others. School is where these kids escape their life to learn cool things and helps them progress in life. By moving toward inquiry-based teaching, students will be more drawn into class and the information we are covering will actually be taken in by the students and not simply memorized. Moving away from a traditional style of teaching can be hard and intimidating, but this training will help ease the transition and help science educators redesign their class for the student engagement and the development of their critical thinking skills.

Summary

Chapter Three outlined an overview of my final project and intended audience of my project. The chapter included a discussion on the layout and format of the website and which resources will be most beneficial to the independent audience. Chapter Four is a critical part of the reflection on my project as a teacher and researcher. Moving forward, I will discuss any major findings, revisit my literature review and discuss which aspects of my research were more influential and helpful throughout my project, any limitations in my professional development training and how my project has benefited my job as a secondary science educator.

CHAPTER FOUR

Reflection

Chapter Overview

The central question of this project is, *How does the incorporation of inquiry-based learning and student choice increase student understanding in a high school science class?* My end goal was to create a website that educators, specifically science based teachers, could use to learn about inquiry-based learning and find examples and resources to incorporate into their classroom. The website makes it easy to learn about what inquiry-based learning is, read about the benefits, see different ways to incorporate it into any classroom, and find resources to help incorporate into a classroom to make the shift toward inquiry-based learning.

In Chapter One, I explained the rationale and reasoning that led to this specific research question. Through personal and professional experience I have found that utilizing inquiry-based learning in a classroom can deepen students' understanding of material. By shifting away from traditional lecture, where the teacher is the focus, inquiry-based learning puts the focus on the students' and teaches them to be accountable for their own learning.

In Chapter Two, I examined and discussed research that highlighted the importance of inquiry-based learning. My research spanned different areas from inquiry-based learning, assessments, higher-order thinking skills, the importance of student choice, and the Next Generation Science Standards. Throughout the course of my research, it became more evident that inquiry-based learning does help deepen students' understanding of class content and also teaches students other valuable skills and strategies to help further them in life outside of the classroom.

In Chapter Three, I provided an overview of my project and website that I created. I discussed the intended audience, the organization of the website and any other considerations I thought about while designing my project.

In Chapter Four, I discuss the learning that happened during this capstone process, including my own personal learning. I also discuss some implications and limitations to my website and areas that it can continue to grow and be elaborated on. Lastly, I also describe how my website and project will be communicated and shared with other teachers and how this project will benefit the teaching profession.

Major Learning

The idea of inquiry-based learning has been around for many years so there is a large amount of research and literature published on the topic. The research process was overwhelming at first, because of the plethora of literature published, but I was able to sort and fit the research into different themes to help organize my own thoughts and help organize the literature into categories. While reading the literature, I found a couple common themes that included the need to switch to inquiry-based learning to make science more accessible to all students. When a traditional lecture style is used in a science classroom, many students, especially English Learner students, aren’t able to make sense of the complicated vocabulary and topics as quickly. When an inquiry-based method is introduced and used in a classroom, the students are able to physically see what they are learning about, put it into their own words, and understand the overall concept before learning about the specific vocabulary. This helps to deepen their learning and avoids the simple memorization of facts. I also found that many teachers don't utilize inquiry-based learning in their classrooms simply because they don't know the best way to. It can be a daunting task to change the way you teach and design new activities to help guide students toward inquiry-based learning but in the end it will benefit the students' learning and also help them learn skills to use outside of the classroom.

Personal Growth

One of the biggest lessons I've learned throughout this project is that the process of learning is continuous and we can always further our learning. My eyes have been opened further into the world of inquiry-based learning and I've discovered the abundance of research and resources available to use and adapt for each unique classroom. I had a lot of understanding of inquiry-based learning from my time in undergrad and year of teaching but as I created the website, I feel like I deepened my understanding even further. During my research it seemed that the biggest hurdle to using inquiry-based learning is just how to start using it. Since finding a place to start seemed like a big issue, my website explains what inquiry-based learning is, points out some of the benefits to using it in a classroom, but then also includes many different examples and activities on how you a teacher can incorporate inquiry-based learning into their classroom. As I have been teaching this year, I have found that many activities that I already had could be easily modified to fit into an inquiry-based model and implementing inquiry-based learning into a classroom can be a lot easier than many educators believe.

Creating a website was fun but also a challenging part of this project process. I enjoyed organizing and laying out the website and often visited other resource websites to see what I liked. I didn't realize how much the aesthetic and layout of the website could impact how people read and take in the information. Creating the website scaffolding was a time consuming process, which I was surprised about, but I really enjoyed that part of the process. I changed the organization of my website pages a couple of times to help make the website more user friendly and easier to find the information you wanted. Originally, I planned to create a subpage for all of the themes I found while doing research, but I found that many of the ideas overlapped and it would be clunky for users to switch back and forth between pages. I ended up using more general subpages and breaking down into more specific topics on each single page. I still want and plan to keep adding resources and examples onto the website as classrooms change and are modified because of COVID and any other challenges that schools are faced with. I believe a website was a good choice for my research question, especially because technology is used so much in classrooms. A website makes the information and resources readily available and easy to find and access.

Implications and Limitations

Research on the implementation of inquiry-based learning has shown that it does help students fully understand and deepen their knowledge on a topic, regardless of age. Having students work with their hands, have some choice in what they complete, problem solve and ask questions are all skills that drive inquiry-based learning but also greatly benefit and prepare the students for life outside of a classroom. Many subjects, especially the sciences, should utilize strategies stemming from inquiry-based learning to help students succeed and stray away from the traditional path of lecturing material to students and as a result the student memorizes the information to spit it back up on a test.

I hope that my website can help educators learn about inquiry-based learning and see how it would benefit students in their class. My website has many different examples and resources on how inquiry-based learning can be easily incorporated in a classroom and are a good fit for those educators that are trying to utilize inquiry-based learning for the first time. My website is laid out in a way that teachers can easily navigate to learn about what inquiry-based learning means, some of the large advantages to it, and extra examples and resources that can be modified to fit any classroom type. My hope is that after they would explore and read through my website, they would begin working with other teachers in their department or school to continue growing and learning about inquiry-based learning and how they can further utilize it in their classroom. I have seen in my own classroom this year how much more motivated my students are and how they work and talk together on activities and projects to problem solve and ask more questions that they typically would. Especially with the changes in learning models due to COVID, inquiry-based learning can be very beneficial to help introduce and motivate students about their learning.

While I'm not in a place of leadership in my school and am just starting as a first year teacher, I think every teacher should take some time to learn about inquiry-based learning and how effective and beneficial it is. I was lucky to spend a lot of time during my undergrad learning about inquiry strategies and was given many resources, but many teachers did not have that same opportunity. I have always talked openly with my coworkers about inquiry-based learning and it has driven many discussions and how it can be used in different classrooms and can look different for every teacher. If I were in a position to plan PD sessions for my building, I think it would be very beneficial for every educator to attend a session and my website would be a great stepping off point.

There are also some limitations to my project including the need to expand my resources and examples for other subject areas outside of science. Since my content area is science, I have many resources of my own that I have adapted to fit an inquiry-based model. While many of the science resources can be changed to fit a different content area, I don't provide any examples for other subjects' projects or topics. Another major limitation is the need to expand on the needs of EL and special needs students. I currently teach multiple EL sections and work with a co teacher and we have been working together to create and plan activities that will set those kids up for success.

Communicating Results

Communicating my results and sharing my website is one of the most important parts of the project to help continuously educate others. Using a website helps to extend the reach outside of a professional development session and can be a great tool that educators can look back at at any time. The website platform I used, Wix, has many different ways for others to communicate back through the website with questions or further discussion.

A big part of communicating my results is talking to my coworkers about it and providing them with the website so they can read through the information and it will spark discussions about the topic. Another way to greatly increase the communication of my results could be through sharing it on social media. Sharing my website on major social media apps like Facebook, Twitter, Instagram, or even Tik Tok can increase the number of people that access and learn from my website.

Benefits to the Profession

This website is a resource that will help educators learn about inquiry-based learning and the benefits it would bring to their students. The website breaks down what inquiry-based learning is, how it can be seen in a classroom, the advantages to using it, and provides teachers with resources and example activities that can be modified to fit their classroom. This website would be a great resource for a professional development session that the teachers can then look back at and utilize while lesson planning. Apart from the website, a big part of learning how to implement inquiry-based learning into a classroom would be by observing other teachers who already use inquiry-based strategies. Being able to watch other teachers and learn from them is a huge stepping stone to feeling confident in using inquiry-based learning. Successful execution of inquiry-based learning will help students' understand the information and content much deeper than through a lecture and will also teach them valuable skills such as problem solving, asking questions, supporting their arguments with facts and data, and working collaboratively. This website offers suggestions and examples of how to implement inquiry-based learning into a classroom with many different activities and strategies. My hope is that this project and website will help current and future educators feel confident in using inquiry-based learning and will modify their classroom and activities to benefit their students' learning.

Summary

Chapter Four provided an overall reflection of this capstone project including my own learnings as a student and educator. This chapter touched on my own personal learning and growth while working on this website and capstone process. I discussed some implications and limitations of my website and areas that the website can still expand. Lastly, this chapter explained how my website will be communicated and shared with other educators and how it benefits the teacher profession as a whole.

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