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## **A Web-Based Collaborative NGSS-Centered Chemistry Unit on the Topic of Atomic Structure**

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A Web-Based Collaborative NGSS-Centered Chemistry Unit on the Topic of Atomic Structure

By

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A capstone submitted in partial fulfillment of the requirements for the degree of  
Master of Arts in Teaching.

Hamline University

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## CHAPTER ONE

### Introduction

High school science classrooms have seen no changes over the years, and there needs to be more standards utilized in the construction of content used in the classroom. In the past, high school science classrooms have focused more on reading textbooks, memorizing definitions, and put a focus more on testing these memorization skills of the textbook rather than students being able to apply their knowledge to real world situations or problems. In a news article written by the National Education Association, states, standardized testing is, “inaccurate, inequitable, and often ineffective at gauging what students really know” (Long, 2023). Furthermore, in an article called, *Teaching without a textbook: strategies to focus learning on fundamental concepts and scientific process*, the author writes how since 1983 he has taught science courses that use a textbook. He was dissatisfied with these available textbooks and made his own web-based course that included both lecture and lab materials. The author also writes that it is difficult to teach with a textbook because most textbooks aren’t written with proper evidence of best teaching practices (Klymkowsky, 2007). Standardized testing is still failing students in classrooms today and teachers are teaching towards these tests. This article was written in 2023, showing there has been no change from this, as science teachers we need to engage students in doing science not just learning from the textbook, facts or concepts. A move towards this in science is the Next Generation Science Standards, or NGSS. There have now been a total of twenty states using NGSS, which applies a more investigative based approach for learning (*Next Generation Science Standards*, 2000). These new standards that are being set can lead to improvement in learning, engagement and application of scientific concepts to the real world in high school science

classrooms, specifically in chemistry. Chemistry can be seen and is known as a rigorous course for high school students because the concepts for students can be hard to grasp because a lot of these concepts are not easily observed. Teachers can change this misconception and turn it into a fun, hands-on learning experience for the students that not only challenges them, but really sparks an interest in STEM for them. These experiences for students can be very beneficial, especially in- person learning; there has been a loss in this type of learning ever since the COVID-19 pandemic (McElrath, 2020). The NGSS standards (2000) can help teachers and students connect through improvements in classroom activities and curriculum design. This overall, can create a more engaging learning environment for the students and have students really learning how science works instead of memorizing facts or concepts. Learning these concepts and how science works has helped me learn as a student and really grow my passion for science.

Next in this chapter I will discuss more in depth about my personal and professional background in Chemistry and Education. I will discuss my role as a student, what sparked my interest in science, what education I have and my student teaching experience as well. Furthermore, I will examine the lessons I have learned from being a student and a teacher in Chemistry. Finally, I will explain my rationale for my research and project and introduce the question I will be answering.

### **Personal/ Professional Background**

As a student, I have been able to learn both in person and online classrooms. I have always enjoyed science from middle school to high school and all the way to university. I saw science as fun and although it was challenging at times it made it more interesting to me. The hands-on learning in labs, research and experimenting I was able to do were so inspiring to me

that it made me want to learn more and pursue it in my future. The first lab report I did was in fifth grade and I had the opportunity to present my research to my peers and other teachers. This project I worked with two other peers in fifth grade and we were given the freedom to create our own research project on whatever we decided. We enjoyed this freedom of being able to choose, but it became difficult to come up with one idea to research. We decided on researching whether the type of vinegar reacting with baking soda changes the reaction. We used rocket bottles to test the reaction and see which type of vinegar made the rocket shoot higher in the air after mixing with baking soda. After we completed our research we created a poster and presented it at a science fair with other peers. This really sparked my interest in science, the research process, and the collaboration and teamwork needed in science to learn. I was able to continue this passion more into middle school where I learned more about Chemistry. I was then able to take a Chemistry and Physics Fundamentals course my freshman year of high school and that made me even more curious about science in general. Finally, in University I expanded my interest into General Chemistry and General Biology courses. Both of these courses had laboratory classes with them and the time I spent in these labs was what captured my interest in science. I was able to apply my knowledge and notes from lectures into hands-on learning in the lab. I loved making the connection between the two which helped me learn more from the lab. This really sparked my interest specifically in Chemistry and I decided to pursue even more of it in the next three years of University. In university, I had a chance to learn chemistry through online learning due to the pandemic. I learned a lot from this experience as a student and I found benefits and limitations to this. The very first benefit I found was that it was in some ways more convenient than in- person learning. I was able to open my computer, join a synchronous call online and just listen to the lecture. In some ways this was also very limiting in my learning. I did not feel like I

was actively learning or participating in discussions and it was easier to zone out resulting in a lack of motivation. A big part of why I started to enjoy chemistry was the interaction I was able to have with my teacher in high school. I felt it was easier to ask questions and participate more actively in class. I was also able to do more hands-on learning, specifically in the lab, which I enjoyed the most.

### *Professional Experience*

I graduated from Hamline University with a major in Education and Chemistry in Spring 2022. Right after graduating I went to do my student teaching position overseas in Doha, Qatar. At this position I worked as a high school chemistry teacher at the American School of Doha. I worked closely with four other chemistry teachers, where we developed a new curriculum for the General Chemistry course at the American School of Doha that followed the Next Generation Science Standards. This new curriculum, with an emphasis on the NGSS, students were very engaged in my lessons and were making so many connections during class. I noticed students were making connections between lessons and also even between different units. There were a lot of those “aha” moments students were having within these lessons where something clicked and they were able to make connections.

### **First Teaching Experience**

Within the first week of my student teaching I was fully teaching two general chemistry courses with 9-12th grade students. I was also helping and learning a lot from my cooperating teacher who was teaching three International Baccalaureate (IB) Chemistry courses. Through this experience I was able to develop lesson plans and collaborate with other chemistry teachers on creating the new curriculum. During this experience I was also able to teach a little bit of online learning through Zoom. This gave me an opportunity to teach both in- person and online and

learn a lot from both these experiences. I was able to experience both in- person learning and online learning as a student, but also a teacher as well. Similar to a student, there were both benefits and limitations to this style of teaching. I knew I would have to work harder to grab students' attention and motivate them to learn, since I felt the same as a student. I was able to find interesting videos of lab demonstrations that were able to spark discussions with the students. I was also able to use different online resources and tools to help students, which I lacked in my online learning experience. I also found as a teacher it was beneficial to open up my computer and start an online call where students can join, but it was hard to have that face to face interaction. It was harder to start discussions and connect with students. In- person learning provides a variety of benefits to students learning that are lacking in online learning.

### *Lessons Learned*

As both a student and a teacher in chemistry, I learned a lot about collaboration, interactions in the classroom and the importance of hands-on learning. As a student, collaboration really supported my learning of chemistry. Any project or homework I did with peers was super beneficial in my learning. Hearing other perspectives and ways of thinking on a topic supported my learning a lot. Furthermore, the interactions I had in the classroom with my teachers were very helpful in my engagement and learning in chemistry. When I felt connected with the teacher and felt comfortable going to them with questions I felt more open and engaged in my learning in the classroom. Finally, as a student I found hands-on learning imperative to my understanding in science. It showed me how to learn from my mistakes and apply my knowledge of certain science concepts to a hands-on activity. On the other hand, I also learned a lot from my student teaching experience about teaching in- person and online. One important lesson I learned was the importance of the interaction you have with your students in- person compared to online.



Not only is it more difficult to get that interaction online but I think it is more necessary and more beneficial to the students to be in-person to learn. I also learned a lot about the importance of hands-on learning and lab activities for students. The students were more engaged during these activities and were making more connections during the post-lab work. This really helps them use their prior knowledge and apply it to a problem that is in front of them. From this experience, I was also able to learn a lot about the NGSS and how to integrate these standards into my curriculum. I was able to learn this by collaborating with other science teachers by creating lesson plans and assessments together. Although it can take a lot of hard work to teach towards the NGSS it was very helpful to have a team of science teachers working together on it. It took a lot of work and feedback from all the teachers to make it happen. We were always adapting and changing the lessons based on student feedback. This is why collaboration is key in creating a curriculum based on the NGSS.

### **Rationale**

Based on my experiences as a student and teacher in chemistry, the problem I have noticed and would like to address is the lack of engagement and interaction in students and teachers in the classroom. This was imperative in both my learning and teaching in science. As a teacher it can be difficult to create lesson plans that help students increase their understanding and accelerate their knowledge. According to an article written by William Major, if we remember the classroom is a social experience for students, and look at it through the lens of mirroring and imitation, students need face to face interactions and instruction with their teachers and peers (Major, 2014). This will help their understanding and learn actively in the classroom. Students are then able to apply this knowledge and understanding to more complex problems in the future. As a new teacher it can be hard to know what is best for your students and their

learning, especially in a high school chemistry classroom. Students come in with a misconception that chemistry is difficult and they already start the class with a negative mindset. Creating an engaging classroom can be difficult at first, especially as a new teacher. This can seem a little intimidating at first, as I experienced in my student teaching, but jumping right into the lessons with an NGSS centered focus made it feel more comfortable. It is important for a science teacher to create an engaging, safe learning environment for your students. The NGSS can provide a guideline for teachers to implement standards that allow for a more engaging classroom. This leads me to my research question: *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?*

## **Chapter Summary**

The Next Generation Science Standards can be very useful in creating a beneficial and engaging high school chemistry classroom. I think looking at different strategies that can be used in chemistry classrooms can be important. There is also significance in lab activities for students and hands-on learning that benefits students. This can be seen especially with in- person learning, compared to online where they lose that value and that interaction with their teacher. Looking at different strategies used in high school chemistry classrooms can be beneficial to understand how teachers can write lesson plans based on the NGSS.

The second chapter will examine the different literature on online learning, in person learning strategies and the Next Generation Science Standards. The literature review will include information on online learning and the advantages and disadvantages associated with it. It will also include information on in- person learning strategies like active learning and collaborative learning for students. Finally, it will include more information on the Next Generation Science

Standards and the benefits of these standards for a science classroom. Then a model for teachers will be created to guide their own creations of NGSS-centered lessons and units.

## CHAPTER TWO

### Literature Review

The Next Generation Science Standards can be great to use in your classroom to increase student engagement and the understanding of science concepts. In order to address the question: *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?* It is important to examine experiences for students in online learning and in person learning to highlight how chemistry is being taught. It is also important to note improvements that could be made to better student engagement and education in Chemistry, through the NGSS. Also, to highlight the benefits of active learning and collaborative learning which can be done through the NGSS-centered lesson plans. It is also important to note good teaching practices in chemistry through the Chemistry Next Generation Science Standards and the benefits of these standards (*Next Generation Chemistry*, 2014). Finally, evaluating web-based NGSS-centered lesson plans that have already been created can be beneficial in addressing what further work needs to be done to create a collaborative website for science teachers.

This chapter will discuss online learning, advantages and disadvantages along with this to outline the importance of in-person learning for students. Tools to create better online learning will be discussed to highlight the benefits of these strategies in in-person learning as well. Next, in person learning will be discussed, focusing on active learning and collaborative learning. Furthermore, the Next Generation Science Standards will be discussed and the various sites that are already out there on NGSS will be evaluated. Finally, this chapter will end with a discussion of themes found in the research and how it relates to this capstone project. It will then conclude with a chapter summary.

## **Online Learning**

Online learning within schools around the world has become widely popular. Ever since the COVID pandemic schools have been forced to go online to keep everyone safe and to keep students learning in a school environment. According to the United States Census Bureau (2020),

From May 28 to June 2, when many school districts across the country are normally in session, 80% of people living with children distance learning reported the children were using online resources. (McElrath, 2020)

This shows the big impact that the pandemic had on schools throughout the US with a big majority of students using online resources for distance learning.

There are both disadvantages and advantages to teaching Chemistry online. This can be seen throughout the world due to the pandemic when schools relied on using online resources for distance learning. Compared to in- person learning, online learning has seen more disadvantages. It is important to note advantages of online learning because there are similar strategies that can be used in in-person learning.

There can be advantages to using online resources in your classroom, especially with the Next Generation Science Standards. If used correctly the online resources can be a great tool for student learning and can be implemented through NGSS- centered lesson plans. Having a web-based site for these types of lesson plans can also be a great tool for teachers to learn and collaborate. There are a ton of advantages of online learning that can be a great tool for both students and teachers in learning.

### *Advantages of Online Learning*

Online learning is used all over the world and has shown both advantages and disadvantages. An observational study and survey was conducted of Polish medical students and data gathered was then analyzed. According to the study,

Ease of access to educational materials and the ability to choose the time and place to study were shown as the strongest advantages of online learning among respondents in our survey (Bączek et al., 2021, p. 3)

This shows students found advantages to online learning over the pandemic that they were unable to get from in-person learning. Another advantage of online learning, according to an article called, *View of the Impact of Online Learning on the Learning Motivation of Junior High School students*, is that it can foster self-regulated learning (Zaitun et.al, 2021). This can be beneficial even in in-person learning classrooms. Creating a lesson or space for self regulated learning can be very beneficial. Another advantage, according to a study done by Robinson and Hullinger is, using asynchronous technology tools promotes reflection, which leads to higher-order thinking (Robinson and Hullinger 2008). This type of reflection can also be used in in-person learning to lead students to higher-order thinking. Although there are advantages to online learning that can reflect into in-person learning there are disadvantages that were brought to learning online. It is important to look at these disadvantages to reflect on what can be done to improve this type of learning.

This type of online learning can be very beneficial in a unit plan focused on the Next Generation Science Standards. Especially, creating a web-based collaborative site can really promote reflection. This reflection can help teachers collaborate and grow these NGSS- centered lesson plans. There are disadvantages along with online learning that need to be addressed in

order to learn and adapt from these mistakes to create a resourceful web-based tool for NGSS lessons.

### *Disadvantages of Online Learning*

Although there are advantages to online learning, there were some disadvantages found as well. From the same study conducted on Polish medical students they found the lack of interaction with patients was their main problem and biggest challenge (Bączek et al., 2021). This is the same in a high school chemistry class, the lack of interaction with students and teachers is a big challenge for learning. The advantages and disadvantages outlined in this survey are similar in all types of learning environments around the world, whether that is online or in person. Another study was conducted on students from University of Jordan and Al-Zaytoonah University in the United Kingdom of Jordan (as cited in Maqableh & Alia, 2021). This study surveyed a total of 853 undergraduate students and the researchers had these students complete an online survey. This study had very similar findings to the Polish students,

Factors behind students' dissatisfaction are a distraction and reduced focus, technology and internet connectivity, inadequate support, workload, difficulty level, interaction, psychological issues, and management. The most important factors behind the students' dissatisfaction are a distraction and reduced focus and students' poor interaction with instructors and colleagues. (Maqableh & Alia, 2021)

Both studies show the impact of online learning experience from a variety of different students all over the world has proven to have a common disadvantage. The lack of interaction with both teachers and students can cause setbacks to students' learning.

This is important to note that improving interaction with teachers and students can benefit students' learning. This interaction can be improved through the NGSS. There are also online

resources that can be very beneficial to student learning. These types of resources can be incorporated into the NGSS- centered lesson plans to improve student learning even further and support them outside of the classroom as well.

### *Creating Better Online Learning Environments*

As teachers, we can create better learning environments for students during an online learning experience for students. A study was conducted on medical students all over Pakistan, both undergraduate and graduate and this study focused both on students' perceptions and teachers' readiness in teaching online. The results of this study shows teachers can improve online learning if We develop online learning modules based on students' ease, accessibility, and interactivity (Sarfray et al., 2022, p. 15).

This shows if teachers are able to focus on what students need during this online learning and adapt to these needs, the online learning environment can be more interactive and beneficial to students. A common disadvantage of online learning shown through these studies is the interactive element between both teachers and students and students to students. Clark-Ibáñez and Scott (2008), outlined ways that teachers can improve their online classes. One important way this can be done is to promote learning through online discussions. This can be a great way for students to connect and respond to each other's ideas. Teachers can also interact with these different ideas and allow them to better connect with their students. This is shown to be a great way to promote active learning in an online environment.

Specifically in a high school chemistry class, online learning has its own limitations. A research study was conducted by McInerney (2012) at a K-12 charter school with 103 high school chemistry students. The study used different instructional strategies to evaluate the impact it had on students' laboratory assignments, assessments and class engagement. This study was



conducted to investigate the relationships between both student understanding of chemistry concepts and success on lab assessments to participation in an online lesson. This study showed that creating synchronous online learning laboratory assignments created higher engagement in students McInerney (2012). Furthermore, the teacher conducted three different online synchronous lab demonstrations. These demonstrations created a ton of excitement and engagement measured through attendance in the study with:

45% of all chemistry students (31/70) in the study attended one of the two classifying reactions lessons or watched a recording, the highest attendance of all synchronous lessons in the study (McInerney, 2012, p. 97).

This is important for students to see these demonstrations in this type of environment because they are unable to do it themselves. This was exciting to them and created higher engagement in the course.

Learning more about advantages and disadvantages to both online and in-person learning has outlined what is needed for an effective learning environment for an in-person classroom. This in-person classroom setting, using the Next Generation Science Standards and tools learned from this research, can create an effective unit plan for Atomic Structure. This plan will create an effective and engaging learning environment for all students.

### ***Improvements to Online Learning***

Online learning has both advantages and disadvantages in a variety of different classrooms all over the world shown in multiple studies that were highlighted. The main disadvantage shown was lack of interaction in this type of online learning environment. This can be improved through online discussions and specifically in a chemistry classroom, online lab demonstrations. These demonstrations promote engagement, higher level thinking and active

participation in students. All these skills are important to have and can be gained from in-person learning in specific.

### **Beneficial Skills Gained from In- Person Learning**

As the pandemic slowed down schools were able to transition back into in- person learning with students. There are a ton of benefits to this kind of learning for students, especially with a variety of skills: higher order thinking, collaboration and active learning. Collaboration in chemistry can be really meaningful for students to improve active learning and critical thinking skills (Andrews et al., 2020). These skills can be related to what scientists do in the field and to real life experiences.

**Active Learning.** Active learning, defined by Cornell University, is when students

engage in their learning by thinking, discussing, investigating, and creating. In class, students practice skills, solve problems, struggle with complex questions, make decisions, propose solutions, and explain ideas in their own words through writing and discussion (*Active Learning /Center for Teaching Innovation, 2023*).

There are a variety of benefits to active learning and some include, providing students opportunities to learn the new material in a variety of ways through writing, talking and problem solving. Also applying new knowledge will help students remember information, concepts and skills. This is also beneficial to the instructor because it provides insight into student learning and thinking by observing and discussing with students as they are actively learning and collaborating (*Active Learning /Center for Teaching Innovation, 2023*).

Even though, in a Science, Technology, Engineering and Math (STEM) classroom, active learning is slowly becoming more used, and more lecture based teaching is still relatively common. Based on a journal article called, *Instructor strategies to aid implementation of active*

*learning: a systematic literature review*, it is a concern for instructors that students will resist the active learning style, but the research done through this article outlines strategies to help promote active learning (Nguyen et al., 2021). According to the research these strategies help instructors promote active learning in a STEM classroom, like high school chemistry is. It helps to establish expectations, explain the purpose, engage with students, encourage students, design appropriate activities, create group policies or rules, connect multiple parts of the course together and review student feedback.

This active learning can be seen specifically in a high school chemistry classroom as well. In a journal article, written by Strain and Pearce, they discuss active learning in the chemistry lab and positively influencing student attitudes towards chemistry. Similar to the journal article, *Instructor strategies to aid implementation of active learning: a systematic literature review*, Strain and Pearce also found it has been difficult for teachers to implement active learning in a science classroom because of the traditional lecture based learning. Strain and Pearce identified a challenge to change student learning from the traditional textbook teaching approach to a more active learning where students can learn the importance and application of the material they are learning (Strain & Pearce, 2001). To help teachers with this a curriculum change was needed to, “include more activities that require students to make predictions, critically analyze their results and explain what happened” (Strain & Pearce, 2001, p. 31). This can be difficult for students at first since they are so used to the traditional reading from a textbook, but implementing this in the classroom can be so beneficial for their learning. As an instructor, encouraging students and promoting active learning can really further their knowledge and understanding in chemistry.

**Collaborative Learning.** According to the Education Endowment Foundation, collaborative learning: helps students work together in smaller groups to make certain that all students participate (Collaborative Learning Approaches, 2023). Students need this type of practice and support with each other to work together and problem solve. As a teacher it is important to design these learning tasks with collaborative groups effectively or else some students may fall behind or get too far ahead.

Collaborative learning gives students the opportunity to connect with peers and also enhance their confidence. In an article written about collaborative active learning in a biochemistry course the authors write that collaboration exercises help students explain their understanding to peers, gain new perspectives and ideas, and make the connection of new content to their prior knowledge (Andrews et al., 2020). This is very beneficial for students' learning and confidence in their understanding. It also provides the development of critical thinking skills. It was also noted that these collaborative discussions were beneficial for instructors to identify the misconceptions students are having on a specific topic. This is very beneficial for both the teacher and students because there are a variety of misconceptions in science that can be hard to identify. With collaborative discussions they can be easily identified and discussed with the teacher and students to clarify misconceptions.

Both active learning and collaborative learning skills are important to have in a chemistry class. These skills can be gained through a variety of activities, specifically through NGSS-centered lesson plans. These types of skills can be carried throughout the whole chemistry classroom and can improve learning through each unit of the class. It will help students make connections to different science concepts. Overall this will improve student engagement and learning.

## Benefits of Next Generation Science Standards

*Good teaching* can be hard to define but in high school chemistry classrooms there are practices that can be followed to allow for an effective learning environment for all students. The Next Generation Science Standards (2000) provides teachers with standards to allow students to have access to a high quality science education (Next Generation Science Standards, 2000). The NGSS can be a great tool for teachers to improve their science classroom and provide a high quality science education. NGSS has shown improvement in student learning and science achievement. In a research report outlining how students benefit from Next Generation Science Standards states,

In the spring 2018 survey, more than half of Teacher Leaders and expansion principals (61 and 55 percent, respectively) reported a “substantial” increase in student engagement resulting from the changes toward aligning teaching with the NGSS (Tyler et al., 2018, p. 3).

Teachers and administrators were asked about what the NGSS did that students found the most interesting and the biggest theme that came up was how it sparked students' curiosity and motivated them to try to understand. Another very important common theme that arose with the results of the interviews was: students in NGSS classrooms were not only gaining skills like communication, critical thinking, and teamwork but they were also gaining a deeper understanding of science (Tyler et al., 2018). This connects to the collaborative learning benefits in a high school chemistry class and that these NGSS standards promote the collaborative learning style for students.

NGSS also provides equitable learning opportunities for all students. According to Krueger, “The NGSS gives more than just objectives; it provides the sense of security that

students all over the country will be given the same opportunities, regardless of where they live” (Krueger, 2012). These standards also provide a way to link different domains of science together through the crosscutting concepts. Students are able to make connections with different concepts and enhance their understanding and be able to apply their knowledge to new concepts.

### **Next Generation Science Standards Sites Available**

It is beneficial to evaluate the sites that already exist that provide NGSS-centered unit plans and lessons that teachers can access. There are a couple of variety of sites that provide these types of lessons, but one limitation is that access to them is very difficult and limited. *American Association of Chemistry Teachers* is a website that provides chemistry teachers with strategies and support for their classrooms. There is a page on using the NGSS in the chemistry classroom but access to this is limited. This website requires a membership with monthly fees to subscribers. This limits access to their website and less teachers using these resources because not everyone can pay for this type of membership (AACT, 2020). Another limitation seen in websites providing NGSS-centered lessons is not providing enough information to implement these lessons. *San Francisco Public Schools* provides free access to their year-long NGSS Chemistry curriculum (*San Francisco Public Schools / SFUSD*, 2023). All this curriculum provides are copies of textbooks and materials needed for the labs provided. There are no lesson plans or any details provided to actually implement this curriculum. Furthermore, it is actually going back to the ways of teaching from a textbook and not providing a way to implement the NGSS into the curriculum. To add on, there are blogs and websites that provide personal experiences from a teacher implementing the NGSS. These experiences can be helpful to read but again difficult for new teachers to actually implement the NGSS into their classrooms themselves. A blog, written by, Tanya Katovich, writes about their stories about integrating the

NGSS and good teaching practices in their chemistry classroom (*Next Generation Chemistry*, 2014). Although beneficial to read it can be very difficult for a new teacher to actually implement these strategies themselves. These limitations addressed show that an accessible and detailed web-based NGSS-centered chemistry unit is needed for implementation.

### **Themes in the Research**

There are some themes in the research that this capstone will address. This capstone will add to these themes and research about NGSS- centered units and add to benefiting a high school classroom. A theme in the research found is the importance of collaboration. It is found in-person learning has provided a lot of benefits to collaborative skills. These skills are helpful both in the classroom as a student, but also as a teacher. It is helpful for students to collaborate with one another and gain insights on something they might not understand themselves from a different perspective. It is also important as a teacher to collaborate with other teachers because both can learn a lot from each other. This capstone project will create a way for teachers to collaborate and share their ideas on this NGSS- centered chemistry unit on the topic of Atomic Structure. This is important to gain feedback and collaborate with other teachers to improve this unit and lessons as much as possible. Another theme found in the research is accessibility is important. Online sources need to be easily accessible or else there is a limitation on who can access it. Online learning has shown it is important to have easy access to resources or else students won't be able to learn. It has also been found that previous websites focusing on NGSS unit plans are not easily accessible. It was difficult to find and some required a payment. This capstone project will be free and easily accessible to all with internet access. This will provide a way for teachers around the world to use NGSS and realize the benefits it has in their classroom learning environment.

Noting these themes can help identify what is needed to answer the question: *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?* This will help improve this web-based site to create as much as an effective project as possible.

## **Chapter Summary**

In order to address the question: *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?* This chapter addresses the disadvantages and advantages to online learning. Learning more about advantages and disadvantages to both online and in-person learning has outlined what is needed for an effective learning environment for an in-person classroom. This highlights the importance of in-person learning for students in a chemistry classroom. The in-person learning provides students to learn actively and collaboratively, which highly increases student engagement and understanding of complex science concepts. They are then able to apply their knowledge and understanding to new concepts. The chapter then starts by outlining the benefits of the Next Generation Science Standards in a high school chemistry classroom and showing why it is effective to use in a curriculum. Next it looks at NGSS websites already available online to focus on what is needed to improve these websites for the project. There were limitations found that can be improved to help strengthen the effectiveness of the web-based site for an NGSS-centered chemistry unit on the topic of Atomic Structure. Finally, this chapter concludes with discussion of certain themes found in the research and how this can be used to create an effective project. The main focus of this is creating an accessible website, free for all to access with an internet connection to be able to spread these ideas of NGSS-centered chemistry unit plans.



Chapter 3 will address the project in detail, the overview, audience and type of project. The Next Generation Science Standards will be discussed further in detail and how to use them to create effective lesson plans for a high school chemistry classroom. The final will be chapter 4, which will be a final reflection of the whole project. This chapter will emphasize the importance of each section of this chapter and how it relates to the project's research question.

## CHAPTER THREE

### Project Description

This project is a web-based design resource for teachers all over the world to access and collaborate on NGSS-centered lesson plans. It is a way to provide teachers with a brief description of NGSS and then provide a unit plan focused on Atomic Structure. Teachers who access this site will be able to provide their own feedback and thoughts of the effectiveness of these lesson plans in their own classroom. This project is a unit plan with various lesson plans applying the Next Generation Science Standards. Each lesson plan is available for anyone to edit, print and make copies for whatever their needs are for. Teachers will also be able to add their own comments and feedback to the lesson plans. This curriculum seeks to answer the research question: *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?* This chapter will discuss project description, audience, timeline and assessment of the project.

This curriculum for a high school chemistry classroom will be based on the Next Generation Science Standards, or NGSS. NGSS was released in 2013 and aims to improve science education for K-12 students through research based standards. These standards, as described by NGSS, allow teachers the opportunity to design their classroom learning experiences for students to stimulate their interest in science (*Next Generation Science Standards*, 2000). These standards have become popular and states are changing their education standards with forty-four states changing their education standards based off of NGSS and Framework for K-12 Science Education. Specifically, twenty states have completely adopted the Next Generation Science Standards into their curriculum (*NGSS Hub*, 2014). NGSS highlights three dimensions of science learning: *Crosscutting Concepts, Science and Engineering Practices,*

*and Disciplinary Core Ideas*. Crosscutting Concepts have students see how the same concepts come up across the different disciplines in science. Science and Engineering Practices have students engage in eight different practices:

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communication Information

*(Next Generation Science Standards, 2000)*

Disciplinary Core Ideas help teachers focus their curriculum, instruction and assessments on the most dominant topics of each science field. These standards will be used to create various lesson plans to increase understanding that accelerates students' knowledge of a specific chemistry concept. The web design used will be using Google Sites as an accessible website for all. This is beneficial because teachers from all over the world will be able to access this site. Furthermore, it will be free to everyone, and more accessible to all. This website will also allow teachers to provide their own feedback in a Google Form format to understand their own experiences and ideas from these lessons.

The Google Sites page will be called NGSS Atomic Structure, with the homepage saying: Next Generation Science Standards Chemistry Atomic Structure Unit. It will have a brief description underneath saying, provided are lesson plans for a Chemistry class using the Next

Generation Science Standards. Below this will be a Mission of the Project description, stating, These lesson plans are available for teachers to use in their own classroom. There is a space for teachers to provide feedback and a place for discussion. These lessons specifically are for a unit on Atomic Structure. Finally at the bottom of the homepage will include a section called Questions, where my email address is provided if any specific questions are had after visiting my site. There is a sidebar on the homepage that provides access to three different pages that are provided on the website. The first page is called NGSS where it will answer the question: What is NGSS? This page will provide a brief description of NGSS and how it is being used in these lesson plans. This is provided for any teachers who may not know what NGSS is and provide them a little background on it to inform them why it is important in creating an effective science classroom. The next page is called, Lesson Plans, where these lessons will be provided along with access to additional resources for the lessons. Finally the last page is called Feedback, where anyone who visits this website can provide feedback on the lessons. This feedback will be gathered through a Google Form embedded into the website.

### **Importance of Web-Based Projects**

It is meaningful to note the importance of web-based projects and how to create an effective website that is accessible to all. From a document provided by Hamline University, called *Web Design Tips* (2023), that was added in the project is, avoid overcrowding in the website, have an organized layout, choose images that compliment your content, and are in focus, with sufficient resolution, and get feedback and support. This web-based project has avoided overcrowding and an organized layout so it is easy to read for the audience and easily able to click through the content. There are images that compliment the content of the Next Generation Science Standards and the chemistry unit on Atomic Structure. Finally, before

launching the website it is helpful to ask peers, friends and colleagues to review and provide feedback on the site (*Web Design Tips*, 2023). Another resource used to create this website as effectively as possible is from the U.S. Department of Health and Human Services (2006) called, *Research-based web design & usability guidelines*. This website provides design and usability guidelines to create an effective website that is easily accessible to all users. One guideline is to provide assistance to users. If there are users that need special assistance and are new users they might need extra help. In this project there is information at the bottom of the page for users to email and ask any specific questions or any feedback they might have. Links are also provided throughout the website for more information on NGSS and the lesson plans on the unit of Atomic Structure. Another guideline is always enable access to the homepage and show all major options of the homepage. This is important for users to easily access all the information on the website from one page (U.S. Dept. of Health and Human Services. (2006). The project design provides all the information on the homepage, with the mission of the project and links to the three other pages on the website. These tips and guidelines were used to create an effective and easily accessible website for NGSS-centered lesson plans focused on the unit of Atomic Structure.

### **Audience**

The intended audience for this project are high school chemistry teachers from around the world. The goal is to create a website where teachers have access to these NGSS-centered lesson plans and provide feedback on them. Teachers will be able to add feedback in a Google Form format and ask their own questions also. It is also intended for new teachers using NGSS and to learn more about NGSS and what NGSS-centered lessons look like. Even if teachers come to the website and don't use the lesson plans for Atomic Structure, it provides them with a brief

description of NGSS and examples of NGSS-centered lesson plans. These can be used as a template to even create their own lessons within a different unit.

### **Timeline**

This project will be completed in the Summer of 2023. Lesson plans will have been completed in the Fall of 2022 during my student teaching. In my student teaching I worked on creating an NGSS- centered unit on Atomic Structure. The next step in the Summer is to organize these lesson plans and create an accessible format for teachers to use from all over the world. All the resources and detailed lesson plans will be organized and then the website can start to be created. Using Google Sites, the website is easily accessible to teachers from all over the world. The Google Sites will start to be created in Summer of 2022, where lesson plans will be added, a brief description of NGSS and a feedback section for teachers to give their comments.

### **Assessment**

To assess the effectiveness of this project the feedback of teachers from a variety of schools will be used. The feedback provided will be on the website, along with access to the lesson plans. The feedback will be evaluated and the effectiveness of the project will be determined. This feedback will be given in a Google Form format on the website so teachers are able to give their opinions and ideas on these types of NGSS-centered lessons. This Google Form embedded into the feedback page on the website is titled NGSS Atomic Structure Feedback. It will provide a variety of questions:

1. Did you use these lesson plans? If so, which ones?
2. Did you feel they were effective in your classroom? Why or why not?

3. Were the students engaged in the lessons?
4. Would you continue using NGSS-centered lessons in your classroom? Why or why not?
5. Would you recommend these lessons to other teachers?
6. Were the lessons and materials easily accessible?
7. What other questions/ comments do you have?
8. If you feel comfortable, what is an email or phone number I can use to contact you about your feedback?

With the provided feedback, I will review the answers and any further questions and review my own lessons. I will go back and edit them if needed and then reach out to the teachers who provided their email or phone number. I will answer any questions teachers may have and contact them with any questions that I have. With this I hope it can start a discussion between teachers about NGSS and the impact it has in a science classroom.

## **Chapter Summary**

This chapter provides a project description, audience, timeline and assessment of the project and shows how it answers the question: *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?* This project will provide a website with various lesson plans for the curriculum that uses the NGSS standards. This website is available for teachers all around the world and will also provide them an opportunity to give feedback. This feedback will be used and gathered to assess the effectiveness of this project. Chapter 4, the final chapter, will be a reflection on the project as a whole and emphasizes the learnings of each chapter.

## CHAPTER FOUR

### Conclusions

This project aimed to answer the question, *What can a web-based, collaborative, NGSS-centered chemistry unit, on the topic of Atomic Structure look like?* An NGSS-centered chemistry unit focuses on going away from the old ways of teaching science. These older ways of teaching don't help students really learn how to do science. This unit focuses specifically on Atomic Structure, but the outlined lessons can be a great tool for other teachers to use for their own unit plans with an emphasis on NGSS-centered lessons. This unit plan contains fifteen days worth of lessons, but can be adapted based on the classroom needs. A brief description of the NGSS, these lessons, and a feedback form is all accessible on Google Sites:

<https://sites.google.com/hamline.edu/ngssatomicstructure>, where anyone on the internet can find and open it.

The process of creating these lesson plans and this project has opened my eyes to what I really want my first classroom to look like. I am looking forward to creating more NGSS-centered lessons and learning from the feedback given from other teachers and my students. This chapter will focus on my reflection of myself as a researcher, writer and learner. It will also revisit the literature review, provide possible implications or limitations to this project and add future similar or related research projects.

### Reflections

Looking back at this project and the whole capstone process I have learned a lot about myself as a researcher, writer and learner. As a researcher I have learned a lot about organization and effectively searching through websites. As a writer, I have learned a lot more about



organization of my thoughts and using effective transitions. Finally as a learner, I have learned it is important to keep an open mind and that I will never stop learning.

First, as a researcher I have learned a lot about organization and effectively searching through websites. Before this project I had practice with research papers, but only small ones with no more than five resources used. This project pushed me to expand my knowledge and research that I have never had to do before. This made it difficult for me at first to start researching because it was hard for me to organize my sources since I was working with so many. I started off by not saving my sources very effectively and just pasting a copy of the website into a document. I found it was more difficult to find what idea this research correlated with in my paper. I then learned to start organizing the sources by content and what I wanted out of the source for my paper. I also learned a lot about effectively searching through a source for the information needed for my paper. A lot of these resources were a ton of pages with some information I didn't need to include in my paper. I found myself more effectively searching through these documents and finding the information needed instead of trying to read every single page. This helped a lot in my research and I feel a lot more confident as a researcher now than I ever had before. I think this was a little unexpected for me. As a researcher I felt pretty confident since I have had experience before, but not at this level. I realized I needed more organization to make my research as effective as possible.

As a writer I have learned a lot more about organization and transitions in this paper. At first, writing this paper my thoughts were not very organized. I found the importance of effective headings were key in the organization of this paper. This especially helped with organizing my ideas and thoughts as well. I also learned about using effective transitions in a paper. It is important to transition from one idea to another instead of jumping right into the next. It makes it

easier for the readers to understand and as a writer to connect my thoughts and ideas. I struggled at this first but I then realized I had to explicitly transition into the next idea and make it clear for the reader.

Finally as a learner I realized no matter how many classes I've taken or how many years of school I have attended there is still always something for me to learn. I think this is important for me to note as I continue into the classroom as a new teacher. Being a new teacher I have so much to learn still and I have to be willing and open to this learning.

This whole process has made me a better researcher, writer and learner. I hope to continue to grow and use these skills as a new teacher in my classroom next year. It is important to be an effective researcher and writer to help your students. More importantly I think it is important as a teacher to be a willing learner for your students as well. Next the literature review will be revisited, focusing on the parts that proved to be most important in my capstone project.

### **Literature Review Revisited**

There are parts of the literature review that proved to be most important for this capstone project. Looking at the themes in the research in chapter two was very effective in creating this project. It helped identify common limitations found on the topic of web-based NGSS unit plans. Noting these themes were important in addressing and answering the research question to improve this web-based site to create as much as an effective project as possible. These themes discussed were, the importance of collaboration and the importance of accessibility.

It was found in the research that in-person learning has provided a lot of benefits to collaborative skills and is helpful both in the classroom as a student, but also as a teacher. As a student from the research: collaborative learning gives students the opportunity to connect with peers and also enhance their confidence. In an article written about collaborative active learning

in a biochemistry course the authors write that collaboration exercises help students explain their understanding to peers, gain new perspectives and ideas, and make the connection of new content to their prior knowledge (Andrews et al., 2020). It was also noted that these collaborative discussions were beneficial for instructors to identify the misconceptions students are having on a specific topic. This is very beneficial for both the teacher and students because there are a variety of misconceptions in science that can be hard to identify. With collaborative discussions they can be easily identified and discussed with the teacher and students to clarify misconceptions. This can be reflected in the website because it is also important as a teacher to collaborate with other teachers because both can learn a lot from each other. This capstone project created a way for teachers to collaborate and share their ideas on this NGSS- centered chemistry unit on the topic of Atomic Structure. This is important to gain feedback and collaborate with other teachers to improve this unit and lessons as much as possible.

Another theme found in the research is accessibility is important. Online sources need to be easily accessible or else there is a limitation on who can access it. Looking at the benefits of online learning, an observational study and survey was conducted of Polish medical students and data gathered was then analyzed. This data showed that ease of access was one of the strongest advantages of online learning (Bączek et al., 2021). Creating an accessible online website can be effective in learning. Looking at the Next Generation Science Standards that are already accessible to anyone with internet access was very important for this capstone project. *American Association of Chemistry Teachers* is a website that provides chemistry teachers with strategies and support for their classrooms. There is a page on using the NGSS in the chemistry classroom but access to this is limited. This website requires a membership with monthly fees to subscribers. This limits access to their website and less teachers using these resources

because not everyone can pay for this type of membership (*AACT*, 2020). This showed me for my project I needed to create an easily accessible website, which I did through Google Sites.

Although, even with this research there are still limitations and implications to this capstone project.

### **Limitations and Implications**

One limitation of this project is that this is my first time using the Next Generation Science Standards for a unit plan. This will also only be my first year teaching so I am not an expert in these standards. I have used these lessons only a couple of times during my student teaching, but never on my own or in another classroom. To my knowledge it went very well for the students, but I need more feedback. This is why I hope I can share these lesson plans with other teachers from around the world and gain their insights and feedback. Providing my email and the feedback form on the website, I hope I can connect with other teachers and collaborate on these lesson plans. Another limitation of this project is that there is no requirement for teachers to provide feedback when they visit this site. This can be difficult to get feedback since it is volunteer based. There is a feedback form and teachers can leave their contact information but there is no need for them to do it. They have to be willing to collaborate with me and try these lessons in their own classroom.

One implication of this project is that I hope it creates discussion and collaboration around NGSS-centered lesson plans in chemistry. I also hope these lesson plans are revisited and edited with feedback given from experienced teachers to really make them as effective as possible.

I think this project can be a great tool for the professional development of chemistry teachers. It can provide teachers with information on the Next Generation Science Standards

which can help teachers set a new way of teaching science. This way teachers will stray away from the older ways and create a more engaging classroom environment. Even if teachers who come and visit my website don't use the lesson plans provided they still gain knowledge on what NGSS is and how it can be implemented in their classroom. These lessons can be used as a guide and don't need to be used directly. I think it is also a great tool for teachers from all over the world to connect with one another and share their own lessons and experiences if wanted. Teachers can always learn something new from one another, no matter where they are from or how long they have been teaching.

After this project, there is still more to be done and learned about NGSS-centered lesson plans. It is important to note future projects and research that can be done after this because the learning doesn't stop here.

### **Future Projects and Research**

A future project for myself is to continue editing these lesson plans on the unit of Atomic Structure. These lessons are not perfect but with feedback from other teachers they can be edited and changed to be even more effective in the classroom. No matter, there can be more research and findings to help improve these lessons.

Another future project for myself is to create more NGSS-centered lesson plans for another unit in Chemistry. This could include chemical bondings, reactions or more. Continuing to create these lesson plans focused on NGSS will create more options for teachers to use in their own classroom and implement themselves. This will then provide more feedback from teachers, and these lessons will continue to be improved.

The communication of my results of this project are important for viewers who come to this website. When I am provided feedback on these lessons I will post them on the website for

anyone who accesses it will see. In my feedback form there is a question that allows the viewer to provide their contact information for further discussion. I will stay in contact with these teachers and continue to build off each other's ideas and edit these lessons. In the future there could be collaboration on more lessons on a different unit as well.

### **Chapter Summary**

This chapter focused on my own reflections from this capstone project, limitations and implications, and future projects and research. I learned a lot about myself as a researcher, writer and especially as a learner. It is important to keep an open mind and continue to be a learner no matter what. A limitation is that I am not an expert in this topic of NGSS- centered lesson plans and I haven't had a lot of experience teaching just yet. It is important to collaborate with experienced teachers and gain feedback to continue to improve these lessons. I hope to connect and communicate with teachers from all over the world and really spread awareness of the Next Generation Science Standards to improve the teaching of Chemistry.

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