A CASE STUDY OF MENTORING HIGH SCHOOL STUDENTS WITH CARE ETHICS IN A SCIENCE RESEARCH APPRENTICESHIP

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DEDICATION

In loving memory to Uncle Sei who embodied care ethics and always confirmed the best in me.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

Science education reform movements have shaped the development of science curriculum. In 1957 following the launch of Sputnik, the National Science Foundation (NSF) funded large projects that focused on inquiry-based learning with the intent to prepare individuals for careers in science (van den Akker, 1998). However, this created a problem for teachers who did not have adequate preparation for technical science curriculum, and for students who were not able to understand the relevancy of science to everyday life (Pea & Collins, 2008). In the 1980s, the second reform movement shifted away from preparing students for careers in science towards understanding the applications of science to society (Yager, 2000), including the infusion of Science, Technology, and Society (STS). This reform movement also sought to improve science education instruction (van den Akker, 1998) and investigated students' cognitive reasoning of science concepts (Pea & Collins, 2008). In 1996, the goal of the National Science Education Standards (NSES) was to improve scientific literacy, such that students are able to think critically in scientific issues and make informed decisions (National Research Council [NRC], 1996; Yager, 2000).

In 2006, an NRC report on high school science laboratory experiences revealed inconsistent learning outcomes and too much emphasis on procedural science without integrating science content and process. To address this, the NRC described laboratory experiences as "opportunities for students to interact directly with the natural world using the tools, data collection techniques, models, and theories of science (NRC, 2006, p. 3). Such laboratory experiences included a variety of activities that may take place indoors in the classroom and outdoors with the intent to improve content knowledge, scientific skills, enhance an understanding of nature of science (NOS), and foster interest in science (NRC, 2006).

Despite education reform movements to improve instruction, classroom science continue to be described as cookbook laboratory experiments, sometimes with few opportunities for students to engage in authentic inquiry (Aschbacher et al., 2010; Quigley, 2014). To address this, the NRC (2012) proposed a new framework that describes the importance of promoting "a more inclusive, focused, authentic science education experience for all students" (NRC, 2012, p. 265). Authentic science has varied meanings; however, science should be relevant to the learner and include historical, cultural, and societal contributions of science (Martin et al., 1990). Authentic science is characterized by active participation in scientific communities (Barab & Hay, 2001; van Eijck & Roth, 2009) and reflects, "the sorts of activities that scientists and technologists do in the real world of science and that such experiences should include student-direct tasks and more open-ended enquiries" (Braund & Reiss, 2006, p. 9). It has been suggested that components of authentic learning include conducting activities within a community of learners and activities are situated in real-world problems to promote inquiry (Rule, 2006).

One way for students to engage in authentic science is through research apprenticeships. During a research apprenticeship, students typically operate in a community of practice. A community of practice has been defined as "a set of relations among persons, activity, and world" (Lave & Wenger, 1991, p. 98) in which a novice works alongside experts to learn a specific skill. As a member practices in a particular community (e.g. science), they operate with particular values, beliefs, and tools that mediate sense-making of the world (Lemke, 2001). Students shift into a community of practice by adopting and practicing the values and activities that are socially accepted within their science community (Lave & Wenger, 1991). To learn the discourse of the science community, students collaborate authentically with "more knowledgeable others, including teachers, scientists, and peers" (Barab & Hay, 2001, p. 77).

From a sociocultural perspective, more knowledgeable others can scaffold learners through experience (Lemke, 2001). As students participate in a science community, they can develop a sense of agency in their learning (Fields, 2009; Kapon, 2016).

To enhance student participation in authentic science, research apprenticeships offered for secondary students vary in design and setting such as extracurricular programs or partnerships with scientists at universities, local schools, and informal learning environments (Sadler et al., 2010). Research apprenticeships may be particularly important for high school students as those who participated in science, technology, engineering, and mathematics (STEM) programs had a stronger desire to pursue a science career than those who do not participate in any science programs (Kitchen et al., 2018). High school students' interest in science can also be attributed to enrichment experiences out of school such as participation in science settings such as laboratories and zoos (Aschbacher et al., 2010). Research apprenticeships provide authentic science contexts for students to engage in a community of practice (Quigley, 2014).

To date, most of the research apprenticeship literature for high school students has focused on several learning outcomes such as developing content knowledge, practices, student understanding of NOS, and self-efficacy (Sadler et al., 2010). However, few studies have focused on the role of caring in a research apprenticeship. While mentorship can have components of caring, caring ethics has not been explicitly studied. Caring appears to manifest through the mentor-mentee relationship during an apprenticeship (Aydeniz et al., 2011; Burgin et al., 2012). Features of caring within mentorship may be important because mentorship can shape students' experiences during the research apprenticeship. Positive experiences include scientists interacting with students to provide a supportive learning environment to enhancing their science content knowledge, practices, confidence, and agency during the research process (Bleicher,

1996; Fields, 2009; Kapon 2016; Richmond & Kurth, 1999). Interactions between students and mentors during an apprenticeship can also foster ownership and belonging to a research community (Hsu & Roth, 2010). Burgin et al. (2012) described how students experienced varied levels of mentorship from high to low involvement. Those with high to medium levels of mentorship support were able to ask for help on aspects of the research project either throughout the apprenticeship or had more help towards the beginning and became more independent over time. In a negative mentorship experience, one participant described a low level of support from the faculty mentor. Mentorship is important in shaping the experiences that occur during the research apprenticeship. However, there is a need for research to identify the specific features of mentorship that mediate the apprenticeship experience.

Statement of the Problem

Despite the importance of caring in the form of the student-scientist relationship, there are no studies to my knowledge that have intentionally implemented caring in a science apprenticeship. Specifically, Nel Noddings' Caring Ethics framework may offer important insights because she views caring in multiple ways. At the most basic level, caring is viewed as a reciprocal relationship between the "one-caring" and the "cared-for" (Noddings, 2013, p. 4). In this caring, Noddings makes the distinction of natural caring from ethical caring, in which the latter describes how the one-caring understands and responds to the cared-for's individual needs. In a more expansive view of caring, Noddings describes caring in the curriculum by "organizing it entirely around centers of themes of care" (Noddings, 2005a, p. 70). Her main thesis is that instead of applying a standardized curriculum, educators should build a curriculum that fosters students' individual interests, ideas, and capabilities (Noddings, 2005a). As Noddings provides an expansive view of caring from one-to-one relationships to caring in the curriculum, this view

of caring may impact student's experiences during a research apprenticeship. As apprenticeships can shape many outcomes from student's career aspirations to the scientific skills they acquire (Sadler et al. 2010), more attention is needed to investigate the role of caring in a research apprenticeship.

Research Questions

The purpose of this study is to investigate the role of Nel Noddings' Caring Ethics in a science research apprenticeship designed with high school students. The research questions are:

a. How does mentoring with the enactment of care ethics shape participation in a science apprenticeship?
b. How do students' conceptions of care ethics compare to my own conception of care ethics throughout the apprenticeship experience?

Study Significance

Educational research on care has focused on several aspects such as measuring care as a construct or describing caring behaviors in the classroom, teacher preparation programs, and communities (Velasquez et al., 2013). However, few have focused on caring in science education. These studies include fostering caring through caring relationships between students, teachers, and pedagogical practices in the classroom (Ritchie & Rigano, 2002; Van Sickle & Spector, 1996) and outside of the classroom in the context of environmental education (Schindel & Tolbert, 2017). To my knowledge, Lyons et al. (2017), Nazier (2014), and Schindel and Tolbert (2017) are the only studies that have explicitly used Nel Noddings' Caring Ethics, specifically components of moral education (modeling, dialogue, practice, and confirmation) to foster students' caring toward the environment. However, there are no studies that have explicitly implemented and analyzed caring in a science research apprenticeship.

In the implementation and analysis of caring in a science research apprenticeship, this proposed study aims to address a few research gaps. First, none of the apprenticeship literature have explicitly used caring as a theoretical framework. This study proposes to use Nel Noddings' Caring Ethics because this may help foster positive outcomes in research apprenticeships for students, but this has yet to be empirically studied. Second, regarding the relationship between researchers and participants, most apprenticeship studies consists of an outsider observing students working with scientists (Sadler et al., 2010; Hsu & Roth, 2010). This proposed study aims to propose a different design in which I am operating as both a scientist and educational researcher working in collaboration with the students. Developing caring relationships with the students may help inform future actions that can improve students' apprenticeship experience. I acknowledge that an ethical consideration is that my positionality places me at a conflict of interest which I will attempt to address with the methodology. However, this positionality also affords me an opportunity to conduct an in-depth study to understand the shared experience with participants. Third, the research on apprenticeships for high school students mostly occur during the summer months in university research laboratories, spanning several weeks with few apprenticeships that are long-term (Abraham, 2002; Sadler et al., 2010). This study differs by transforming a science teacher's classroom to student's research needs for the duration of one academic semester. While the classroom may not have all the resources and high-end equipment of a university research laboratory, using the science classroom setting makes scientific research accessible to the participants' research interests.

Lastly, the science content of this study will focus on diatoms which are a type of microscopic algae and my area of expertise. Diatoms are important for a variety of applications such as biotechnology, forensic science, and environmental indication for water quality and

climate change (Smol & Stoermer, 2010). To date, most of the published research on diatoms are scientific papers. A few educational practitioner papers on diatoms appeared in *American Biology Teacher* to introduce readers into diatom ecology, collection, identification, and their ecological function (Christensen, 1971; Conger, 1956; Hungerford, 1998). However, few publications on diatoms and education have followed since. The publications include diatoms and art (Mayama, 2005), use of diatoms for through classroom activities, Sultany & Bixby, 2016), an online identification tool (Shayler & Siver, 2006), and SimRiver, an online water quality simulation (Mayama et al., 2011). To the author's knowledge, there are no science education research studies on diatoms.

Definition of Key Terminology

Caring Ethics:

Nel Noddings' Caring Ethics (also known as care ethics or an ethic of caring) is first viewed as a relational approach between individuals such as the student-student relationship and student-teacher-researcher relationship. Second, caring ethics is viewed as the collective relationships in the research apprenticeship such as student-external scientists and community members. In these relationships, we listen, reflect, and respond to each other to enhance each other's well-being through a caring relationship. Lastly, caring ethics is viewed as implementing curriculum in the form of a research apprenticeship that is tailored to the students' individual research interests.

Community of Practice:

The students and scientist's collective participation in a group, enacting norms and conventions that are socially accepted by scientists. The norms may be as broad as thinking with the tenets of Nature of Science (NOS) to discipline-specific content knowledge and practices.

Mentoring:

Providing students with guidance on how to conduct scientific research, career advice, and opportunities to foster their interest in science.

Science Research Apprenticeship:

Novices (students) working in collaboration with an expert (scientist) on their science research topic of interest. Students work as scientists to investigate their research, collect data, analyze, and discuss their findings.

CHAPTER TWO: LITERATURE REVIEW

The literature review covers four topics. The first three areas review previous research on apprenticeships, mentorship, and ethics. The rationale for these three specific areas is that this research aims to investigate the enactment of care ethics through mentorship in a science research apprenticeship. The fourth section of ethics includes Nel Noddings' Caring Ethics as a theoretical framework.

Apprenticeships

Apprenticeship has been defined as the "process through which a more experienced person assists a less experienced one, providing support and examples, so the less experienced person gains new knowledge and skills" (Dennen & Burner, 2008, p. 426). The purpose of apprenticeships has changed throughout history. During Medieval times, less experienced persons worked for their masters through apprenticeship, learning specific practices and trades (Aldrich, 1999). Novices worked in guilds alongside other craftsmen and when they became experts, they were called journeymen (Hay, 2017). In the Pre-Industrial Revolution, institutions offered apprenticeships to train novices for medical professions (De Munck & Soly, 2007). During the Industrial Revolution, apprenticeships started to decline as mass production with machinery required less specialized training. Following the Industrial Revolution years, apprenticeships currently serve a new function in vocational and technical schooling to prepare individuals for industry (Gordon, 2014). Although apprenticeships serve a practical function to prepare the general workforce, apprenticeships also serve as a pedagogical model for learning (Dennen & Burner, 2008).

Several theoretical ideas in education have influenced apprenticeships as a model for learning. First, Vygotsky suggested that learning occurs within specialized social and cultural

contexts, which has been described as Cultural-Historical Activity Theory (CHAT). CHAT describes how learning is mediated by: a) subjects who conduct the activity; b) the object which is the rationale for the activity; c) the tools, language, and artifacts that are used to make meaning; d) shared rules and conventions used in a community; e) the members who comprise the community; and f) the divisions of labor for the activity (Engeström, 1987; 2001; Jenlink, 2013; Vygotsky, 1978a, 1978b). Participation within a community allows novices to learn from more knowledgeable peers in the zone of proximal development (ZPD). ZPD is defined as the "distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978b, p. 86). This suggests that social interaction is important in mediating learning. This parallels the idea of apprenticeships because novices are able learn more by working with experts in a social community compared to working alone (Dennen & Bruner, 2008).

Second, another idea that influenced apprenticeships as a model for learning was Lave and Wenger's (1991) description of legitimate peripheral participation (LPP):

> Legitimate peripheral participation provides a way to speak about the relations between newcomers and old-timers, and about activities, identities, artifacts, and communities of knowledge and practice. It concerns the process by which newcomers become part of a community of practice (p. 29).

This suggests that novices operate in LPP to learn the specific norms and conventions from more knowledgeable others to gain entry into a community of practice (CoP). A CoP at minimum consists of two individuals (novice and expert) and can consist of more working together in social relations to practice the specific knowledge and skills in their community (Coy,

1989). CoPs consists of at least one shared interest and can take many forms from butchers and tailors learning in an apprenticeship to institutions such as schools and virtual settings (Lave & Wenger, 1991; Wenger, 1998). Participation in CoPs include mutual engagement, shared repertoire, and joint enterprise consisting of involvement in activities, shared resources, and achieving goals, respectively (Wenger, 1998).

A third idea that contributed to the importance of apprenticeships as a model for learning was Collins et al. (1991) conception of a cognitive apprenticeship. Historically, apprenticeships only focused on physically training novices on how to complete tasks by working alongside experts through modeling and scaffolding towards independence. The authors described cognitive apprenticeships to focus on promoting student's conceptual thinking in the problem-solving process of learning (Collins et al., 1991). To support student's thinking, a cognitive apprenticeship design should consider the content area for probing student thinking, methods for developing expertise such as scaffolding and modeling, sequencing tasks to increasing difficulty, and situating student's learning in a CoP. Collectively, these approaches in a cognitive apprenticeship aim to promote learners' conceptual thinking in domains such as mathematics, reading, and writing through LPP and apply the knowledge in multiple contexts (Bockarie, 2002; Collins et al., 1991; Hennessy, 1993).

In summary, Vygotsky, Lave and Wenger, and Collins et al. contributed ideas to sociocultural learning that inform apprenticeships as a model for learning. Vygotksy (1978 a,b) highlighted that learning is mediated by cultural contexts and social interaction in a community. Similarly, Lave and Wenger (1991) described how novices socialize into a community through LPP. Collins et al. (1991) reconceptualized apprenticeships in the context of education to support conceptual development of knowledge. Collectively, these authors contribute to the idea that

novices learn specialized knowledge, practices, and values through authentic participation in a community of practice.

Apprenticeships in Science Education

Apprenticeships are important in science because the situated activities in the form of scientific CoPs aim to build knowledge claims within a paradigm (Trefil, 2007). CoPs have operated under different paradigms in the endeavor for scientific knowledge, suggesting science is value-laden in the philosophical viewpoints (Barrow, 1988; Brush, 2000). In the positivist paradigm, Popper suggested that the demarcation of science is falsifiability, and scientific knowledge is accumulated by scientists' objective perceptions of reality (Barrow, 1988; Popper, 1953). In contrast, Kuhn (1970) discussed how scientists ascribe to a particular paradigm because "they are the source of the methods, problem-field, and standards of solution accepted by any mature scientific community at any given time" (p. 103). In other words, the conceptions, methods, and interpretations within a paradigm are determined by the science community and are subject to change with negotiation as new evidence arises. This implies that scientific communities do not operate objectively in decontextualized environments, but rather within specific social interactions within CoPs to construct scientific knowledge (Brush, 2000; Lemke, 2001). Science education scholars recognize that different science methodologies and activities depend on the scientific discipline and that the community determines what knowledge is socially accepted (Abimbola, 1983; Cobern, 1998; Hodson, 1988).

Cognitive apprenticeships are a model for novices to learn the socially accepted values and practices of any scientific community (Sadler et al., 2010). To learn the values, Gee (2004) makes a distinction between everyday language and ways of inquiry as discourse in contrast to the Discourse of science to learn the academic language of science and scientific values. Novices

learn the specific conventions in the language of science (Munby, 1976), shared activities (Lemke, 1990), scientific practices (Duschl & Osborne, 2002; Osbourne, 2014), and the values through enculturation into science (Driver et al., 1994; Roth, 1990). Interactions within a science CoP of graduate students, postdocs, and advisors can mediate learning for novices (Thiry & Laursen, 2011). It has been suggested that learners "do not develop a sense of self in being a scientist simply by engaging in scientific problems, but rather through engagement in the discourse of the scientific community and in the context of the values of the community" (Barab & Duffy, 2000, p. 15). Engagement in apprenticeships, often in the form of CoPs allows learns to appropriate the Discourse of science and can promote scientific literacy (Gee, 2004; Roth & Lee, 2004; Sadler et al., 2010).

Apprenticeships often occur by participation in scientific research communities which vary in setting, structure, and goals (Sadler et al., 2010). First, research apprenticeship settings can occur in formal settings such as a university research laboratory (Burgin & Sadler, 2013) and school (Kapon, 2016) to informal settings such as national parks (Dresner & Worley, 2006) and science camps (Barab & Hay, 2001; Fields, 2009). Second, research apprenticeships can be designed as a formalized program that occurs in the summer months for several weeks (Burgin & Sadler, 2013) to a localized program for one year (Kapon, 2016) for K-12 students, undergraduates, and teachers (Sadler et al., 2010). Third, research apprenticeships vary in the structure of the CoPs from one-one interactions between mentees and mentors to organized activities between laboratory members in a research group (Feldman et al., 2013). Fourth, research apprenticeships vary in their aims which can be specific from studying students' understanding of inquiry (Aydeniz et al., 2011) to broadly characterizing participants' experiences during an apprenticeship (Hsu & Roth, 2010). Mostly importantly, depending upon

the aim(s) of an apprenticeship, studies may focus on one outcome, e.g. identity formation (Varelas et al., 2005) to multiple outcomes such as learning inquiry, NOS, and career paths (Burgin et al., 2015).

To date, the literature often uses CoP, apprenticeship, or cognitive apprenticeships as a conceptual lens to characterize sociocultural learning during a research apprenticeship (Barab & Hay, 2001; Bleicher, 1996; Burgin & Sadler, 2016; Burgin et al., 2012; Richmond & Kurth, 1999; Ritchie & Rigano, 1996). Within the CoP or apprenticeship conceptual lens, these studies focus on how students appropriate the Discourse of science through situated learning into the culture of science. Although not explicitly defined, Richmond and Kurth (1999) described that the culture of science encompasses how students participate in science through gaining scientific knowledge, practices, and an understanding of norms within a scientific community. The authors studied high school students and found that students participated in the culture of science by learning the academic language of science, gained conceptual understanding and laboratory skills over time, and mediated learning with collaboration (Richmond & Kurth, 1999). The following subsection describes how students participate in the culture of science.

Participation in the Culture of Science

One feature of apprenticeships is learning the culture of science can include students engaging in scientific practices. The National Research Council (NRC) describes that scientific practices include a process of investigating science which consists of asking questions in an investigation, collecting, and analyzing data, using evidence to build an argument, and communicating results (NRC, 2012). Several studies have reported high school student's entrance into the culture of science through learning scientific practices. For instance, McMiller et al. (2006) studied middle and high schools students who participated in university research for

eight weeks and found that students felt more confident conducting scientific research and laboratory-specific skills such as mathematical calculations and preparing solutions. Similarly, Ebenezer et al. (2011) studied high school students' use of innovative technology (IT) including Geographic Information System (GIS) and data sensors to study Lake Erie and found that students increased their IT competency and ability to conduct scientific inquiry. Furthermore, gaining scientific skills can help underserved students learn the culture of science regarding how scientific research is conducted (Luehmann, 2009). It has been suggested that when students enter the culture of science, learning scientific practices can contribute to conceptual development of science concepts over time (Ritchie & Rigano, 1996).

As students participate in the culture of science, outcomes may include increased self-efficacy, identity formation, and confidence (Sadler et al., 2010; Shell et al., 2011). Kitchen et al. (2018) conducted a national survey and found that high school students who participated in STEM enrichment programs were significantly more likely to desire to pursue science careers than those who did not participate in programs. In addition to the desire to pursue science, students may be more prepared for advanced biology programs after participation in science apprenticeships. For instance, Markowitz (2004) evaluated the impact of a summer science research program for high school students and found that students' enculturation into science prepared them academically for advanced science courses and continued to foster their interest in science after the program.

Inquiry and Nature of Science (NOS)

Another feature of apprenticeships is learning inquiry and NOS. As students learn the culture of science, they may do so by specifically engaging in scientific inquiry and NOS. Although inquiry and NOS are two different constructs, some apprenticeship research studies

explicitly or implicitly study these two ideas together because of the relationship between inquiry and NOS and/or are both important aims for science education (Lederman et al., 2013). First, the constructs will be defined and then discussed in the context of apprenticeship research.

Definitions

First, inquiry is often debated and viewed either as a pedagogical means to teach science or as the intended outcome for students to develop scientific knowledge (Abd-El-Khalick et al., 2004). Inquiry aims to shift learners away from the transmission model towards constructing their own knowledge by doing science. The inquiry process often starts with a question, and has the students collect data, analyze the evidence, and draw conclusions. However, Bevins and Price (2016) critique the linearity in this view of inquiry and expand inquiry to include student motivation and ownership. Instead of generalizing inquiry as a universal process like the scientific method, science education researchers suggest its use will depend on the context and desired learning goals (Abd-El-Khalick et al., 2004).

NOS evaluates and questions the historical and philosophical ideas of how science developed through time, what constitutes scientific knowledge from other forms of knowledge, and how scientists conduct their research (Lederman, 2013; McComas, 2008). The views of science range from positivism to postmodernism, from perceiving an objective reality to socially constructing reality, respectively (Barrow 1988; Brush, 2000). Science educators have developed the tenets of NOS to provide a framework for K-12 education on the characteristics of science. The tenets describe how science differs from other forms of knowledge. These include depending upon empirical evidence for knowledge claims and being subject to change as scientists gather more empirical evidence (McComas, 2008). The tenets of NOS are not meant to be prescriptive, but rather provide a guide for major ideas about science. The tenets may fall

under the following major ideas: there are similar ways of thinking and operating in scientific discourse, society influences scientific research which does not produce purely objective knowledge, and science cannot investigate all inquiries about the world (McComas, 2014).

The relationship between inquiry and NOS has been debated. Park (2008) describes how science educators view the relationship in two ways. First, the relationship is viewed as "NOS through scientific inquiry" which assumes that learners will gain an understanding of NOS by participating in scientific inquiry (p. 753). Second, the relationship is viewed as "scientific inquiry through NOS" in which an informed knowledge of NOS affords the learner to do scientific inquiry beyond the false myth of the scientific method (p. 755). However, this relationship is not always reciprocal, as teaching inquiry does not necessarily enhance knowledge of NOS (Schwartz et al., 2004). To distinguish inquiry and NOS, it has been suggested that inquiry represents actions that learners enact during a scientific investigation, whereas NOS represents the philosophical base for the assumptions while conducting scientific work (Lederman et al., 2013). More research remains to investigate the relationship between inquiry and NOS (Park, 2008).

Context

The research apprenticeship literature has either investigated inquiry, NOS, or both constructs together. The literature on high school students indicates varying degrees of understanding of inquiry and NOS.

First, there are studies reporting that the majority of students have naive views of inquiry and NOS. Bell et al. (2003) found that despite an eight week apprenticeship for high school students, most did not change their views of NOS, with the exception of one student recognizing that there can be competing theories to explain phenomena and three students recognizing that

science is not limited to a singular, scientific method. Similarly, Burgin and colleagues found that two to eight-week apprenticeships do not necessarily change the majority of high school students' misconceptions of a singular scientific method, the role of theories, and theories turning into laws. However, apprenticeship experiences may mediate minor changes in thinking for a few students to recognize that scientific knowledge is tentative, there are multiple methods of science depending upon the discipline, and the role of creativity in conducting science (Burgin, et al., 2015; Burgin & Sadler, 2013). However, even a yearlong apprenticeship may not be enough to change some misconceptions such as 'the' scientific method, subjectivity in scientists' preconceptions, and how theory development occurs (Aydeniz et al., 2011).

Second, there are studies reporting that students have mixed to informed views of inquiry and NOS. Charney et al. (2007) found that a four week apprenticeship can significantly improve high school students' view of NOS, such as recognizing the tentativeness of science when conducting research and negotiation of science among science communities. Similarly, Etkina et al. (2003) studied high school students' participation in a four-week summer program and x-ray research throughout the school year and found that students improved their understanding of NOS through problem-solving throughout the research process. Mixed to informed views of NOS may also depend on whether students received an explicit, reflective, or implicit approach to NOS in the apprenticeship; those with the explicit NOS approach had a better understanding of NOS such as recognizing the subjectivity and sociocultural elements of science (Burgin & Sadler, 2016). Furthermore, varying levels of involvement in collaboration, mentorship, a student's intellectual contribution to the research could influence understanding NOS (Burgin et al., 2012). Kapon (2016) studied high school students' perspectives on their collaboration on research and found that students valued their development and ownership during the inquiry

process. It has been suggested that more research is to analyze the relationship between programmatic aspects (e.g. collaboration, mentorship) and NOS as an outcome (Burgin et al., 2012).

Collectively, learning the culture of science including inquiry and NOS during a research apprenticeship promotes participation in authentic science (Sadler et al., 2010). To mediate these outcomes, an important feature of apprenticeships is mentorship with peers, laboratory technicians, and scientists who scaffold learning for novices (Barab & Hay, 2001). Although studies have included a general description of the structure of mentorship during a research apprenticeship, few studies have specifically focused on how the mentorship occurs for high school students (Kapon, 2016). Mentorship needs more research because previous studies have documented difficulties in learning science in an apprenticeship such as complex language used by scientists and lack of support to learn scientific practices; the use of reciprocal dialogue between students and scientists may address challenges in mentorship (Hsu & Espinosa, 2018). The next section outlines the role of mentorship in science education and previous research on mentorship in research apprenticeships.

Mentorship

Overview of Mentorship

Mentoring has been defined as "a one-to-one situation whereby knowledge and wisdom are imparted by the expert to the mentee. The protégé typically younger and less experienced, receives career support and psychosocial (e.g. emotional, cognitive) benefits" (Mullen, 2017, p. 35). In terms of career support, mentorship is important for helping novices learn the knowledge, values, and ethical practices as they participate in communities (Brown et al., 2009). In the psychosocial element, effective mentorship should promote positive encouragement and develop

trust between the mentor and mentee (Brown et al., 2009). Although mentoring is typically viewed between an expert and novice, this view has been expanded to include mentorship in groups, institutions, and organizations (Mullen, 2017). This expanded view of mentorship has created research debates about what constitutes mentoring or where it occurs, such as the distinction between mentors versus coaches, or mentoring in person compared to an online environment (Ehrich et al., 2002; Mullen, 2017). It has been suggested that more research is needed to understand the effectiveness of mentorship in particular contexts.

In education, mentorship has been used in a variety of contexts such as professional development for teachers (Leat et al., 2012), higher education, and K-12 educators mentoring students (O'Shea, 2014; Young & Harris, 2012), and students serving as peer mentors (Terrion, 2012). Depending on the context of the study, the aims vary from career development for professionals (Darwin & Palmer, 2009) to improving emotional well-being, behavior, and academic success of students (O'Shea, 2014). Positive outcomes for mentors can include personal satisfaction and growth, with mentees feeling encouraged and increased their self-esteem; negative outcomes include mismatch in advising, lack of support, time constraints (Ehrich et al., 2002). The outcomes will vary as mentoring is described as "inevitably changing, situated, and partial because of its contextual dependency" (Mullen, 2012, p. 8). As there are varied outcomes, it is important to review mentorship in the context of science education.

Mentorship in Science Education

Mentoring has been in applied in science education in formal and informal settings. The formal setting includes structured programs or classrooms for teachers and students. First, mentoring has been integrated in teacher preparation programs (Hudson, 2004) and professional development for in-service teachers (Oliver et al., 2009; Pegg et al., 2010; Wang et al., 2008).

Hudson (2004) suggested that mentoring should include specific, pedagogical aspects such as pedagogical content knowledge (PCK), modeling teaching practices, and providing feedback. Outcomes include improved PCK (Appleton, 2008), classroom practices, and teacher retention (Ingersoll & Strong, 2011). Second, teachers have used mentoring in their classrooms to assist students with inquiry-based projects (Symington & Tytler, 2011; Tal & Argaman, 2005). The mentorship can vary depending upon the experiences of the teacher; experienced teachers may support students' inquiry ideas more than less experienced teachers that are more authoritarian in their mentoring (Tal & Argaman, 2005). If inquiry is embedded over time, sustained mentoring can scaffold students into becoming more independent on inquiry projects (Symington & Tytler, 2011).

In the informal setting, mentorships in science education have been applied in enrichment programs such as summer camps or apprenticeships for teachers and students. First, scientists have worked with teachers in science laboratories to provide them with professional development to improve their knowledge and classroom practices (Pop et al., 2010; Westerlund et al., 2002). Second, scientists or older peers have mentored secondary students (Aydeniz et al., 2011; Monk et al., 2014; Sadler et al., 2010; Tenenbaum et al., 2014) or undergraduates (Linn et al., 2015) in authentic science projects. The outcomes of the study tend to focus on characterizing student's attitudes, career identity, content knowledge, NOS, or skills, with few that have focused on mentorship (Bennett et al., 2018; Sadler et al., 2010).

Mentorship in a research apprenticeships affords learners with authentic participation to gain entrance into the culture of science. Bleicher (1996) focused on a case study of a high school student's participation in a six-week apprenticeship and found that different mentors and their levels of expertise served as rich resources for learning. The student's interactions with the

mentors allowed him to learn the practices in the laboratory and conceptual ideas of the research (Bleicher, 1996). Similarly, other apprenticeship research with high school students show that students develop skills in laboratory practices and conceptual development by working collaboratively with peers and laboratory members (Richmond & Kurth, 1999; Ritchie & Rigano, 1996). For instance, Grindstaff and Richmond (2008) characterized the role of high school students' peer interaction during an apprenticeship and found varying degrees and different kinds of support from technical support, emotional support, and cognitive support in mediating learning. Recent research has also described the role of laboratory members (experts) in mediating learning for students (novices) through conversations and social modeling. Collaborations with more knowledgeable others contributed to student's content knowledge, feeling like they participated in authentic science, and inspired their career aspirations (Hsu et al., 2009; Hsu & Roth, 2010; Hsu et al., 2010).

There are a few studies that have described aspects of mentorship in research apprenticeships, particularly for high school students. High school students are an important population to study because those who participate in STEM programs including apprenticeships are more interested in pursuing science as a career than those who do not (Kitchen et al., 2018). Furthermore, high school students may lose interest in science due to lack of engaging experiences and competing interests (Aschbacher et al., 2010). If high school students participate in research apprenticeships, this can lead to positive outcomes such as career aspirations, increased content knowledge, understanding of NOS, and self-efficacy (Bennett et al., 2018; Sadler et al., 2010). The existing literature indicates several aspects of mentorship that may positively or negatively impact high school students' apprenticeship experience.

First, the mentorship relationship can vary with high school students being mentored by one or more experts including scientists, graduate students, or teachers working with scientists (Burgin et al., 2015; Kapon, 2016). The design of the mentorship appears to contextual and produce different outcomes. In a positive outcome, Bleicher (1996) described how three different graduate student mentors had developed individualized mentoring styles to contribute to one high school student's scientific discourse. In a mixed result, Burgin et al., (2015) described how two high school students in the same laboratory had two different mentors and outcomes. The high school student with a positive outcome had a mentor that valued her contribution, whereas the student with a negative outcome described her mentor as mean and felt that she was assigned menial tasks. Similarly, the level of support from high, medium, to low depends on the degree of mentor-mentee interactions (Burgin et al., 2012).

Second, another important aspect of mentorship is building a community. As mentor-mentee interactions shape the level of support, this can positively support students feeling that they are part of the research community. Richmond and Kurth (1999) reported that high school students enjoyed the relaxed, supportive environment through interactions with scientists in the laboratory and during meetings. Similarly, high students have reported that they felt trusted and played an important role in adding to their mentor's research (Burgin et al., 2015; Hsu & Roth, 2010). Students' belonging in the community might be related to two elements: 1) the independence that students develop over time as they learn their knowledge and skills (Ritchie & Rigano, 1996) and 2) the degree of agency in the design of the research. In most apprenticeship studies, students are working on the scientists' research agenda (Sadler et al., 2010). However, student agency in the research design varies with agency in the research design to no agency by following routine laboratory procedures (Burgin et al., 2012). To date, Kapon (2016) is the only

study in which students had agency in choosing their research topic in physics, conducting the research at school. Benefits included student ownership and collaboration with their advisors. However, agency in projects also posed challenges for both students and advisors in having the knowledge and resources to implement the study. Student agency in the conception of the research is necessary, as it has been suggested that "if participants' experiences do not evolve to include a wider range of epistemically demanding practices such as data analysis, hypothesizing and developing research questions, then learning gains on higher order outcomes will likely be limited" (Sadler et al., 2010, p. 253). This suggests there is a need for research apprenticeships that allow students to develop agency in the research process.

More research is needed on the direct role of mentorships in science education apprenticeships. Mentorship is important because it allows more experienced others to socialize novices into the science profession (Resnik, 2012). An important aspect of mentoring is that "supervisors play a unique and critical role in conveying to trainees professional standards and ethical values" (Bird, 2001, p. 461). These ethical values can range from conducting ethical research as it pertains to protecting participants, minimizing conflicts of interest, appropriate data management, and data reporting (Horner & Minifie, 2011). However, ethical issues can occur during mentorship including mentors abusing their power, blurred lines between professional and personal lives, and difficulties that arise when making decisions that impact both parties (Warren, 2005). This suggests that many ethical aspects of mentorship should be taken into consideration when teaching about ethics of the profession and enacting ethics in the mentor-mentee relationship (Barker, 2006; Resnik, 2012). The next section outlines ethical frameworks for thinking and operating in which have implications for mentoring.

Ethics

Normative Ethics

Historically, ethical decision-making by individuals has been guided by normative ethics, which strives to describe principles as the basis for moral judgements. Two common frameworks of normative ethics include consequential ethics and non-consequential ethics (Gensler, 2011). Consequentialist theories of ethics are based upon analyzing the consequences of each course of action to determine the "principle of benefit maximization" (Strike & Soltis, 2009, p. 11). In the 18th and 19th century, Jeremy Bentham and John Stuart Mills contributed to the idea of utilitarianism, in which a moral decision is made on the basis of maximizing the good and minimizing pain as much as possible. This occurs by using rules to guide one's actions, but rules are subject to exceptions if breaking the rules can lead to a better outcome to maximize the good (Gensler, 2011). Forms of utilitarianism range from egoism, in which individuals maximize the benefit for selves to ethical universalism to enhance the benefit for everyone (Frankena 1973; Gensler, 2011).

In contrast to consequential ethics, non-consequential ethics rejects moral decisions on the basis of consequences. It posits that some actions are inherently wrong, even it if maximizes the benefit (Gensler, 2011). In the 18th century, Immanuel Kant described the categorical imperatives, which represent the principles that individuals should follow on a universal basis and be judged by the intentions of the actions (Cahn, 2009). People should be treated as ends and emphasize "equal respect for persons" (Strike & Soltis, 2009, p. 15). In the 20th century, William Ross described prima facie duties which are actions that humans are obligated to do. Examples include keeping promises, but prima facie duties are subject to exceptions when there are more

pressing duties (Gensler, 2011). Other characteristics of non-consequential ethics may include the ideas of beneficence and developing virtues such as wisdom and justice (Gensler, 2011).

Moral Development

Normative Ethics

Normative ethics is one framework to apply principles moral reasoning in situations (Strike & Soltis, 2009). To conceptualize moral reasoning, Jean Piaget defined moral values as "a system of rules, and the essence of all morality is to be sought for in the respect which the individual acquires for these rules" (Piaget, 1948, p. 1). Building upon Piagetian ideas for moral development, Lawrence Kohlberg (1958) studied boys to analyze their stages in moral reasoning and characterized several levels of moral development. At the preconventional level, an individual makes decisions from personal motives and determines what is deemed acceptable to avoid punishment. During the conventional level, individuals align their actions with socially accepted behaviors that promote order. In the postconventional level, individuals make decisions that promote universal good to society and develop their own ethical worldview (Kohlberg, 1971). A major idea is that moral development will be influenced by one's social participation with society (Kohlberg & Hersh, 1977). In social interactions, individuals learn what is deemed acceptable or not acceptable to the norm, which may be contrary to their own values and create disequilibrium. From a developmental perspective, such interactions can result in the individual assimilating to the norm or challenge their moral thinking to consider alternative perspectives (Thomas, 1992).

Emergence of Caring Ethics

As Kohlberg and colleagues continued to study moral reasoning in boys, this began to influence other studies and create negative perceptions of females. For instance, Bar-Yam,

Kohlberg, & Naame (1980) reported that moral reasoning was higher in Muslim boys than girls, stating that the girls "showed little interest or concern about social issues" (p. 358) that were discussed in the classroom compared to boys. Carol Gilligan (1977) challenged Kohlberg's model, suggesting that his studies showed a bias towards males and that moral development from a female's perspective is different compared to males. She argued that instead of relying on universal rules and abstract reasoning to make moral decisions, females may make decisions on the contextual basis of caring relationships. She analyzed pregnant females' moral reasoning on abortion and continuing the pregnancy. From this, Gilligan used Kohlberg's frame of preconventional to postconventional levels, but defines each level quite differently from the caring perspective: 1) Preconventional level, in which individuals focus on making decisions around themselves for survival. 2) Conventional stage in which individuals consider the impact of their decisions on others as self-sacrificing (e.g. how an abortion impacts spouses and family members). 3) Postconventional stage in which individuals reconcile decisions to respect themselves and others (Gilligan, 1977). Gilligan's perspective of care ethics suggests that decision-making is complex and contextual to each situation.

Additional critiques to moral reasoning with normative ethics is the assumption that principles can be broadly applied across multiple contexts (Noddings, 2016). Normative ethics does not account for individual contexts which can make a universal principle difficult to apply in certain situations (Cahn, 2009). Related to this, the second critique is that it assumes humans make decisions as rational beings that are objective in their moral judgements (Gensler, 2011). Third, consequential and non-consequential ethics place hierarchy on which principles are more important than others (Noddings, 2013). Lastly, reasoning often occurs on abstract situations without enough information (Strike & Soltis, 2009), and being unable to anticipate the long-term

consequences of decisions (Gensler, 2011). Collectively, these critiques stem from the nature of normative ethics being focused on principles to determine moral judgements (Cahn, 2009).

Theoretical Framework with Noddings' Caring Ethics

In *Caring: A Feminine Approach to Ethics and Moral Education*, Nel Noddings (1984) offers an alternative approach to patriarchal, ethical frameworks by situating caring at the center of human decisions. First, instead of reasoning from abstract situations, Noddings describes moving from "abstraction to concretization" (Noddings, 2013, p. 36), by focusing on the individualized context of caring relations (Noddings, 2013). Second, instead of assuming that humans are objective beings, Noddings recognizes that humans are individuals with unique talents and capabilities (Noddings, 2005a). Furthermore, individuals are also shaped by societal views on gender, race, and socioeconomic status (Cahn, 2009), implying that people do not analyze and reason with the same perspectives. Third, Noddings is against the idea of hierarchy and prescribed principles as this fails to promote caring relationships (Noddings, 2003, 2005a). Lastly, as normative ethics is often reasoned without enough information, more information can be gathered about an individual's needs when entering a caring relationship. For instance, Noddings describes the importance of dialogue in moral education, stating, "Thus dialogue serves not only to inform the decision under consideration; it also contributes to the habit of mind-that of seeking adequate information on which to make decisions" (Noddings, 2005a, p. 23). Noddings' caring ethics differs from traditional ethics by focusing on concrete, situational, caring relationships instead of abstract reasoning on a universal basis. To further understand caring ethics, it is necessary to explore Noddings ideas.

Relational Approach

In characterizing caring ethics, Noddings describes caring as a reciprocal relationship between the "one-caring" and the "cared-for" (Noddings, 2013, p. 4). She makes the distinction of natural caring from ethical caring, in which the latter describes how the one-caring understands and responds to the cared-for's individual needs. Characteristics of the caring relationship include motivational displacement, engrossment, and reciprocity. In ethical caring, the one-caring uses motivational displacement by "stepping out of one's own personal frame of reference into the other's" (Noddings, 2013, p. 24) to care for an individual's needs. In engrossment, this allows the one-caring to recognize the cared-for's expressed and inferred needs. Expressed needs tend to be expressed from the cared-for, whereas inferred needs derive from the perspective of the one-caring (Noddings, 2002). Reciprocity is received by the one-caring who contributes to enhancing the ethical self (Noddings, 2013). In the caring relationship, both the one-caring and the cared-for should critically evaluate the "effect of actions on caring relations" instead of the dichotomy of right and wrong (Noddings, 2002, p. 241), to help guide decisions and maintain caring.

To facilitate care ethics in all realms of encounter and response, Noddings proposes that a moral education to enhance caring consists of modeling, dialogue, practice, and confirmation (Noddings, 2013). First, modeling demonstrates how to care for others (Noddings, 2016). Second, practice engages in caring for others at many scales from caring at home to society (Noddings, 2002, 2016). Dialogue allows individuals to critically engage with each other's views and improve caring relationships with feedback (Noddings, 2016). Lastly, confirmation consists of encouraging the best in each other. Applying a moral education with these four approaches allows people to develop their ethical ideal (Noddings, 2013).

Scholars have critiqued caring ethics for several reasons. First, it was implied that care ethics is open to multiple interpretations and may focus too much on emotional response without attention to moral principles (Crigger, 1997). Second, the "feminine" approach as suggested by the title of Noddings' book and examples of a mother relationship that she draws upon is too restrictive to account for all caring relations (Hoagland, 1990). Third, the unequal status in 'caring' relationships could reinforce negative relationships including abuse and oppression (Card, 1990; Houston, 1990). Lastly, reciprocity in caring relationships may exclude those such as strangers who need help (Hoagland, 1990). Noddings (1990) offers her rebuttal on their misunderstanding of care ethics; caring is not meant to ignore moral reasoning, leaving abusive relationships are necessary for safety, and caring for those in distant relationships including strangers is needed. However, Noddings does acknowledge that the language to describe caring was vague and needed revision (Noddings, 1990). To address caring in a more inclusive approach, Noddings updated her original book by changing the title from *Caring: A Feminine Approach to Ethics and Moral Education* (Noddings, 1984) to *Caring: A Relational Approach to Ethics and Moral Education* (Noddings, 2013).

Conceptions of Care

The conceptualization of care in the literature is complex with multiple interpretations (Pettersen, 2012). In the philosophical sense, care can be interpreted as a virtue that an individual develops to act morally (Allmark, 1998; Stockdale & Warelow, 2000). In the everyday interpretation, care is perceived as a feeling or emotion (Rabin & Smith, 2013). Care is also perceived as a practice or behavior that is enacted and characteristic of an individual (Held, 2006). In addition, care can take on the forms of caring about, for, offering care, and receiving care (Held, 2006). The enactment of care can be done for altruistic or selfish reasons (Petterson,

2012) To address the ambiguity of caring, Noddings makes a distinction between natural caring and ethical caring, in which the latter consists of building a relational approach with individuals to society by using components of a moral education, pushing back against notions of caring as a characteristic, virtue, and principles to follow (Noddings, 2008, 2013).

Scholars have criticized the original definition of care ethics as not being situated in historical and cultural contexts beyond "White feminist notions of caring" (Antrop-González & De Jesús, 2006, p. 411). In particular, descriptions of caring were assumed to be framed from White experiences and demonstrated colorblindness to other experiences of care ethics (Thompson, 1998). In the context of education, another critique of care ethics was the idea of institutional caring for the sake of meeting educational policies in contrast to genuine, caring relationships (Wilder, 1999). To expand upon the definition of care ethics, researchers have termed critical caring, often explored in the context of education to be more inclusive for marginalized populations and various cultures (Pimentel, 2011). A more inclusive view of care ethics is needed as caring differs in specific, cultural contexts (Kang, 2006).

Studying Care

There are both quantitative and qualitative methods for studying care (Velasquez et al., 2013). For quantitative methods, care ethics has been measured with survey instruments. First, Skoe developed an Ethics of Care Instrument (ECI) using Gilligan's framework for moral development to measure moral reasoning on a scale from only considering self to considering both self and others (Skoe, 2014). The ECI instrument has been used to compare moral reasoning across different populations. For instance, a comparison of Canadian and Norwegian youth showed that females reasoned higher on the scale than boys and were more aligned with relational approach to ethics, whereas boys aligned with a non-relational approach (Skoe et al.

1999). Another study compared young adults from Norwegian and Brazilian using the ECI instrument and found that Norwegians scored higher; this could be due to cultural differences in the value of individualism in Norwegians compared to collectivism in the Brazilian culture (Vikan et al., 2005). Second, another care instrument based on Noddings' framework is the Caring Action and Responses within Encounter Survey (CARES) to measure how students respond to encounters with patients. For instance, Brubacker (2005) designed and tested the CARES on US nursing students to measure their caring during interactions with patients which demonstrated the enactment of caring; furthermore, self-reports were mostly consistent with their instructor's scoring (Brubacker, 2005).

Qualitative studies on care have varied in the data collection methods. First, care has been studied with questionnaires or qualitative surveys. For instance, Nowak-Fabrykowski (2010) analyzed teacher's use of care in the classroom by asking four open-ended questions on a questionnaire, revealing that teachers implemented care through the curriculum and their interactions with students. Similarly, McBee (2007) characterized a mix of preservice teachers, teachers, and faculty perspectives on care with an open-ended survey and categorized major characteristics of care identified by participants, which included helping students and building relationships with them. Second, care has been studied through reflective journals (Goldstein & Lake, 2003). For example, Lake et al. (2004) studied preservice teachers' implementation of care ethics in teaching and responded to electronic journal prompts; the findings showed that preservice teachers improved on caring practices, although they did not fully recognize how to integrate all aspects of care. Third, interviews have been used to study caring ethics with teachers. For instance, Rogers and Webb (1991) conducted observations and interviews with teachers and found that teachers demonstrated care through dialogue and connection with

students. Lastly, there are studies that use a combination of data collection methods described above to triangulate the findings. For instance, Kim and Schallert (2011) studied a professor's interactions with preservice teachers in the class and on an online platform, with data collected from multiple sources (audiotapes of class, field notes, interviews, observations, online platform, researcher's reflexive journal). The findings revealed that the professor developed different caring relationships with students which depended upon building trust (Kim & Schallert, 2011). Collectively, these qualitative data collection methods have been largely applied to studying care ethics in educational contexts.

Caring Ethics in Education

One area of research focuses on the theoretical and practical considerations of caring ethics in nursing and medical education. From the theoretical perspectives of caring in nursing education, scholars have critiqued that the definition of care ethics has multiple interpretations and does not account for times that universal principles are needed for ethical decision making, such as care at the institutional level (Allmark, 1995; Kuhse, 1995). To balance caring ethics with normative ethics and principles of justice, scholars have suggested merging the two (Botes, 2000; Paley, 2002). From a practical perspective, researchers have studied how nursing students reason in ethical situations. For instance, Peter and Gallop (1994) compared how nursing and medical students responded to two dilemmas and found that females scored higher on caring than males. Others have also used caring ethics as a guide for nurses to make decisions that promote the well-being of patients and inclusion of caring practices in medical education (Branch, 2000a, b). An example of such inclusion is a simulation laboratory that integrates care-ethics and empathy to help students practice providing care for patients (Vanlaere et al., 2010).

A second area of research has characterized teachers' implementation or interpretation of caring in K-12 classroom setting. In a case study of one elementary teacher's interactions with children found that caring was demonstrated by helping students reach their academic and social growth through her instruction; it was suggested that caring should shift beyond feelings of caring towards actions that demonstrate caring for students moral growth (Goldstein, 1998). In another study on preservice teachers' conception of caring, preservice teachers held a simplified view of caring as a natural emotion, rather than the complexity of practicing care in the classroom (Goldstein & Lake, 2000). Initial conceptions of caring could be improved, as preservice teachers' field experiences helped them recognize the difficulties in caring for students, such as balancing between their authority as educators and helping students feel cared for (Goldstein & Lake, 2003). However, in the implementation of care ethics, studies have documented the difficulties in balancing care ethics with classroom management (McLaughlin, 1991; Weinstein 1998), how caring dispositions and behaviors could be perceived differently based on gender (Vogt, 2002), and conflicts between personal care and following institutional guidelines (Colnerud, 1997).

As mentioned earlier that critical caring ethics emerged to include diverse populations, a third area of research has focused on critical caring in urban school environments with culturally and linguistically diverse students. It has been suggested that an extension of critical caring with Noddings' framework for a moral education can facilitate culturally relevant teaching practices (Shevalier & McKensize, 2012). Parsons (2005) studied the enactment of caring, particularly in a diverse elementary school with a white teacher with black students; the findings demonstrated that the teacher provided a safe learning environment for students to have a voice and confirm care for each other. The author suggested that caring in the classroom should consist of culturally

relevant caring to make learning equitable for all students (Parsons, 2005). This may include creating classroom curriculum that is relevant to students' diverse identities (Antrop-González & De Jesús, 2006). Similarly, students at a diverse middle school described their teachers as caring if they interacted with them, talked to their parents, and encouraged them to achieve their best (Alder, 2002). Likewise, a case study of a high school teacher educating refugee students enacted caring in the classroom by being patient with students, modeling caring behaviors, using appropriate pedagogical support for ELLs, and confirmed caring to build their confidence (Hos, 2016). Although these studies demonstrate positive outcomes, a case study revealed that it can be challenging and discouraging for a teacher to enact care for diverse students when other teachers in the school were against the implementation of a bilingual program, demonstrating the difficulties in enacting care (Pimentel, 2011).

In summary, caring ethics has been studied with quantitative and qualitative measures. Qualitative approaches have been mainly used to study care ethics in the context of education with student-teacher relationships, teacher conceptions of care, and the expansion of critical caring. Although these studies have shed light on caring ethics in education, the settings of these studies were situated in the formal classroom setting. Learning can take place outside of the classroom in informal learning environments such as aquariums, the outdoors, laboratories, museums, and zoos (Braund & Reiss, 2006; Falk & Dierking, 2010). Despite the value of informal learning environments contributing to life-long learning (Falk & Dierking, 2010), there are a few studies that have studied caring ethics in informal learning environments such as the outdoors (Nazir, 2014; Schindel & Tolbert, 2017).

Caring Ethics and the Environmental Education (EE)

In a brief history of the environmental movement in the United States, publications in the 1960s such as *Silent Spring* and *The Quiet Crisis* that highlighted environmental issues (Carter & Simmons, 2010). During this time, the *International Union for the Protection of Nature* (IUCN) advocated for the conservation of nature (Palmer, 2002). New laws such as the Clean Air Act of 1965 came into effect to protect the environment. In 1970, the Environmental Education Act promoted Environmental Education (EE) curriculum development and funding in schools (Carter & Simmons, 2010). Later in the 1990s, EE was implemented in education standards (Carter & Simmons, 2010). The conception of EE began to include ideas of sustainability to resolve environmental issues (Tillbury, 1995), although there is current debate about the inclusion of sustainability as a result of globalization (Jickling & Wals, 2008).

EE has no singular definition as it has drawn upon several disciplines including "biology, geography, chemistry, geology, physics, economics, sociology, natural resources management, law and politics" (Raven et al., 2008, p. 7). To understand EE, the Environmental Protection Agency (EPA) states that EE is "a process that allows individuals to explore environmental issues, engage in problem solving, and take action to improve the environment" (Environmental Protection Agency [EPA], 2019). The use of EE is open to broad interpretation such as viewing it as curriculum and instruction to a means for creating social justice. The aims and outcomes of EE include scientific literacy and enhancing environmental awareness (Carter & Simmons, 2010; Hart, 2015; Hodson, 2003). For instance, educators have held various perspectives on the purpose of EE such as fundamental coexistence which means promoting sustainable behaviors, fostering moral stewardship to preserve nature, or using skilled community activism to address local environmental issues (Fraser et al., 2015).

Although the perspectives of EE vary, the basis for EE is to promote environmental action (Stevenson, 2007). To promote stewardship, several authors have suggested the use of care ethics as a framework (Fien, 2003; Martin, 2007). Whyte and Cuomo (2016) state that "ethical paradigms centered around caring are able to acknowledge the significance of caring for all kinds of others, as well as the complex value of ecological interdependencies, and the limitations of worldviews that deny reliance on nature" (p. 235). The value of care ethics for EE is using place-based education to build connections with the local environment, attending to children's social-emotional development, and fostering positive attitudes and relationships with all forms of life for the environment (Venter & Ferreira, 2014). It has also been suggested that using Nodding's elements of modeling, dialogue, practice, and confirmation can support the implementation of care in citizen science projects and development towards ecojustice (Lyons et al., 2017).

Noddings discussed the importance of connecting with nature and place to facilitate ethical treatment towards plants, animals, responsibility to preserving the environment, promotion of happiness, and global citizenship (Noddings, 2003, 2005a,b). For instance, she states that "students should be involved in direct, hands-on environmental projects...just as they should contribute to the care of the young, aged, and disabled, so they should contribute to cleaning up streams, planting trees, and maintaining gardens in parks and school yards" (Noddings, 2005a, p. 136). In caring for other humans, the ethical caring should also translate in caring for non-humans. Noddings contends that building a curriculum of care with the environment fosters relationships with other humans and nature, facilitates student interest in learning about the environment, and engages students in intellectual discussions on

environmental issues (Noddings, 2005a). The role of care ethics in fostering environmental responsibility through interactive, outdoor learning has implications for science education.

To date, there has been very few EE studies that have been specifically framed with Nodding's caring ethics. For instance, Nazir (2014) analyzed how educators at an outdoor school exemplified Noddings caring ethics in their teaching. The teachers used dialogue to talk about caring for the environment, modeled positive behaviors towards organisms in the environment, students had opportunities to practice care with nature, and confirming care in each other through encouragement (Nazir, 2014). Similarly, Schindel and Tolbert (2017) characterized one high school teacher's caring actions and found that he fostered caring relationships with his students and engaged them in environmental restoration of a local park for the greater benefit to the community. In addition to caring actions of the teachers, care is also enacted by the students. Quigley and Lyons (2017) conceptualized care ethics in EE, specifically in the context of science education to describe how their students were engaged in "care-based scientific work" (p. 256). In this study, students were concerned about the spread of dengue fever through the Aedes mosquito. To address this problem, students researched high-risk areas for their development and created solutions on their campus. The authors suggested that care ethics can support learning science content, scientific practices, and more importantly, active citizenship (Quigley & Lyons, 2017). The same authors also conducted a literature review and proposed the integration care ethics in citizen science projects to foster "care-based citizen science" (p. 201), which remains to be investigated with the explicit integration of care ethics (Lyons et al., 2017).

In summary, this literature review discussed the role of apprenticeships in providing authentic contexts for students to learn science. To further aid student participation in science, mentoring through care ethics offers an approach for professionalization into the field. Within

care ethics, most studies have focused on caring attributes in teacher-student relationships in the classrooms with little research on care ethics in scientific work with students, particularly in environmental education. This study aims to address the research gaps by using care ethics in a science research apprenticeship with environmental education.

CHAPTER THREE: RESEARCH METHODOLOGY

Mentor-Mentee Positionality

Milner (2007) describes the importance of positionality because the "researcher's multiple and varied positions, roles, and identities are intricately and inextricably embedded in the process and outcomes of the educational research" (p. 389). My positionality is crucial to this study because I am positioned as both the scientist mentoring students and the educational researcher collecting data with students. As this can create ethical conflicts, I seek to dissect my own experiences with elements of currere. Pinar (1975) describes currere as a process of reflecting on one's lived experience by connecting the past, present, and future in the larger context of society. Although I do not use all stages of currere, I dissect my own experiences which shape my views and multiple identities as a scientist, mentor, science educator, and educational researcher.

I am an Asian American, female scientist who struggled in my science journey. Growing up, I did not care about learning science. If you had told me that I would become a scientist one day, I would not have believed it. Other than my first-grade teacher providing hands-on science with caterpillars, most of my K-12 learning occurred by transmission in a science textbook and I did not perform well on tests. I attended public schools with most of the students on free or reduced lunch. Therefore, our school did not have the resources for inquiry-based laboratory science. This also meant that I had some teachers who did not care to teach science, who sat in front of the classroom doing nothing (even sleeping) while we read our textbooks. Most of the science I experienced was reading scientific texts to learn factual information and regurgitate the information on an exam. In high school, my inclination towards science slightly changed when I was exposed to watching the portrayal of science on television through *Forensic Files*.

Enamored by the glamorous science of getting the perfect DNA sample, quick analysis, and prosecuting the perpetrator, I thought this was how science worked. This led to my interest to major in Forensic Chemistry at Loyola University New Orleans. Over the course of my first semester, my excitement quickly turned into worry as I was not prepared for any of the content, did not know how to study, and earned poor grades. Through some trial and error, I switched majors to Criminal Justice and settled on Biology during my second year.

My first biology laboratory was Cells and Heredity with Ms. Terry* (pseudonym). She was a tough grader and I was very intimidated by her and my classmates. Most of them had attended prestigious, private high schools in New Orleans while I came from a public high school that did not prepare me for college. I also noticed that most of my classmates were White. I cannot remember if I was the only Asian or other minorities, but we were definitely outnumbered. I recall one class in which we were learning how to use the microscope. Everyone else was able to get their specimen in focus quickly while this was my first exposure to ever using a microscope. I felt embarrassed that I had to raise my hand frequently and ask my teaching assistant for help. I realized that I needed to work extra hard to succeed in the class. I remember writing my first laboratory report and on the day that Ms. Terry was returning our reports, she said with disappointment to the class that the highest grade was 87. I thought I probably failed but when she gave us our papers, I was very excited to see that was my grade. However, my classmates were clearly not happy with their grades. While this helped me gain slight confidence, I got the sense that my classmates were beginning to make assumptions about me over the course of the semester, e.g. I was smart because of the false notion that “All Asians are good at math and science.” As my career progressed through graduate school, I noticed that I was the only Asian American female studying ecology in my program. Likewise, when I

participated in enrichment activities, I often remained as the only or one of very few Asian American females in ecology. There were times I felt insecure because I did not know if I deserved to be there. I also questioned if people held higher expectations of me because I was an Asian American who was supposed to be "smarter." I also wondered if I was given certain opportunities to simply fill a diversity checkbox for a program or institution. Despite these feelings of insecurity, I had supportive mentors who eased my participation and inclusion in science.

Mentee Experiences

Over the course of my undergraduate and graduate career as a mentee, I had supportive research mentors. My first supportive mentor was Dr. Synura* (pseudonym), my undergraduate research advisor. I recall that one night I watched a *Forensic Files* episode about how diatoms, a type of microscopic algae, were used to solve a criminal investigation. At the time, I did not know anything about diatoms but learned that Dr. Synura was a faculty member in the biology department who specialized in algae. I approached him via email and then we met in person. He took time from his schedule to have with one-on-one discussions with me about diatoms. Over time, this led to working in his laboratory and working on my research interest with diatoms and forensics. Throughout the research process, Dr. Synura gave me the freedom to test ideas, figure out the experimental design, and support when I needed help. He exposed me to the world of academia by encouraging me to apply for grants and present the research at conferences. During my senior year, I did not know what I going to do after graduation. Dr. Synura asked, "Have you considered graduate school?" I honestly did not even know what graduate school was, but he told me about it and encouraged me to apply. His encouragement led to my current path. My second supportive mentor was Dr. Actinella* (pseudonym), my master's advisor. Like Dr. Synura, she

encouraged me to apply for grants and present at conferences. More importantly, she listened to me in my most vulnerable moments when I was stressed, crying, and feeling like an imposter. Collectively, both mentors taught me the importance of supporting students' interests, encouraging students to pursue opportunities that could positively influence career growth, being available to help, and attending to their emotional well-being in the moment. Beyond personal growth, both advisors also exposed me to the professional realities of science. When I learned how to conduct scientific research in the laboratory and the field, I learned that science means you need funding, experimental design takes trial and error, data are messy, and there is always some degree of uncertainty in science. Scientists publish research that is debated among scientific communities and sometimes the rebuttals can get heated. This made me realize that science is not as perfect as I once thought, and science cannot have all the answers to our questions.

My experience with unsupportive mentorship negatively impacted my mental health. I prefer not to mention certain details to protect myself and this individual. However, it would be disingenuous if I did not share this experience because it shaped my views on how I do not want to be as a mentor. The mentor did not have realistic expectations for when tasks should have been completed. Tasks were dropped on me last minute without consideration of my schedule and I was expected to complete them with a quick turn-around. Throughout our experience, there was a lack of scaffolded guidance, feedback, preparation, and questionable, ethical practices. In retrospect, I also realize that I should have taken more responsibility to be more assertive and stand up for myself. Perhaps this could have made the professor aware of how I was feeling. This could have potentially created mutual understanding and minimize the distress that I have caused to this professor and myself. I have learned the following lessons from this experience: 1) In

working with students, ensure we are on the same page and understand what goal(s) students want to achieve and do not impose my interests. 2) Check with students on a frequent basis to ensure that their research timeline is tailored to their schedule and that they are not feeling overwhelmed. 3) Provide constructive feedback and be prepared to discuss the next steps to help them move forward productively. 4) Model positive, ethical practices and be honest about it. Essentially, it is important to be a present mentor such that students are not feeling lost without guidance and support.

Mentoring Experiences

Drawing upon my own experiences as a mentee, I began to mentor students in science. My first professional experience mentoring a student on scientific research occurred in the spring of 2016 when I worked with an undergraduate student named Derek* (pseudonym). My advisor asked me to mentor him on a small diatom project. Derek and I decided to meet once a week in the laboratory. During our sessions, I began providing Derek with practice on how to identify diatoms to genus level. When I felt he was ready to progress, we processed samples together, counted diatoms under the microscope, and analyzed the data. In moments of doing laboratory activities, we listened to 70's and 80's rock music. While Derek enjoyed the classics, he introduced me to Indie Rock music, which I now enjoy. Our experience ended with a poster that he presented at the Midwest Ecology and Evolution Conference (CEEC) hosted on campus. In working with Derek, I learned the importance of modeling learning for students and getting to know them personally, including their cultural contributions. If I were to improve this experience, I think I should have provided Derek with more opportunities to vocalize what he specifically wanted to learn out of the research experience and ask him about his perspectives throughout the research process.

In my second professional experience in mentoring was different because I was in a supervisory role overseeing a teaching assistant. However, I wanted to reduce the power dynamic as much as possible by being an approachable mentor. My experience with Laney* (pseudonym) challenged my own ignorance and assumptions. Laney was an assistant to my colleague and me for a class she had previously completed. I assumed that since she had taken the class, I did not need to review certain aspects of the class material and laboratory tasks. I gave her a structured timeline for projected tasks to be completed each day. In the past, students had completed these tasks without expressing any issues. However, by the end of the first day, Laney was in tears. I was terrified and constantly questioned myself on what I failed to do. I spoke with Laney and she stated that the expectations were too much. It was at that moment, I became the mentor that I feared of becoming and was disappointed in myself. The next day, I sat down with Laney and I disregarded the timeline. I also reduced our course needs and asked her what project she wanted to work on. Each day, it was a balance of first modeling the tasks with her, and then the second half of the time, she was working independently on the tasks. Laney also had time to work on her research project of interest. I could see that she was much happier with the changes. On the last day of class, she admitted to me that she had a particular disorder and has being stigmatized by it. I appreciated that she had the courage to share that with me. From this experience, I learned that upfront, experiences need to be tailored to the individual's needs, capabilities, and interests. I have to acknowledge that I may have a hard time grappling with less structure. However, instead of imposing a structured timeline without feedback, students deserve agency in articulating their individual needs, critiquing suggestions that I may have, and discuss any challenges that they anticipate. I acknowledge that I might struggle finding

a balance between students' and my own desires for learning. I hope to address this by continually challenging my own assumptions and try to understand student perspectives.

In my third experience, I mentored a high school student named Emily* (pseudonym) on diatoms from October 2017-March 2019. We worked together on the diatom-turtle project in collaboration with her high school teacher Mr. Chelydra* (pseudonym). Over time, as Emily developed the knowledge and skills to do research more independently, she took ownership in her project comparing the environmental implications of fossil and modern diatoms. Our experience working together was one of pure enjoyment, but became my pilot for my dissertation. Although I originally did not anticipate this becoming my research topic, I wanted to collect data in an exploratory approach to understand what Emily was learning from this research experience. I began working one-on-one with Emily in October 2017. I wrote the IRB in November 2017 and obtained approval by January 2018. From January to August, a colleague and I conducted a total of eight interviews with Emily at random times without that surrounded prior and after major events such as conferences. However, I did not plan well so I often did not notify Emily in advance on when I wanted to interview her. I randomly asked in the beginning of one our meetings and she consented. I also started a research group with my colleagues to dissect what Emily had learned. We coded the interviews together and found interesting results, which led us to start a manuscript. It was not until March 2019 that I shared the manuscript with Emily and included her voice in the paper. I was unsure of how to include Emily in the research process and felt that I should have included her more in the educational research process. As a researcher, I felt that I failed to enact caring ethics in the research process of asking Emily how she felt about the data collection as we progressed and I should have been more transparent.

Paradigm

Although my science identity still thinks much like a positivist, my paradigmatic views began to shift when I started my Ph.D. in Science Education. I remember that my first semester, I was present at a dissertation defense that used a qualitative case study with four participants. With my strictly positivist lens at the time, I was very judgmental and skeptical. I did not understand the point of doing qualitative research if there was no generalizability. I refused to be open-minded about qualitative research at the time. However, my science education courses exposed me to social constructivism as a theory and practice for promoting authentic learning. Furthermore, during my second semester, I enrolled in Qualitative Inquiry to fulfill my research course requirements. Throughout the semester, we read *Thinking with Theory in Qualitative Research* by Jackson and Mazzei (2011). The book really challenged my thinking in terms of analyzing the same data through various theories and lenses which yielded very different interpretations. I began to realize that perhaps there is not a singular truth to explain the world. I reflected on my own identity as a scientist who operated in the positivist paradigm. Although scientists try to portray objective knowledge, I realized that as scientists in the diatom field, we have operated in our own ecological theories to which we ascribed. My thinking on paradigms was expanded upon my third year when I took a class on Nature of Science (NOS) which represents the characteristics of the scientific enterprise. The entire semester, we discussed and debated what constituted science and what did not. That demarcation has inherently left out non-westernized views of science and plays a role in how science is portrayed as purely objective knowledge without valuing other cultural knowledge. This has been problematic for our education system because it portrays science as neutral, acultural, and boring. Furthermore, the assertion of the science ideology as one truth value eliminates multiple truths that may exist

about the world. The dense, scientific information in my textbooks made science inaccessible and disinteresting, which is why I hated science in my K-12 schooling.

Currently, I have to acknowledge that as a scientist and science educator, I have moments when I still struggle with rationalizing between my positivist and constructivist views. In the role of science educator and researcher, I am taking the position within the constructivist paradigm. The constructivist paradigm makes several assumptions. Ontologically, constructivism views that many realities are contextual and relative. Epistemologically, constructivism views that knowledge is subjective and is either individually or socially constructed. In line with this, the methodology uses qualitative research to investigate context-specific factors that interact with the construction of multiple realities (Lincoln et al., 2013). These assumptions are mostly, philosophically compatible with Noddings' ideas that our realities are situated in our relations with each and other and with other caring encounters that shape our perspectives (Noddings, 2002, 2013).

One critique Noddings (2005a) poses against constructivism and science is the idea of indoctrinating students in habitual practices. She states that caring can be difficult when:

> Teacher education and educational research inculcate certain theories and modes of practice as scientifically approved ways of things. In the past few decades, for example, an idea called "constructivism" (which for the most part, I endorse, has been influential in teaching). I have listened to teachers insist that they would *never* use drill and practice methods in their classrooms because children "learn best" when they "construct" their own knowledge, and drill is clearly proscribed by constructivism… Routinization cannot possibly facilitate deeper investigation. (p. xix)

Science is a discipline that has aspects of routinization. However, there is a misunderstanding that there is only one way to *think* and *do* science. As there may appear to be conflicts between Noddings, science education, and mentoring, I discuss the interaction between ideas to mediate understanding and my position for this research.

Interactions of Noddings with Science Education and Mentoring

Noddings' vision for an ideal education poses several contradictions for science education and mentoring. First, due to education reform movements following the launch of Sputnik, this has led to the continual development of rigorous science standards. The Next Generation Science Standards (NGSS) outlines the K-12 science standards across the US, with the rationale that "many recent calls for improvements in K-12 science education have focused on the need for science and engineering professionals to keep the United States competitive in the international arena" (NRC, 2012, p. 7). This statement reaffirms Noddings critique of economic success that socializes school children to place more value on topics such as science that are associated with economically successful occupations and devalues other subjects (Noddings, 2005a). Second, NGSS outlines the specific scientific ideas that students should know in science. This standardized curriculum leaves out opportunities to discuss science topics that may be of interest to students. Third, NGSS outlines scientific practices that students should know to investigate scientific knowledge, which tend to be prescriptive. To understand the current, dominant view of science, we need to investigate the positivist paradigm and its implications for science education and mentoring.

An important aspect of science education is NOS which evaluates and questions the historical and philosophical ideas of how science developed through time, what constitutes scientific knowledge from other forms of knowledge, and how scientists conduct their research

(McComas, 2008). In demarcating science from other forms of knowledge, this paints the positivist view of science which creates some conflicts with Noddings' ideas. The first conflict is the degree of closeness between researchers and participants. In the claim for scientific knowledge, an assumption in the positivist paradigm is that the relationship between the researcher and participants are "independent of one another" (Ponterotto, 2005, p. 131) as scientists strives to produce objective knowledge. This directly conflicts with Noddings' relational approach between the one-caring and the cared-for, as she states that "taking relation as ontologically basic simply means that we recognize human encounter and affective response as a basic fact of human existence" (Noddings, 2013, p. 4). This impacts my dual role as the scientist and mentor (one-caring) in my encounters with students (cared-fors). On one hand as a scientist, I recognize that scientists are historically driven by the positivist paradigm. On the other hand, as a mentor, I recognize the importance of establishing and maintain caring relations with my students to help them self-actualize. This dichotomy presents a problem as I am one individual who is caring for students as both a scientist and mentor. In both roles, I have to acknowledge my positionality to address the conflict. First, my previous training as a scientist in the positivist paradigm indoctrinated me with the idea that scientists produce objective knowledge. However, studying in the education field has shifted my thinking to recognize that scientists conduct research within "social, political, and gendered interests" (Brush, 2000, p. 115) and therefore, the acquisition of scientific knowledge is subjective. Second, science is a collaborative effort and I value working with students as we co-construct knowledge together. Therefore, establishing a caring relationship with students in a science apprenticeship is my priority over the positivist view of the distancing myself from participants.

The second conflict occurs in our analysis of an objective, Westernized science or acknowledging cultural, non-western science. One major problem of positivism in science education is that realist language has been used to communicate that scientific knowledge is an absolute description of the natural world (Munby, 1976), from a Westernized viewpoint (Cobern, 1998). This creates two conflicts for Noddings caring ethics. The first problem is the truth value of science as absolute, as Noddings contends that we should consider different perspectives of science including creation science. She states that, "Most scientists reject creation science as unscientific, and it's important for students to know this. If scientists are right in this rejection, it does not mean that a creator, design, or purpose is ruled out" (Noddings, 2006, p. 253). As one-caring, motivational displacement would help educators acknowledge that other forms of knowledge such as religion are equally valuable as science. We should provide the cared-for with opportunities to engage in such dialogue on the truth value of science and what constitutes reality from different viewpoints. Second, in reflecting on the cultural view of science, we should critically analyze who are the agents that contribute to scientific knowledge. The Western view of science often portrays scientists as a "stereotypical dispassionate, objectively rational man" (Cobern, 1998, p. 19) and the stereotype of a scientist is an old white male in a laboratory coat (Chambers, 1983). Noddings would likely advocate for the cultural contributions of individual scientists by respecting their multiple identities and talents. She describes the importance of knowledge situated in culture, stating that "One purpose of global education and multicultural education is to supply students with knowledge of other people and their customs" (Noddings, 2005a, p. 113). As the one-caring confirms the best in the cared-for, it is important to highlight the diversity of scientists who have contributed to science, and in turn, help diverse students see themselves as scientists (if they wish to choose this occupation). Collectively, dispelling the

notions of science as absolute and being done by an objective, uniform scientist can enhance students interest and participation in science.

When conducting science, it is often assumed that there is only one way to conduct science by the scientific method. The third conflict is the problem of a universal, scientific method or creativity in the methods of science. As scientific claims for an objective reality depends on empirical evidence, scientists often use inductive and deductive reasoning to confirm or refute knowledge claims (McComas, 2008; Richards, 1983). This has led to the view that the scientific method is a prescribed, linear way of doing science by defining the problem of interest, research question, and proposing a hypothesis, designing an appropriate method to test the question, gathering and interpreting data, and making inferences to generalize the data. This leads to the misconception that the scientific method is a step-by-step process to conducting science (McComas, 1996). Noddings would critique the scientific method as one way of knowing:

> The desire to reduce all teaching and learning to one well-defined method is part of a larger pattern in science, epistemology, and ethicists...The problem is that the standard lesson is almost useless for teaching major concepts and engaging students in problem solving, reflection, creative expression, cooperative interaction, or intellectual discernment. (Noddings, 2005a, p. 7, p. 9)

While the scientific method may serve as a guide to conduct a scientific investigation, it is important for students to have agency in developing their methods to recognize that they do not have to follow the scientific method as a linear process. This is important because science educators have revealed that when looking at the history of science, scientists have used creativity and imagination to design a variety of science methods (Brush, 2000; McComas,

2008). Furthermore, as controversial as this is, students could develop a method to gather knowledge that does not fit in the positivist paradigm and could be deemed 'unscientific' by the science community. However, as one-caring for students' ideas, Noddings would ask us to critically analyze the impacts of forcing institutionalized ideas upon people. Forcing students to follow a prescribed method would fail to provide students with a democratic approach to fostering their critical thinking (Noddings, 2003).

In summary, science education has been heavily influenced by positivist ideas in the science community that contend with Noddings' ideas of care ethics. The positivist ideas have painted the views that scientists maintain a distance from their participants to obtain objective knowledge, scientific knowledge is absolute and acultural, and science is conducted using the scientific method. In thinking with Noddings, we have to consider alternative views of science to care for others in our encounters with them. This includes recognizing that other forms of knowledge are equally valid as science, appreciate the cultural contribution of non-western science, and provide students with agency in developing their methods of conducting science. As scientists and mentors, it is important to place ourselves in cared-fors' perspectives to value their contribution to science.

Research Design

Enactment for Care Ethics in the Apprenticeship and Research Process

The purpose of this study was to understand how the implementation of care ethics and mentoring in a science apprenticeship shapes high school students' participation in science. The enactment was guided by Noddings' components of moral education of modeling, practice, dialogue, and confirmation (Noddings, 2013). Below is an example of how the four components of a moral education were used to enact care ethics in the apprenticeship. Dialogue was used to

create a caring relationship with students and build rapport, specifically by trying to learn about students' personal and professional interests. This allowed me to try to understand what particular topics in science that students liked and I sought opportunities that aligned with their interest such as reaching out to scientists and discussing papers of their interest. I also tried to create chances for modeling, practicing, and confirming care as we collaborated on group activities in the classroom and outdoors, interacting with others and the environment. I acknowledge that my attempts to use all four components were successful for some students and perhaps not for students whose participation declined during the apprenticeships. It is possible that my view of care ethics was not congruent with their views of how I enacted care. At the end of every meeting, I used reflexivity to reflect on my actions and thought about future improvements for the next time I met them.

Dialogue, modeling, practice, and confirmation were used to guide the research process to enhance care ethics with participants. Dialogue was used to build a caring relationship with participants and understand how they feel throughout the research process to inform our decisions. Enhancing participant's decision making was necessary because a major problem in qualitative research is the power relations between the researcher and participants, which could result in the (un)ethical treatment of participants (Karnieli-Miller et al., 2009). Research ethics is often viewed as following a set of predetermined guidelines; however, this approach does not demonstrate caring ethics towards participants and is not sufficient to account for ethical dilemmas that may arise (Guillemin & Gillam, 2004; Rallis et al., 2007). For instance, Rallis et al. (2007) drew upon case studies from their own research and illuminated how the IRB procedures of consent were prioritized over the participants' agency, which did not address their sensitivity and placed pressure on them to participate in the research. It has been suggested that a

relational approach should be established before following through with the procedural aspects of consent and approval (Rallis et al., 2007). To reduce the power dynamics and ensure care ethics was placed, I was upfront with the participants on day one about everything about this dissertation study. I also stated that they were welcome to ask any questions and raise any objections and concerns if they arose at any point. In addition, I tried to pay attention to non-verbal cues throughout this study to ensure that students were comfortable and if they were not, would be ready to change my actions in the moment to enhance caring for them.

In modeling care ethics in the research, students were invited to contribute to the inquiry such that "they become participants in the research rather than subjects" (Guillemin & Gillman, 2004, p. 271). Although this research did not use an action research approach, this study drew upon elements of participatory action research (PAR). PAR is often defined as a way for both researchers and participants to collaborate and solve a problem and it may take several iterations of implementing an action, evaluating the action, and deciding the next steps towards providing a solution (MacDonald, 2012). PAR was an ideal approach for promoting caring ethics because participants have agency in the process which fosters a mutual relationship (Ritterbusch, 2012). Furthermore, it considers the contextual experiences of participants in their environment, valuing their perspectives beyond the researcher's own knowledge (MacDonald, 2012). As conflicting perspectives may arise, dialogue and co-decision making was used to resolve any issues. Overall, students' co-inquiry in the research aligns with Nodding's ideas of fostering a reciprocal relationship. This was done by obtaining students feedback on how they wanted to collect the student-generated data source. On the first day, I provided students with the option of using photovoice, science notebook, or "What I did/What I learned" (WID/WIL) journal entry. As we progressed throughout the apprenticeship, students decided to complete the WID/WIL. I also

used dialogue to obtain their feedback to learn what can be improved and incorporate their feedback in my future decisions. For interviews, students were invited to write questions if they wanted to ask me anything and ask any questions that they had for me during the interview. Lastly, I used reflexivity which Berger (2015) described as:

> …turning of the researcher lens back onto oneself to recognize and take responsibility for one one's situatedness within the research and the effect that it may have on the setting and people being studied, questions being asked, data being collected and its interpretation (p. 220).

As I participated in this research with subjectivity, I could not remove myself objectively from this research. After the end of each session, I documented my thoughts, beliefs, assumptions, and biases. Reflexivity was used to address the biases in my positionality because previous research has shown how it influences the relationship with participants, what information they decide to intentionally share, and my interpretation of data (Berger, 2015; Etherington, 2007; Rallis & Rossman, 2010). Furthermore, reflexivity raised my awareness of the "cultural, political, social, linguistic, and economic origins of one's perspective and voice as well as the perspective and voices of those one interviews and those to whom one reports" (Patton, 2015, p. 70). Reflexivity drew transparency on how I both maintained and failed to create a caring researcher-participant relationship.

Lastly, confirmation was used to practice care ethics in the research. Noddings described that in confirming care for others, we should not assert our own expectations but consider the expectations and goals of students (Noddings, 2013). In using dialogue, modeling, and practice, I asked students what they expected of me as the researcher to promote reciprocal relations. Creating and (re)negotiating the expectations throughout the research process was used in my

attempts to reduce misunderstandings and the power-relations in the researcher-researched relationship.

Context of the Case Study

A case study is viewed as a "contemporary phenomenon within its natural context" (Hancock & Algozzine, 2016). This research aligned within several characteristics of a case study. First, the case focused on the implementation of care ethics and how it shaped student participation in a science apprenticeship. Second, a case study occurs within a bounded system (Patton, 2015). In this research, the bounded system consisted of a semester-long apprenticeship of Hoco High School (HHS)* (pseudonym). HHS is located in Historic Independent School District (HISD)* (pseudonym) which is in a large metroplex. In the 2018-2019 academic year, HHS served 2,532 students and the student population consisted of 62.4% Hispanic students, 26.7% White, 6.8% African American, 2.3% Asian, and the remaining ethnic groups as other. Furthermore, 64.9% were economically disadvantaged, 11% represented English Language Learners (ELLs), and 5.9% obtained special education services. For measures of student achievement, the school earned an overall B rating according to state testing results and the graduation rate is 90% (Texas Education Agency [TEA], 2019).

This case study focused on one high school teacher's students since he initiated a turtle survey, a project that is a collaboration between myself and Mr. Chelydra* (pseudonym) at HHS and the turtle survey offers HHS students and anyone in the local community with the opportunity to participate in citizen science to monitor the turtles in the local river. In the past, the turtle survey occurred once a month at the river for about four hours, in which students caught turtles, documented the species and body measurements, tagged, and released them. Documentation of the turtles helped us understand the health of the turtles and the water quality.

Participation in the project was completely voluntary and free for any HHS student and the general public who wanted to learn about turtles. The research was conducted ethically with the permits from the Nature Wildlife Organization* (pseudonym) and approval from the county's water district. I have participated in this project since its initiation in October 2017 and created a sub-project for my pilot investigation from January 2018 to August 2018.

Subject population

The inclusion criteria and characteristics of the participant population were high school students attending HHS. To recruit participants for this case study approach with IRB approval, I used purposeful sampling (Patton, 2015) to work with five participants who were interested in participating in the turtle survey and/or the research apprenticeship. I asked Mr. Chelydra for recommendations of students he thought would be interested in participating in the diatom-turtle project and asked him to introduce me to the students. I decided to ask for no more than five participants to keep the apprenticeship community small so I could maintain caring relations within a small group. Furthermore, recognizing that attrition can occur (as it did in my pilot study), I sought to have a minimum of one participant. My backup plan was that if I could not obtain enough participants, I would expand the participant population to other high school students.

Recruitment procedure

At the school level, I scheduled a meeting with the principal at HHS and was transparent about my research and obtained a letter of support. At the classroom level, I set up a meeting with the participants and their parents in Mr. Chelydra's classroom with his presence. This meeting consisted of getting to know each other and then introducing ourselves with name, grade, academic interests, and personal interests, and our experiences. Once we got to know

more about each other, I held an open dialogue about who I was as a researcher and was transparent about my dissertation. I discussed my pilot study as an example. I followed up by asking the participants to think about their interest in the project, heard what they wanted to get out of the experience, and gave them my contact information.

I set up a second meeting for those who were interested in participating. The meeting was held at the turtle survey since that was a convenient time and place for us to meet again. Prior to this meeting, I notified them in advance that I would ask for consent if they chose to participate in the educational study and invited their parents to the meeting. There were no monetary incentives, gifts, or favors provided to avoid coercion to participate in the study. I also noted that if they choose not to consent but would still like to learn the scientific research, they were welcome to participate; not consenting would not affect their participation or their grades and academic performance in any class.

Consenting procedure

For those who attended the second meeting, I brought the IRB forms and explained each form and what they were consenting to (e.g., media release). Since they were minors, I explained that I would ask for parental permission if they chose to participate and parents were invited. To avoid any discomfort, coercion, and pressure, Mr. Chelydra was present and I gave students the IRB packet to take home with my contact information. I asked participants if one week was sufficient to think about their participation and they agreed that was fine. I asked them to return the packet to me or Mr. Chelydra if they chose to continue to participate in the study.

Apprenticeship Design

In using a similar design from the pilot, the apprenticeship took place in Spring 2020 semester from January to May. In the beginning of the semester, I started with diatom research in

Mr. Chelydra's classroom but wanted students' input to diverge projects to align with their interests. I made myself available three times a week after school to accommodate student schedules and we meet from thirty minutes to three hours during a session. During our meetings, we did a variety of activities such as processing diatom samples, identifying diatoms under the microscope, reading scientific papers, preparing experiments, scientific posters, etc. These activities were guided by a combination of ideas that I brought forth and students' ideas of what they wanted to do for upcoming sessions. We also held the turtle survey twice in the spring before the COVID-19 pandemic. After the school closure, we transitioned online using Zoom. Since we did not have access to scientific equipment, we completed virtual activities that related to diatom-turtle research and their individual interests such as forensic science. Below is a timeline of the apprenticeship activities and data collection (Table 1).

Table 1

Timeline with an Overview of Apprenticeship Activities and Educational Data Collected

Timeline of Science Apprenticeship and Educational Research Activities		
Week	**Overview of Activities**	**Data Collection**
Pre-planning: January 22, 2020	N/A	Recruitment Meeting
Pre-planning: January 26, 2020	First Turtle Survey	Consent Meeting
Week 1: January 28-31, 2020	Met with the participants to get to know their interests and discuss this dissertation study up front to answer any questions they had. They learned a brief introduction to diatoms.	Field Notes
Week 2: February 4-7, 2020	Students learned how to process diatoms, observe them, and completed their morphology models.	Field Notes

Week 3: February 11-14, 2020	Students processed diatoms, observed them, and completed morphology models.	Field Notes Interview #1
Week 4: February 18-21, 2020	Planned forensic experiment with Margaret; Alyssa and Merry started on the fossil-diatom project.	Field Notes WID/WIL
Week 5: February 25-26, 2020	Margaret carried out her forensic experiment; Alyssa and Merry continued the fossil-diatom project.	Field Notes Interview #2 WID/WIL
Week 6: March 3-6, 2020	Margaret observed the samples from her forensic experiment; Alyssa and Merry continued the fossil-diatom project. Alyssa, Margaret, Grace, and I took a short trip to a local science laboratory.	Field Notes WID/WIL
Week 7: March 12, 2020	Spring break: attended the turtle survey and spent time there with Margaret.	Field Notes
Weeks 8-9: March 14-20, 2020	COVID-19 school closure	
Week 10: March 31-April 3, 2020	Reconnected with students. Our first meeting in the week on Zoom was a virtual fieldtrip to reconnect. For our second meeting, Margaret, Alyssa, and Merry learned about diatoms as indicators of water quality.	Field Notes WID/WIL
Week 11: April 10, 2020	Margaret and Alyssa worked on data analysis for the poster. We also discussed how to bring their interests in an online environment.	Field Notes Interview #3 WID/WIL
Week 12: April 14-17, 2020	Alyssa and I discussed a paper on biodiversity; Margaret and I did crime scene investigation activities.	Field Notes WID/WIL

Week 13: April 22-24, 2020	Alyssa and I discussed a paper on contaminants in aquatic ecology; Margaret and I did fingerprint and anthropometry activities. We also worked as a team to write the abstract for the upcoming conference.	Field Notes Interview #4 WID/WIL
Week 14: April 27-May 1, 2020	Alyssa, Dr. Diatom, and I had a discussion on Zoom about her career path; Margaret and I did ink chromatography activities. We also worked on career preparation and resumes.	Field Notes Interview #5 WID/WIL
Week 15: May 6, 2020	Margaret and I did forensic activities on DNA extraction and blood stain analysis.	Field Notes WID/WIL

Data collection

Observations with field notes

To address trustworthiness in observations, I held persistent and prolonged observations (Hendricks, 2017). I had been an active observer and participant of the school for the last three years and continued to make consistent observations. This included a thick description of the setting and how participants interacted in the setting to provide enough information for readers to envision the setting to enhance the transferability of the study (Creswell, 2013). For any new places and interactions that emerged out of this research, I recorded all observations.

To construct fieldnotes, I conducted observations of both the outdoor component at turtle survey and the indoor laboratory experiences. As I had participated in turtle survey for three years, I made observations of the following elements: physical environment, verbal and nonverbal communication, and activities (Patton, 2015), including activities that occurred during the research apprenticeship and the educational process. First, the physical environment included

a description of the outdoor set up of the turtle survey along the local river and the indoor laboratory inside Mr. Chelydra's classroom at HHS. I also recorded the presence of objects that shaped the culture created in the space, tools that were used in conducting activities, arrangement of objects that facilitated or hindered activities, and how people were situated in the physical spaces.

Second, the verbal and nonverbal communication was recorded on how participants (students, teachers, scientists, and parents) were interacting with each other through conversation and body language (e.g., gestures) and how people were in contact with nature with special focus on the diatoms and turtles. Priest (1986) defined that a component of outdoor education is how humans interact with nature through our senses and domains. This project provided multiple opportunities to engage all the senses. Along the river, students typically saw turtles basking and heard them 'plop' in the water to hide. Later during the turtle survey when students checked the turtle traps, students often observed different species of turtles and remove them from the traps for closer inspection. This included smelling the turtles because some particular species can emit an odor. For example, musk turtles are also known as "stinkpots" because they release a smell that is speculated to provide a warning to predators (Ernst et al., 2009). Observations included information on the degree to which students engaged with their senses in nature.

Third, observations were recorded on the activities occurring throughout the research. The outdoor component included observations of what students were doing with their research projects. For instance, if they chose to study the turtles at turtle survey, I documented their interactions with turtles such as if they measured turtles, wrote data down, and explained scientific concepts to peers. During the indoor laboratory component, I documented what students were doing in the laboratory such as if they identified diatoms under the microscope,

completed data analysis, and discussed scientific literature and how they participated in such activities.

Lastly, I recorded observations on all educational research activities as it pertains to data analysis. This included observations of when data were collected, how data were collected, and participants' reactions throughout the data collection process. As it was difficult to write everything down as activities were occurring in the moment, I made short bullet point notes on paper. Immediately after activities were complete, I expanded on the bullet points and typed all observations in a google document. The observations included notes on what occurred and how the participants and I interacted. More important, I documented reflexivity in my experience which included my emotions, biases, and any initial interpretations that emerge from the observations. Lastly, I included any list of words, concepts, or themes that I initially notice were emerging from the data. Supplemental material such as photographs during the experience were included in my notes.

Students' ownership of a data source

The power relations between the researchers and participants can impact the type of data collected, the frequency of data collected, and how the data are collected (Karnieli-Miller et al., 2009). To reduce the power relations and enhance care in this study, I used the PAR element of cooperative inquiry to understand how the participants and I could work together to collect data and make meaning (Heron & Reason, 2006). To approach cooperative inquiry, I discussed the goal of the study and asked students to choose a data source or create one of their interest on the first day that we met. We discussed what type of data they wanted to collect, the format of the data and the frequency of how often they wanted to collect data. To provide some initial options, I gave them the examples of photovoice, a student notebook, and the WID/WIL journal entry.

For the photovoice, I showed them an example of how they could take any picture that interested them and how we could discuss their perspectives for why they chose to take the picture. For the science notebook option, I showed them an example from my pilot study on how to document whatever they chose regarding their experience including drawings and amount of text that interested them. Lastly, for the WID/WIL journal entry, I showed the template which looks like a t-chart in which on the left column, they write what they did for the day and on the right column, write what they learned for the day. I gave students time to decide and let them know I was more than happy to help them design the student-generated data source. Students stated that they were not sure what they wanted to select. Students later mutually agreed that the WID/WIL journal entry was their data choice of interest. Fielding (2011) described that when students are able to have agency in the research process, "students move from being discussants to being co-enquires into matters of agreed significance and importance" (p. 70). Throughout this process, dialogue and practice to ensured that we were enhancing care in the process of generating a data source of students' interest.

Focus group interviews

The interviews consisted of semi-structured focus groups. A focus group is defined as "an interview with a small group of people on a specific topic" (Patton, 2015, p. 465). The rationale for a focus group interview was to allow participants to share their learning experiences. The benefit of focus groups was that it promotes "interactions among participants [which can] enhance data quality" by participants corroborating perspectives and also share unique experiences (Patton, 2015, p. 478). Although the aim was to have students engage together in a focus group, there were times a student missed an afterschool session so some interviews were done with individual students. For each interview, they were provided with interview questions

in advance so they would know what they would be asked and were invited to write their own questions if they wanted to ask me anything. The purpose of having them write questions was to promote co-inquiry and use dialogue to address the unequal research-participant relationship.

Furthermore, as ethical dilemmas arose during the interview process that can have repercussions for the participant (Huckaby, 2011), I considered the following approaches for minimizing power relations. Hewitt (2007) proposed that ethical researchers consider the following elements when conducting interviews with participants. 1) Acknowledgement of bias; as the researcher, I was transparent with participants about my biases from my experiences as a scientist and educator which have shaped the way I viewed and interpreted the research. I also reported my own biases throughout the research process to illuminate how it influenced my interpretations. 2) Rigor, which was addressed by reporting inequities in the power relationship between the research and participants. To minimize power relations, I used dialogue to ask students about their perspectives, such as the data collected to acknowledge and respect their views of the research. I asked for their opinions to determine if I interpreted their conceptions of care ethics correctly after the interview which they corroborated or gave me feedback to readjust my interpretation. 3) Rapport, which was established by building a caring relationship with students to ensure their needs were prioritized over my own research agenda. This was done by considering empathic neutrality which is "An empathic stance in interviewing seeks vicarious understanding without judgement (neutrality)" (Patton, 2015, p. 46). I tried my best to be attentive and respectful to student opinions without judgement. 4) Respect for autonomy, which was addressed by always asking participants for their consent throughout the research process and I provided opportunities for participants to ask questions and vocalize any concerns, including withdrawal procedures without penalty. 5) Avoidance of exploitation by minimizing

any distress throughout the interview. As Noddings discussed expressed and inferred needs, I paid attention to verbal and non-verbal cues to ensure their well-being was prioritized and was ready to stop at any point that they expressed discomfort. 6) Confidentiality was addressed by assigning each participant a pseudonym and removing any identifiers.

Before the pandemic, the interviews were conducted in person in Mr. Chelydra's classroom around students' schedules. After our transition online, the interviews were recorded online during our Zoom sessions. I always asked for their consent before every interview and paid attention for any signs of discomfort during the interview process since I wanted to prioritize care. All interviews were audio-recorded and a total of five interviews were completed in the semester and transcribed by the researcher.

Data Analysis and Trustworthiness

Creswell (2013) described the importance of gaining insight into the data by initially organizing and reading the data. All the data sources were organized in a manner by which they could be read in a line-by-line format. The field notes were typed in a google document; the WID/WIL journal entries were either hand-written or typed. Similarly, the audio files were transcribed as a word document for organization. Once the field notes, interviews, and WID/WIL journal entries were in a format that could be read line-by-line, I carefully read through the data and made hand-written notes of labels (e.g., concepts and ideas) that pertain to Noddings' care ethics, mentoring, and apprenticeships.

Once I created the labels on the margins, I created a list of codes, which involves "aggregating the text or visual data into small categories of information" (Creswell, 2013, p. 184). Once all the data were coded, I looked for major patterns in the data to observe the major themes that emerge from the data. Themes are "broad units of information that consist of several codes aggregated for form a common idea" (Creswell, 2013, p. 186). The themes were analyzed

to determine how care ethics shaped student participation with supporting examples and also compared student's conception of care ethics to my own conception.

Trustworthiness of data analysis and interpretation were addressed in two ways. First, triangulation of data was used to address consistency in the findings (Creswell, 2013). The three sources are the field notes of my observations, the WID/WIL journal, and five focus group interviews. Second, I had others corroborate the findings. Member checking was done by asking the participants to analyze my interpretations of the data and offer feedback; note that only two of the five participants responded back. I also asked an outsider who was not involved in the study to analyze my interpretation and provide suggestions. Incorporating a critical friend and dialogue can be used to resolve any inconsistencies in coding and interpretation (Creswell, 2013; Hendricks, 2017).

Ethical Considerations

Procedures to maintain confidentiality and data storage

To maintain confidentiality, the participants were assigned a pseudonym and any identifying information was removed. The signed consent forms and hard copies of data were stored in a professor's office in a locked cabinet. Electronic data were stored on a password-protected computer and were only accessible to me. Three years after the study is complete, physical copies of information will be destroyed in a secure manner and electronic data will be deleted.

Potential risks and precautions to reduce risks

The anticipated risks with this study were minimal with regards to the three parts to the study including the outdoors, laboratory, and educational data collection. First, this study took place in the outdoors and poses considerations for risk management, which was necessary to

identify, assess, and reduce the risks (Dickson, 2012). Risk management consists of demarcating the parameters for where the activities will occur and what concerns arise as a result of participating in the defined areas. Second, assessing the risks includes evaluating the terrain, length of participation, and available resources to handle risks. Lastly, mitigating the risks include improving procedures to handle the risks, training staff, and having an alternative backup plan (Dickson, 2012).

For the risk management in this study, the potential identified risk was participating in the outdoors with changing weather and uneven terrain. To evaluate this risk, Mr. Chelydra sampled these sites on his own first before bringing students out to the turtle survey. To minimize risks, he chose areas at the sites that provided the easiest walking path and created maps of where to meet. He chose three locations along Penny Restaurant*, Rigano Plaza*, and Turtle Trail* (pseudonyms). Prior to scheduling the turtle survey, Mr. Chelydra always checked the weather forecast. When he scheduled the turtle survey, he emailed students and their parents of the weather forecast, the specific site being sampled for the day, and asked everyone to wear sturdy tennis shoes and bring water. However, if there was any weather threat (e.g., cold and warm temperatures beyond the normal range or thunderstorm), the survey was canceled and participants were notified in advance. During the turtle survey, paths were chosen to minimize falling but it was impossible to find completely flat terrain as the river is situated at the bottom of the slope. To minimize any risk, the adults including myself reviewed all safety precautions to ensure that participants walked safety while maintaining respect for surrounding natural areas. In the case of an emergency, first aid kit was available. I also brought sunscreen, a second-first aid kit, and hand-sanitizer for students.

Second, the indoor portion of the study took place in Mr. Chelydra's classroom with minimum, anticipated physical risks. Participants used laboratory equipment, including a light microscope and handled glass slides with diatoms. To minimize any risks with using the equipment, students were oriented on how to use the equipment properly and also how to safely dispose of broken slides in the glass disposal box. In case of an emergency, a first aid kit was present in the classroom.

Third, there were minimum anticipated psychological risks associated with educational data collection, such as feeling vulnerable during discussions, feeling anxious, or not wanting to share information. At any point that the participants wanted to terminate data collection, the could verbally indicate so and I would have stopped immediately. Throughout the study, deception was not used. To minimize risks associated with data collection, I used an ethics of care and considerations, as described previously, to maintain trust with the participants.

Researcher Positionality and Reflexivity Throughout the Research Process

Prior to discussing the results, I felt that it was important to reflect on my research positionality as it pertains to the design of the research question and methods. The purpose of stating my researcher positionality below was to be transparent about how my thoughts and actions shaped the results.

First, I reflected on my own assumptions and biases. Going into the initial stages of thinking about this research, I held the view that care ethics would positively shape student experiences. However, as I began reading the literature and carrying out this study, I realized that students may not feel they are being cared-for. I had to be open to the possibility of a lack of care ethics shaping both the apprenticeship and research process in ways that I would not be able to anticipate. To address this throughout the research design, I chose to reflect and record my biases

while I completed this research. I continually asked for student feedback throughout the research process to gain insights on what I could improve. Students also had the option to communicate with their teacher if they were not comfortable communicating with me.

I also acknowledge the manner in which the research questions were specifically framed and how my actions unfolded influenced the interpretation of the results. Corlett and Mavin (2018) stated the importance of acknowledging how the research process is constructed from our social experiences and cannot be free of objectivity. The first research question asked about mentorship with the enactment of care ethics, which implies the assumption that my mentorship was inclusive of enhancing care for students. I am aware that students may not have perceived my mentorship as caring and may not want to say anything to avoid difficult conversations or hurting my feelings. Not knowing all aspects of their perspectives of my mentorship could have made it difficult to know if I truly embodied care ethics or not in my mentorship. To address this, I tried to be attentive to how students were responding. If I felt something was not helping students or enhancing care, I tried to self-correct my actions in the moment. Furthermore, this first research question also studied how the mentorship with care ethics shaped student participation. The interpretation of what constitutes participation is subjective. While I perceived participation as being present and making the most of the apprenticeship experience, students could have perceived participation differently, such as showing up but not necessarily being engaged in all of the activities. The second research question studied student conceptions of care ethics compared to my own conceptions of care. This study did not explicitly teach students about Nel Noddings' Caring Ethics, while I am privileged as a researcher to have taken a graduate student course on care ethics and specifically knowing Noddings work. Therefore, this inherent difference in our knowledge already made our interpretations of care ethics different.

My rationale for studying this question was already valuing student perspectives because I did not believe there was a "right or wrong" answer, but rather unique insights that students and myself could offer during this research. My research questions were situated in the specific context for which this research occurred in and acknowledges that no generalizable truth claims can be made from this qualitative study.

Researcher Identity

First, I was positioned as an outsider in collaboration with insiders (students) since I was not an official member of the school community. Second, I was positioned as an educational researcher and science mentor in the study which complicated the research process. I imagine that if I were an outsider who was not the mentor and only interviewing the students, the students could feel more comfortable sharing their thoughts knowing that they would not have to directly share their thoughts with their mentor. My dual positionality as a researcher inherently created a power-dynamic in which students could have felt like they should answer a particular way if they wanted to continue the scientific mentor-mentee aspect of the work. To address this, I let them know that their choice of participating or not participating in the educational aspect of this research would not have an impact on their ability to participate in the science mentor-mentee aspect of our work. I also paid attention to verbal and non-verbal cues during the research process, ensured that another adult was around during our interviews, asked students for feedback, and reflected immediately on my experiences with the participants. Even though I made these efforts to practice and model care, I acknowledge that it was impossible to separate myself strictly being a researcher versus being a mentor as these roles were intertwined. This dual positionality could have impacted our researcher participant-relationship as the implications of what they said during data collection could have shaped our mentor-mentee relationship. My

identity as the researcher-mentor could have influenced the selection of information that students chose to share during interviews and their WID/WIL journal entries in a manner to avoid ways of damaging the mentor-mentee relationship.

Another power of difference was our identity as it pertained to age, race depending on the participant, and lived experiences. While we all shared a common interest for science and were all females, I was situated as an older Asian American graduate student working with young White or half-to-fully Asian American high school students. Although I tried to relate to the students during the entire research process and create a reciprocal relationship, it is possible that students perceived my racial identity, age, and researcher role as an identity that they could not fully connect with. I imagined that if I were a student working with an educational researcher for the first time, the research process such as participating in an interview could feel like a foreign process and create inequities in the researcher-participant relationship. To address this, I wanted our research-participant relationship to be reciprocal. As I had written interview questions, students were invited to write interview questions and ask me anything if they wanted to do so to reduce the power dynamics in the researcher-participant relationship. I also asked for student feedback on anything that I could improve on. As they shared their thoughts, I always followed it with statements of gratitude so they knew that I valued their opinions. I attempted to make the researcher-participation relationship as a reciprocal collaboration as students contributed to selection and generation of the student-generated data source which was the WID/WIL journal entry. As we progressed in the second half of the apprenticeship, I reflected and realized that I needed to be more vulnerable in sharing the student-generated WID/WIL, so I began sharing it with the students to improve on my research relationship with the students. Throughout the

research, dialogue was to reduce the differences in the researcher-participant relationship and gather student feedback on what could be improved.

Method reflexivity

A qualitative case study was chosen for this study. The criteria for the bounded system consisted of a high school teacher and his students (as described above). In reflection of my methodological choice, I was privileged in being able to work with one high school teacher and his students at the local high school, as I was collaborating with the team prior to this dissertation study. My selection for this school was intentional because the apprenticeship we created was the basis for this dissertation study. However, I have to acknowledge that those who attend the turtle survey and were enrolled in teacher's classes tended to be students who were considered in the literature as "high academic achievers" in science, with primarily White and Asian American students. Because I chose to work with this teacher and his students, this excluded marginalized students such as African American or Hispanic who were typically not enrolled in this teachers' courses or attended the turtle survey. The selection of the participants could have created alternative findings, as this apprenticeship experience could have looked differently with minority students' perceptions and experiences with caring ethics.

The design of the data sources influenced how the researcher and participants' voices were represented and their implications for interpretation. Bergmark (2020) challenges dual researchers-educators to consider how they are implementing care ethics in the research process by allowing multiple voices to be valued in the research process. The three data sources collected were the field notes, semi-structured interviews, the WID/WIL journal entries (as described above). The field notes documented only my own observations, events that occurred during the apprenticeship, my biases, and my thoughts. At times, I felt ashamed for writing down my

thoughts in my field notes, such as an instance of a student making a statement and not knowing if it was a joke or a sarcastic comment. In moments like these, I realized that I could not be objective in my interpretation. I tried to be more neutral by paying attention to how the student interacted with others during the duration of our session in my attempt to gather more evidence and context to interpret their statements. In the semi-structured interview, I wrote interview questions and students were also invited to write and ask their own interview questions. It was my desire to have students use their agency to construct and ask their own interview questions to include their voices more, but they chose not to write any interview questions. Their voices were expressed through answering my questions and offering suggested feedback. Lastly, students' voices were expressed in the WID/WIL journal entries without the interjection of my voice. For all data sources, I tried to promote dialogue by continually asking students for suggested improvements throughout the research process.

As mentioned above to address trustworthiness, I shared the data with a critical friend and with the students. When I asked the students for feedback, only two of the five responded. For those that did not respond, I speculate that I either did not create a caring relationship for them to respond or they were simply too busy. In the writing of the dissertation, I have also reached out to them again asking them if they have any questions about the dissertation and mentioned they could have a copy if they wish to read it and I sent a copy to Mr. Chelydra for review. In reflection, it was a challenge to find a balance between getting their feedback to ensure their voices were being represented correctly, yet also perhaps expecting too much of their time.

CHAPTER 4: RESULTS

How Mentorship with Care Ethics Shaped Participation

The five students who participated in this study did so on a voluntary basis after school. As they had different backgrounds, schedules, commitments, and levels of interest, this shaped their participation. Below are five case studies presented in the order of most to least participation. The rationale for this organization was to provide an understanding of how those who engaged in mentorship with care ethics were able to conduct research projects and/or learn topics that aligned with their interest, whereas those with less participation in the mentorship with care ethics did not conduct research projects and/or engage in learning topics of their interest.

Margaret

Margaret was a white female student. At the recruitment meeting, she was sitting next to Grace. When she introduced herself, she mentioned that she was interested in Forensics and I stated that was my interest too. Her mother was sitting at the front but at another table by herself. I learned that she worked at the local community college. Margaret was fairly quiet and she and her mother left after the meeting. Over the course of the apprenticeship, I learned that Margaret has a brother, several generations of her family have lived in Texas, likes Harry Potter, and is interested in studying forensic science. The first time I worked with Margaret was at the first turtle survey. Margaret and Grace were both dedicated in helping me sample diatoms from the turtles. Although she was very quiet, she worked well with Grace and they were respectful in taking turns to ensure they both had equal opportunities to engage in field work.

Margaret participated a total of twenty-one times after school throughout the apprenticeship and usually participated twice a week. In the first meeting, she attended with

Grace. I asked her what her interest was for research, and she said she was not completely sure yet. When we got activities started, she looked at the diatoms in *Art Forms in Nature* (Haeckel, 1974). After they took turns examining books, Margaret started looking at diatom specimens under the microscope. I wanted them to learn to identify a diatom and I probed their thinking on what they noticed. They figured out how to identify the diatom and I gave them high fives. Margaret was pretty quiet but I think it was just because she was shy. As they were looking at specimens on two microscopes, Grace was viewing specimens under the higher quality microscope. She asked Margaret if they wanted to switch to give her a chance using the higher resolution microscope. At the end, they both looked at live specimens and then we chatted. I asked if they wanted to delve into any specific topics to read from a paper and Margaret said that diatoms and forensics would be cool if it was about a forensic case.

The second time we met, Margaret came with three other participants. I did not anticipate four of them showing up at the same time. In the beginning, we asked each other about music preferences. Margaret said she liked all music including country. I told her I did not know country music well but liked Carrie Underwood, Dolly Parton, Reba, and Shania Twain and Margaret said those were good artists. During our short paper discussion on the introductory diatom article, Margaret did not have much to say. Again, she was an introvert but she was very respectful and listened attentively. When it came time to view diatoms, make observations in teams and attempt identifications, Margaret worked with Merry. Both Margaret and Merry were introverted, so there was initial awkwardness with both of them taking turns to view the specimens and finding a specimen of interest, but they cooperated well. They found *Aulacoseira* and Merry helped Margaret figure out it was sitting on its side. Margaret found either a *Fragilaria* or *Ulnaria*, and I asked her if a raphe (slit) was present or not on the diatom. Margaret

made a good observation there was no raphe so she was able to figure out it belonged in the araphid group. The last specimen they viewed was *Navicula* and they figured out the identification together so I gave them high fives which marked the end of the session.

The third time Margaret participated, she helped pipette diatoms from the beaker into the centrifuge tubes and started the centrifuge. I explained to her that the purpose of centrifugation was to clean the diatoms so we can see their cell wall features and identify them easier. Given that last time she expressed that she thought a diatom and forensic paper would be cool, I picked the Siver et al. (1991) paper for us to read and discuss together. As we were discussing, I asked questions to probe her thinking. During our discussion, I realized that I assumed too much about her prior knowledge and the paper was too complex for her. However, she still did her best to answer questions. To speed up the discussion since I could tell it was too complicated, I asked how this compared to her biology textbooks. She stated that this scientific paper was much more specific than what she normally reads. She told me that she was not as interested in reading a paper in the future and I told her that I completely understand. I appreciated her honesty and we shifted back to focusing on centrifuging the samples. I think that went much better as we did several rounds of decanting some excess water from the samples, adding more water, and centrifuging again several times. As there were periods of waiting, we heard Beatles music playing in the background. I asked her if she liked the band and she said yes; she asked me if I had seen the movie Yesterday, which I had. I felt she was opening up more and it was easier to get to know her with our one-on-one meeting.

The fourth time Margaret participated, she did her first interview. Although her responses were short, there was a light-hearted moment when she stated that she learned about diatoms

existing and we all giggled. During the interview, she stated her views on mentoring during the apprenticeship:

> Um, I definitely would not be as excited about it if I was just learning about it in class or something and it definitely helps that it's like, just a small group, hands-on. Small mentoring thing...I like that you have such a wide variety of things that we can do more about diatoms, and that a lot of it is hands on and not just reading paper after paper after paper like we do in class sometimes.

After the interview, I wanted them to have options, and Margaret chose to decorate her morphology box while learning diatom morphology. She chose to decorate *Tetracyclus* and made a detailed drawing on her box. As we were working, we all chatted about various topics from Six Flags to scholars they learned about in Psychology including Vygotsky and Erickson. Margaret again expressed her interest in forensic science and I encouraged her to seek future opportunities. I told her when I was her age, I was an intern at the police department in my hometown. After she left, I found out about the local police department's program for youth and shared it with her in an email.

The fifth time Margaret participated, she arrived with Merry and Alyssa. I wanted everyone to start planning research projects. Since forensic science was her interest, I gave her ideas of new areas of research in aquatic forensics and she said that she was most interested in comparing submersion on different clothing types. We discussed what materials she wanted to test and what we had available at home - she decided to select cotton, polyester, and denim. I also asked how long she wanted to submerge the clothing and she said one hour. She stated that she would be willing to stay longer if needed to look at the diatoms on the clothing. As I wanted a safe place for her to do research without others disturbing her experiment, I consulted with Mr.

Chelydra and he stated that the pond at the school would be a good place. At that time, he was able to give us access to the pond so we all walked together to take a look. Margaret and I paid attention to the surroundings of the pond so we could figure out how to submerge and retrieve the samples easily. We developed a game plan such that next time she could start her experiment. At the end of the session, she read a little about the application of diatoms and forensics in my book by Smol and Stoermer (2010). After the session ended and I went home, I was excited because I found polyester and denim material at home that she could use for her experiment. I texted her and she thought that it was great.

The following day, which was her sixth time for participation, Margaret was prepared to set up her experiment. I first told her that at the end of the semester they would all have an opportunity to present their research at a mini-symposium at the local university (which was canceled due to the COVID-19 pandemic). To get started for the day, Margaret began cutting out the different types of clothing into standardized three by five-inch pieces. Since Grace still was not sure about what research project she wanted to pursue, she helped Margaret cut the pieces of clothing. Margaret cut denim, Grace cut the cotton, and I cut the polyester. As we were working, we were talking about the Psychology class they were taking together and personality types. Margaret stated she is an introvert depending on the context. We also talked about books we liked to read and the college experience. As it came time to set up the types of clothing, Grace contributed an idea for how to submerge the clothing from the edge of the pond. We thought it was a good idea, so we attached the pieces of clothes to string. Since the weather was bad that day, we decided to wait on setting up the experiment and use the rest of the time for other activities. Margaret chose to look at samples from my diatom-forensic experiment for the remainder of the time.

In Margaret's seventh time for participation, I asked her if she wanted to start the experiment on this day or the following day. She decided to set it up the following day, so we finalized the details of her experiment, such as if she wanted to look at live or dead aquatic specimens as there are tradeoffs to both approaches. To ensure we had clean materials for the following day, we washed the beakers together. I also gave Margaret a notebook and told her it would help if she documented details from her experiment. Mr. Chelydra also commented on the importance of recording information in a scientific notebook. In her WID/WIL, she wrote that she "undid hangers, wash beakers, and tiny grabbers I cannot remember the name of" and learned "different ways to take diatoms of clothing." At this point, she was still new to many aspects of doing an experiment and learning the scientific tools and equipment used to carry out scientific experiments.

The following day, Margaret's eighth time for participation was an important event for her in the apprenticeship as she carried out her forensic experiment. Both Margaret and I took all her materials from Mr. Chelydra's classroom and we set up her experiment at the pond at the school. Since the submersion was going to happen for an hour, we returned to the classroom and she worked on creating the introduction section to a poster. Merry came to the class and told us that she saw some students fooling around by the pond. We did not want them to compromise Margaret's experiment so we checked the pond and everything was fine. Once we were back to the classroom, Margaret continued on the introduction section and part of the methods section. After an hour, we collected the samples from the pond. We also gathered simple data with the Nitrogen and Phosphorus test strips. I happened to make a comment wondering about the temperature and on a hunch, Margaret decided to get a thermometer from Mr. Chelydra's classroom to measure the temperature. We brought the samples back into the classroom and she

analyzed the specimens. She looked at the polyester samples while I looked at denim. Since we were just viewing specimens, we also did the interview in a conversational style. When I asked about her involvement, she stated “I’m pretty happy about my involvement...this is just stuff I’ve never done before.” When asked about the role of mentoring, she said “I wouldn't know any of this stuff without the mentor, and I wouldn’t be able to do any of it.” In her WID/WIL, she wrote “started poster, collected data for poster” and learned “there is a specific poster for the science project.” At the end, she asked me if I needed help cleaning up despite her parents arriving. I told her not to worry about it and she left. Later in the evening, Mr. Chelydra shared with me a funny Facebook post from Margaret’s mom. Margaret told her mom “look at this diatom I found today” and Margaret’s mom stated she was “secretly googling diatom” and shared a picture of Margaret showing a picture of a diatom on her phone.

In the ninth time Margaret participated, Merry was also present. They were respectful to each other but since they are both introverts, I felt that the dynamic was not quite the same when Margaret is paired with Grace. Since Margaret did not get to finish examining at her aquatic specimens from her experiment, she continued looking at her samples while Merry was looking at her fossil-diatom samples on the other microscope. The three of us talked about college and Margaret said she was not sure yet what she would want to look for in a college. We shifted the conversation to the coronavirus. Margaret thought that people were creating panic on the news and I also thought at the time it would not get as bad as reality turned out. After Merry left, Margaret stayed and told me about a movie she just watched called “My Hero Academia: Heroes Rising.” I felt that this conversation contributed to our caring mentor-mentee relationship. When her parents arrived, it was time for her to leave.

In the 10th time of her participation, she joined Grace, Alyssa, and me on our visit to the nearby university research laboratory. We dropped their backpacks off at my apartment since it was on the way and then made our way to the laboratory. Students learned about the various research projects from mercury contamination in fish, horned lizard project, and aquatic invasive plant. Although Margaret was very quiet, she seemed interested as she was paid attention and leaned in during moments when the scientists were showing a piece of equipment. After the visit, they picked up their backpacks and departed their ways as we walked back to the school. Since Margaret's parents were not there yet and I did not want her to leave her alone as it was evening time, we sat on the bench near the front of the school and chatted for almost an hour. Given that she was introverted, I felt like this was the first time she really opened up and we had a good conversation. I learned about a science fair project she did years ago looking at mold growth on different types of cheeses. We also talked about our families and life at the school. When her father arrived, she thanked me for waiting with her.

Margaret's 11th time of participation was an optional turtle survey because it occurred over spring break on March 12th. While others may have had plans for spring break, Margaret was the only one from the group to show up. There was a small team of us and Margaret was very active in helping Mr. Chelydra record pit tag numbers and later, both Margaret and the other student helped me sample the turtles for diatoms. Margaret and I talked about her visit to university and she stated that they did not have the forensic program that she wanted. We talked about crime shows such as Forensic Files, Cold Case, and Snapped. Towards the end of the turtle survey, Margaret and Mr. Chelydra pulled out the last turtle trap and we cleaned up. Margaret told me her family was cooking a crawfish boil and that I had mentioned I loved crawfish boils.

She said I could probably come but I did not want to intrude. This was the last time I saw Margaret before the COVID-19 pandemic shut the school down.

During our first session together online since the school was shut down due to the pandemic, Margaret, Grace, Alyssa, and Merry joined the Zoom session. This was Margaret's 12th time participating in the apprenticeship. I wanted us to have fun since it seemed like uncertain times. As every person was provided a virtual field trip that aligned to their interest, I found the Indian State Police Crime Laboratory for Margaret to explore. When asked if she wanted to share what she learned with the group, she showed us the carport where evidence was processed, the fingerprint laboratory, and the firearms room. At the end, we discussed what they wanted to do in future sessions and how to work on diatom-turtle poster if they were still interested. The team agreed to re-shift our focus on diatom-turtle poster for the conference since we did not have access to microscopes and equipment to complete their projects and said our goodbyes.

Margaret was joined by Alyssa and Merry who to help collect data during the 13th session. At the beginning of the session, I gave them an overview of water quality analysis and how we would compare water quality of Texas turtles compared to Oklahoma turtles. I paired Alyssa and Merry to work together. Originally, I paired Grace with Margaret, but since Grace did not come, I worked with Margaret. As we had data on the diatom taxa on turtles, all three students and I researched Pollution Tolerance Index (PTI) values associated with the diatom genera. After we collected data, we shared it and constructed a graph. I asked them what they noticed, and Margaret stated that she noticed that the environment was slightly cleaner for turtles in Oklahoma compared to Texas. We discussed our findings in relation to activities around the

river in Texas. Since we were meeting virtually, students typed their WID/WIL in the chat. Margaret stated:

> What I did: was collect diatom data from a research paper and order to put together an abstract on why people should care about diatom health. What I learned: I learned that you want less nutrients in your water for it to be healthier, what an abstract is, and Oklahoma has cleaner waters than Texas.

Her response demonstrated that she understood the aim of the research and she contributed to collecting data to make these inferences in the research.

Margaret and Alyssa showed up for the 14th session and consistently for the remainder of our online apprenticeship meetings. First, we did a focus group interview together. Margaret stated that, "I think it's working well that you're giving us options on what we can choose to do." After the interview, I gave them three options that pertained to data analysis and poster preparation. The students decided to work together to read a new scientific paper that came out on diatoms on turtles in relation to water quality and both took notes. As they read, I was working on another aspect to help get the data analysis done. After we shared what we learned, they wrote a WID/WIL. Margaret wrote:

> What I did: I read an article and took notes over it, anything I thought was going to be important to us in making the poster. What I learned: What the BDI [Biological Diatom Index] was, and that there are many factors that can influence the diatoms living there, like light exposure or stuff turtles produce.

At the end of the session, Alyssa noted that she was bored because after the COVID-19 pandemic began, teachers had short assignments that she could complete fast. I asked both of them if they wanted to meet more frequently; Monday through Thursday could be dedicated to

their interest and we could finish the diatom-turtle poster on Friday. They both liked that plan and Margaret wanted to learn more about forensic science.

Margaret's 15th session was her first time learning about forensic science. I wanted to ensure that despite it being an online environment, it was as interactive as possible. I would send Margaret a list of materials to find at home in advance and she was always prepared for the sessions. During this session, she learned about making observations in forensics, Locard's Exchange Principle, and how to secure a crime scene. As there are several search patterns at a crime scene, we both stood up and practiced how to do all four search patterns in our rooms at the same time. Next, we viewed a mock crime scene on Google Poly and we both did sketches of the crime scene. We took turns sharing our drawings and it was neat to see how her drawings were different from mine. I showed her an example of how forensic scientists sketch a crime scene and we refined our drawings. Next, we practiced photography as forensic scientists photograph the crime scene. She said it was hard for her to rotate 360 since she had headphones on. I told her that she did not have to move if she did not want to. Next, we learned how to package trace evidence in a bindle paper. I modeled it for her and we both folded it together practicing it with a piece of paper. Lastly, I talked about the importance of chain of custody. At the end, I showed her a video of police officers mishandling evidence in the Orenthal James Simpson trial and how he was acquitted. I asked Margaret if she wanted to continue learning forensics and she did. In her WID/WIL, she wrote:

> What I did: Intro to forensics, going through a crime scene and the do's and don'ts of collecting evidence. What I learned: How people collect evidence and the different types of ways you can contaminate it.

Margaret worked with Alyssa and Merry to help put the poster together during her 16th session. I wanted them to first explore different poster formats, so I had old posters for them to look at and pick one they liked. Margaret looked at an old poster on diatoms in chironomid guts and shared with the group that the poster indicated that the diatoms in the gut were not exactly the same as the diatoms in the sediment and pointed out design features that could have been improved. We worked as a team to figure out our poster format and started working on a specific section of our interest. Margaret wanted to work on the methods section. We all worked on our individual sections at the same time but the problem we found out at the end was that it did not save any of our changes. Alyssa came up with a solution by creating a new google slide but we were all bummed that it did not save our changes. We decided that we would work on our sections throughout the week and shared our WID/WIL.

In Margaret's 17th session, we had our second forensic science session. In the beginning of the session, we discussed the procedures for making of criminal sketches. We practiced how to make our sketches, use a reference chart, and gave each other feedback to improve our drawings. As she described her brother, I tried to draw him. Vice versa, it was her turn to ask me what my person of interest (in this case my dad) looked like and she tried to draw him. We shared our drawings and made refinements with feedback. After our drawings, I shifted us towards learning about the Bertillon measurement system. She was prepared in advance as she already had her measuring tape ready. We did our measurements together at the same time on the webcam and shared our data. After collecting the data, I asked if she thought it was a reliable system. She said it was not, so I shared with her the Will West and William West Case in which both men had the same Bertillon measurements. Following this activity, we learned about types of fingerprints. We drew our fingerprint cards on a piece of paper. I did not want her to go buy

materials so I asked her if she was alright with coloring her fingers with a marker as a way to get ink for her fingerprints. She was fine with that and I did the same thing. Since her marker was almost dry, her brother came on the webcam and we said hello. She asked him to go get a fresh marker. We both colored our fingers and then pressed our fingerprints on a fake fingerprint card. We categorized all of our fingerprints into a loop, whorl, or arch pattern. We shared our findings and Margaret told me she had eight loops, one whorl, and one arch. I told her that I had eight whorls and two loops. We compared our data to the population frequency and learned that loops were the most common, followed by whorls and arches. Afterwards, we wanted to make our own fingerprint dust. I saw on the internet that this can be created by scraping the graphite from a wooden pencil, so we both tried it. As we scrapped our wooden pencils, I showed her my powder and she also shared her powder on the webcam. Next, we both placed tape over our objects and the placed the tape on a piece of paper. She told me that she was using her mom's makeup brush to dust her prints. Although I could not get a good print, she said she was able to retrieve a partial print and it was neat to see it. To plan for the next forensic session, I asked her if she was interested in trying DNA extraction with a piece of fruit and she said she could manage that with items at home or from her family member living nearby. We both had a lot of fun as we both took a picture and shared our fake fingerprint cards at the end. In her WID/WIL, she noted:

> What I did: marked several types of fingerprints and ways to record a person o[r] you can tell who they are. What I learned: I learned that there are names for specific types of fingerprints, the bertillion system was a way of measurin[g] people.

Alyssa and Margaret worked together during the 18th session to write the abstract to be submitted to the conference. To give them an idea of how an abstract should look, they read different abstracts from a previous turtle conference. Then, we all worked together in a google

document to write the abstract. They worked on the sections that corresponded to the sections of the poster on which they were working. After we were approaching the 300-word limit, we proceeded to do the interview. I asked Margaret how she felt about her involvement in this apprenticeship and she said it was good. When I asked her why, she stated, "I think I enjoy doing this, like I, it's fun to learn how this stuff is happening." I do recall during this interview, we had lots of lag on Zoom which made it difficult to understand what we were saying. Margaret said she was going to leave the Zoom and call me on her phone. When she called in, it made the remainder of the interview run smoothly.

For Margaret's 19th session, we engaged in our third forensic lesson. First, I taught her about the importance of ink chromatography in a forensic investigation. We both set up our chromatography experiment using markers, paper towels, and water in a cup. As always, I emailed her a list of materials to find at home in advance and she was always prepared and ready to set the experiment up. To give our ink chromatography time, we completed the checks activity. I told her that as investigators, it is important for us to make inferences from checks and gather evidence. We worked as a team to come up with tentative explanations which we changed as we gathered more evidence. Margaret stated that a limitation was that since we looked at nine out of thirteen checks, our theories could change if we had more evidence. She understood that one purpose of the activity was to demonstrate that inferences are based on limited evidence that is available. After the checks activity, we conducted handwriting analysis. We talked about the Jon Benet Ramsey case and looked at the handwriting of the ransom note. We both took turns making observations about writing characteristics that we noticed were unusual. We found it was quite odd that the $118,000 mentioned in the ransom note was the same amount as Mr. Ramsey's Christmas bonus at work. We watched a short video in which a forensic writing expert noted

how the writing looked very similar to Mrs. Ramsey's writing. Although this was not a smooth transition, I planned another activity on powder analysis. I mentioned that investigators could find an unknown substance at the crime scene. Margaret and I both grabbed sugar and salt out of our kitchen and tested how they would react with chemicals we had at home. I did not have vinegar, but Margaret did so she tested their reactions with vinegar and I tested it with hydrogen peroxide. We tested how our substances reacted with water. We learned how the textures of the substances can change and described what we saw. She observed how vinegar made the salt dissolve. As it was nearing the end of the session, we shared our paper towel chromatography results with each other on the webcam. In her WID/WIL, she wrote:

> What I did: Tested ink chromatography with marker and pens, and then looked at the different reactions of substances w[h]en they were introduced to something new. What I learned: Even if I did change my handwriting later, people would be able to tell its me, and what ink chromatology was.

Although she got the name of the technique wrong, Margaret seemed happy about the activities we did and I appreciated her being prepared and stayed engaged the entire time.

For Margaret's 20th session, Alyssa showed up with her. My original plan was for them to work on the abstract. However, we found out the conference had removed the link because they were not sure if the conference was going to happen or if they were going to transition online. I had to change the plan last minute, so I ended up making it career preparation day since this was the last time I was going to work with them together. They both wanted to work on creating a resume, so we all did so for our own personal experiences. After we shared what we learned, we did my last interview with Margaret and Alyssa. When asked what mentoring meant to them, Margaret stated that: "I just think it's where one person with more experience and knowledge

helps teach another one." When she stated this, I was thinking about Vygotsky in the back of my mind. When asked about how mentoring impacted her participation, she stated:

> I really enjoy this a lot more, I actually want to come, because like if you weren't super nice about everything, I probably would not have come to the Zoom meetings because I would not be comfortable talking…your kind of mentoring us in like general life because no one has really talked heavily about how to write a resume, or giving me links, and like stuff I need to do to apply for college so it's pretty cool.

We ended the session on a positive note with my colorful plushie making an appearance and we all smiled, giggled, and waved our goodbyes.

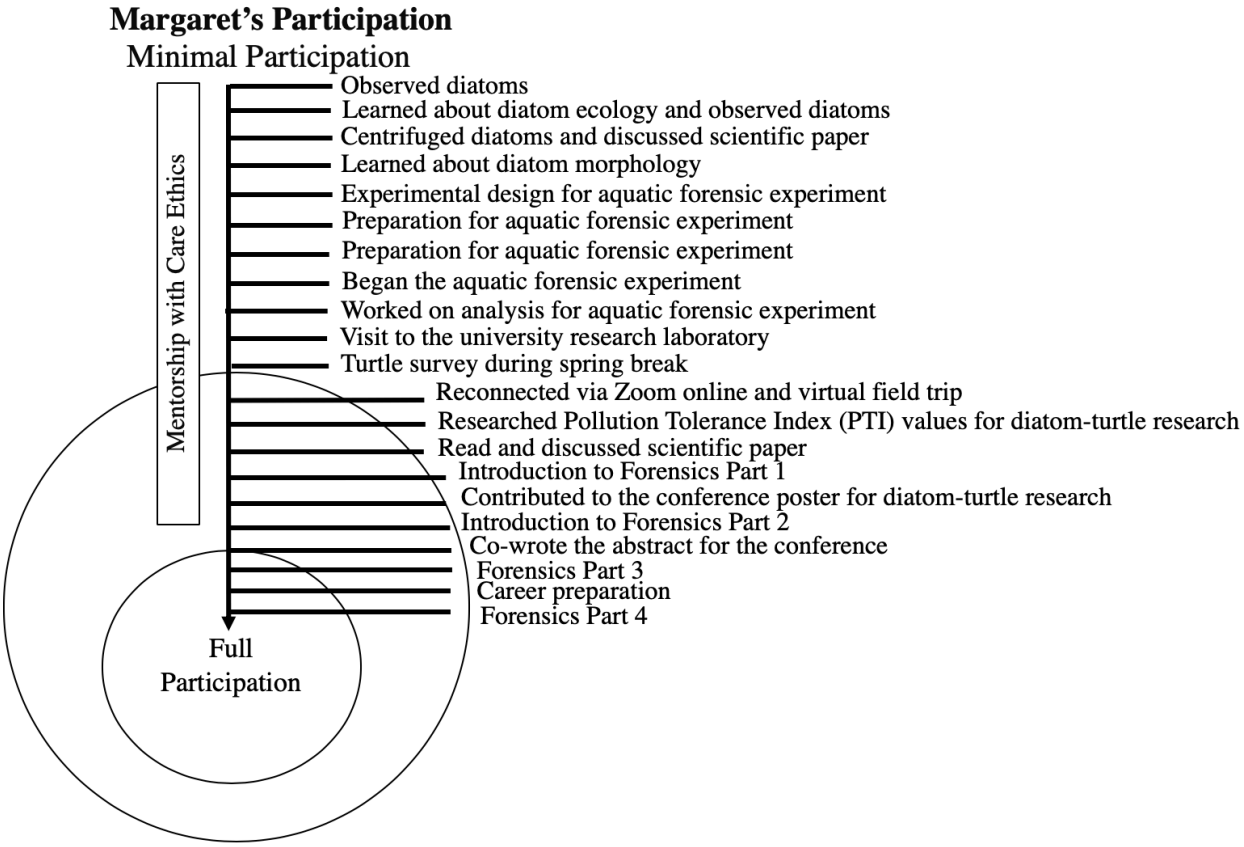
Since we did not get to try DNA extraction, we wanted to have our very last session together, which marked Margaret's 21st time for participation. I emailed her a list and she was able to gather all the materials. We talked about the importance of DNA and then both of us took the time to go step-by-step to extract our DNA from fruit. As we were waiting for the DNA to form in our cups, we did some blood spatter exercises. We both taped pieces of paper together and used food coloring to simulate blood spatter. First, we tested blood spatter at different heights and she noticed that the diameter got bigger as you increased the height. Second, we made different bloodstain patterns and categorized them (transfer stain, passive stain, and spatter). Margaret was able to simulate blood spatter better than me and texted me her picture so I could take a closer look at it. It was fascinating to see her satellite spatter pattern. For our third exercise, we dropped blood at different angles by having paper on a clipboard. She decided to hold her paper on a book instead and changed the angle of the book. When I asked her about what she noticed, she noticed that the blood spatter pattern got skinner as we increased the angle of the drop. We watched a short video on the angle of impact so she could see how that was used

to calculate the area of convergence. For our last exercise on blood spatter, we tested blood drops at low, medium, and high velocity. We both stood up from our chairs and simulated the drops on a piece of paper. When we were doing high velocity, I went too fast and made a mess. We shared our findings and made eight droplets in our high velocity simulation. We checked back on our DNA extraction and it did not work for either of us. At the end, I wanted to share forensic careers of possible interest to her since I knew it would be our last session. I gave some ideas about necessary education, average salary, and programs in Texas. At the end, we appreciated each other; I sent up a follow up text thanking her and she responded very kindly.

Collectively, Margaret participated the most in the apprenticeship (Figure 1). Although she was introverted, I learned that her being silent in moments did not equate to disinterest. As she stated early on that her interest was in forensics, caring ethics with mentoring resulted in her being able to incorporate her interest in an individualized research experiment that she implemented. Although the pandemic interrupted the second experiment we planned, Margaret still participated in her forensic interests online. She was always prepared in gathering materials from her home for the activities and was actively engaged in our discussions. Of the participants, she and Alyssa were the only ones who consistently came twice a week and also showed up consistently. Her active participation allowed her to maximize the most out of the apprenticeship.

Figure 1

Margaret's Participation Throughout the Apprenticeship



Alyssa

Alyssa was a half-Mexican and half-Chinese female student. At the recruitment meeting, she was sitting next to Merry. As they were sitting in the back, I did not get a good look at their faces and only took a quick glance. I asked Mr. Chelydra if they were siblings and they were not. I felt extremely embarrassed that as an Asian American, I stereotyped them thought they were siblings. They were quiet at the recruitment meeting, but I recall that both of Alyssa's parents came which gave me the impression that they were highly involved parents. At the end of the recruitment meeting, Alyssa's mom came up to me, thanked me, and shook hands. Through personal conversations, I learned that Alyssa was very interested in science, was active in the science club that competed with other schools, was also involved in a political club on campus, and her other brother was an active participant of the turtle survey.

At the first turtle survey, Alyssa and Merry helped collect diatoms from turtles and the rest of the day, they went with the other high school students looking for turtles. I did not get to know her very well that day but developed a good mentor-mentee relationship after school when the apprenticeship started. Alyssa was highly involved in the apprenticeship as she came for a total of nineteen times. Throughout the apprenticeship, she generally came twice a week and wanted to stay longer but her parents coming to pick her up ended our time together. I could tell she was really enthusiastic about learning.

In Alyssa's very first session, she learned diatom basics and observed diatoms. As I wanted to get to know her interests, she stated she was interested in scientific reading and writing. We developed a plan of potential topics for future paper discussions. At the end of the session, she looked at live diatom specimens.

During the second session, Alyssa was not sure if she should address me as "Ms. Wu" or "Shelly." To reduce the power-dynamic in our mentor-mentee and researcher-participant relationship, I asked her to address me by my first name. I could tell that Alyssa wanted to be respectful towards me. As we began, she read the introductory diatom article and we had a brief discussion about it while Merry was making diatom observations. Alyssa then worked with Merry to make observations and identify their diatom. After Merry left, Alyssa and I discussed the Neil and Allen (1954) paper. She asked a lot of questions and was surprised to learn that scientists could publish before getting their doctoral degrees. She was thinking conceptually as she made the connection that Carla caught a musk turtle from the bottom of the river and that could influence the amount of algae on the turtle shell. As she left, she stated that she wished she had her own car so she could stay longer.

In her third visit, it was unexpected for four participants to show up at the same time. Since Alyssa had already read the introductory article but the others had not, she read Burge et al. (2017) on the topic of paleolimnology. After I facilitated a paper discussion with all participants, Alyssa and Grace observed diatoms and worked on learning identification. After everyone left, Alyssa stayed so we continued our discussion of the paleolimnology paper. I gave her an introduction to paleolimnology and diatom stratigraphy. The paper talked about life histories and Alyssa asked me about diatom reproduction. We discussed how diatoms reproduce both asexually and sexually, and I could see her taking notes and we ended the session on diatom taxonomy.

During Alyssa's fourth visit, she worked with Merry to learn diatom morphology, and Carla was also present at this session. To help probe Alyssa and Merry's thinking, I asked them questions about diatom symmetry and parts of the diatom cell. I used my *Luticola* model for explanations. As they were learning diatom morphology, the topic of politics came up. Alyssa and Merry told me about their participation in "Students Politically Unite" to try to create more unity instead of division among political parties and we talked about many political issues. I mentioned that there was a documentary on Netflix by Robert Reich who stated that the biggest party is not Republican or Democrat, but the non-voting party. We continued discussing major issues in school and then horror movies. At the end of the session, we watched the National Geographic diatom video and we all giggled as I was dancing to the music in the video.

I originally anticipated that Alyssa would come on February 11th, but before the session, she let me know she had a lot going on and I was completely understanding. She came on Friday as usual as her fifth visit and worked with Merry to identify diatoms samples that we processed from the turtles. After Merry left, Alyssa decided she wanted to finish learning about diatom

morphology and decorated a diatom box and we briefly discussed Gordon (2009) on diatom applications in nanotechnology. Afterward, I modeled how to make diatom slides by inverting the cover slip on the slide with corn syrup and Alyssa practiced making a few slides. Lastly, we looked at *Pinnularia* and she asked me about the morphology. Towards the end of the session, I held the first interview with Alyssa and learned that she enjoyed her involvement in the project because I was open to what she wanted to learn.

The sixth visit was an important turning point with Alyssa and Merry beginning their research projects. Alyssa had indicated earlier that she was interested in paleolimnology so I wanted a project that aligned with her interest. She examined fossil-diatom samples that I brought. In the beginning of the session, Alyssa made observations, while Merry looked at diatom-turtle samples since she had not indicated a specific topic of interest. As she took a peek at Alyssa's fossil sample, she became much more interested so they decided to work together on this project. They spent the session making initial observations and taking pictures of diatoms from Newport Beach, CA.

Alyssa and Merry continuing the fossil-diatom project during the seventh visit. As I was helping Carla learn about diatom morphology, Alyssa and Merry made observations and took as many pictures as possible of all the specimens in the sample. I introduced community analysis so they would understand our end goal with figuring out environmental inferences. After everyone left, Alyssa continued to stay and look at the diatom samples, particularly what I called the "radioactive" diatom until her parents came. In her WID/WIL entry, she wrote:

> I learned how different the sample diatoms were from what we normally see. They are generally more pennate (?) (circular) and seem to be more intricate. I identified a

> "radioactive" diatom. From overhearing Carla's conversation, I learned diatoms can be found literally anywhere where there is moisture...I also learned the difference between parts of a sponge from an actual diatom.

During the eighth visit, Alyssa and Merry worked together on the fossil-diatom project while I was assisting Margaret with her forensic experiment. Margaret needed lots of help so I was not able to interact with Alyssa and Merry during this session. This was an example in which I had a difficult time giving my attention to all participants equally. However, Alyssa and Merry already knew the routine and continued taking images and documenting their diatoms and the session ended when they left. Normally I would meet with Alyssa on Friday, but for Friday of that week, I was distressed. The previous night, I was at an event in which one of my colleagues was robbed and a gun was pointed at her. We were all a couple of feet away when this occurred and saw our colleague fall to the ground and she went to the hospital. She ended up being ok but all of us were not emotionally well. I was not in the right state of mind to work with Alyssa on Friday and canceled the session.

The week before spring break, all of us were fairly busy. Normally I would see Alyssa on Tuesday but she communicated with me that she had a lot going on and I was understanding so she did not come. On Wednesday of that week, Alyssa did not normally come but I let her know that we had a visit planned to a research laboratory at the nearby university. She came which was her ninth time participating after school. We all dropped our backpacks off at my apartment since it was on the way and then headed to the laboratory. During the visit, I could tell that Alyssa was listening attentively. As an undergraduate student happened to walk in during the time, she told us about her research. I asked her if she had presented a poster yet - she said no but that she would be doing it soon. I think that was when all of the students began to realize the importance

and unusual opportunity for high school students to present a poster. Alyssa's WID/WIL entry indicated that she learned a lot from this trip:

> I learned that research could take a long time, even for such little results. Unlike our labs where we expect the outcome, a lot of times, you just don't know when we are conducting research. I learned about how in Peru, the sustainable programs that encourage catching big fish rather than these young ones has both pros and cons. Pro: allows the population to replenish themselves. Con: biomagnification especially of mercury can be bad for humans. Rainbow throat of the same species may come back to certain places to have more babies and there may be genetically different between the two. I learned about the invasive species (I don't know how to spell it) that needs to be heavily researched because it costs $900 million a year. The plants in Florida have become resistant to the herbicide. I learned about the research of how horned frogs, whose diets are more varied and have less predators. They are working with zoos to reintroduce them into Texas, but they need to know about which region they came from before releasing them into the wild.

The 10th time participating was the last time I saw her in person before the COVID-19 pandemic. She did not stay long but assisted Merry with making the poster for the project. Alyssa was on her phone a lot, but I know this was unusual and she was not trying to be rude. She was communicating with her parents on a pick-up time and then she left.

After the pandemic started, Alyssa participated for nine more times virtually via Zoom sessions. During the first week back on Tuesday for her eleventh session, she joined the group to reconnect after the school shut down. She did not want to share her screen, but listened attentively to Margaret and Grace sharing their virtual tours. Alyssa also sounded stressed with

Advanced Placement (AP) exams so I was understanding. On Friday of that week (her 12th session), Alyssa helped research Pollution-Tolerance Index values associated with the diatom taxa that we found on turtles. After we compiled our data and I began asking questions to explain why the Texas turtles might be in a more polluted habitat, Alyssa stated that there was a lot of elephant poop from the zoo being released in the river. She was the most inquisitive as she asked me how nutrients would impact algae in the river. We ended our discussion on how human activities have added excess nutrients to aquatic environments. The following week during Alyssa's 13th session, I did not want to overwhelm students since they had AP exams so I decided for us to just meet on Fridays. I wanted to give them options to prepare the poster, and Alyssa and Margaret decided that they wanted to read the new diatom-turtle paper. After we shared what we learned, we did the interview together. Alyssa stated in the interview that she enjoys her participation because she is provided options and she can actually participate instead of watching me. In her WID/WIL, she shared that:

> The diatoms from the turtles were comparable to the samples from stones and plants. However, at one of the sites, there was one group that gave inaccurate results. Looking from the graph due to how skewed it was, the BDI [Biological Diatom Index] may best be calculated from doing median. This also means that more individuals need to be used to decrease variability and overcome outliers. There are many factors that could affect the species of diatoms on the turtles besides water equality. To me, it makes me a little more hesitant to trust the results if there could be other influences. One advantage to using turtles is that they move and may give a more diverse, better indication of water quality. The mass effect could explain why the epizoic, epilithic, and epiphytic results are similar.

She learned a lot from this paper and at the end of the session, she asked me about the mass effect hypothesis and if she could learn more about it. I asked them if they wanted to continue meeting once a week or more, and they indicated they wanted to meet more. I wanted to ensure the experience was tailored to their interest so we decided a game plan for next time and increased our frequency to twice a week.

In the 14th session to follow up on her interest to learn about the mass effect hypothesis, we read the paper in advance to prepare for our discussion. It was a very complicated paper so I prepared a short PowerPoint with lots of visuals to help her make sense of some of the concepts such as alpha, beta, and gamma diversity. To help scaffold her thinking, I asked her questions as we progressed throughout the paper. The major concepts we discussed were niche relations, habitat diversity, the mass effect hypothesis, and ecological equivalents. I wanted to situate these concepts in what we have learned and talk about the diatom-turtle research. At the end, I wanted to know if she had any questions and she asked me several such as how long it takes to publish and how the publishing process works. She wanted to continue a paper discussion and I asked what her topic of interest was. She said she wanted to know more about diatoms on water quality, so I asked her if she wanted to read a paper by Dr. Diatom* (pseudonym) and their colleagues. I explained that they studied the effect of pharmaceuticals on aquatic life in streams and Alyssa expressed an interest in the paper. I also mentioned the possibility of speaking with Dr. Diatom one-on-one, so reading this paper could also provide us background knowledge to have a conversation with her. Unexpectedly, we spent the end of the session talking about college and her aspirations. In her WID/WIL, she wrote what she learned from our discussion:

> I learned how to calculate the beta diversity. I learned the impact factor of papers is the average number of citations per year. I learned about habitat diversity and how it mains

species diversity. I learned that niche differentiation is how species occupy certain niches and require different environmental factors. I learned that convergent evolution was how species from completely different habitats can evolve to occupy the same niches.

The repeated discussions on scientific papers over the course of the apprenticeship has allowed her to learn complex, scientific concepts and also the norms of how scientific papers are published and cited.

In the 15th session, Alyssa, Merry, and Margaret created the poster together for the turtle conference. To ensure we were all on the same page about designs we wanted to choose, each looked at old posters and took turns sharing what we liked and what could be improved with the design. We voted on which poster format was the best and began to select what specific sections of the poster we wanted to work on. Alyssa decided to work on the discussion section, while the other two and I were working on other sections of the poster. After about an hour of work, it was frustrating that our changes did not save as we were all working collectively on a document. Alyssa said it may have been an issue with it technically being a PowerPoint slide, so she converted it to a Google slide to help us save our work. Since we did not finish, we decided to finish our sections on our own.

Alyssa and I discussed the paper from Dr. Diatom on the effect of pharmaceuticals in aquatic environments during the 16th session. We talked about the effect of drugs on aquatic life and then the Baltimore Watershed. Then, we talked about the methods used in the study, in which the authors created artificial streams to test the effect of amphetamine on bacteria and diatom communities. As we discussed the data, we only focused on a couple of elements trying to gather the “big picture” on findings. As I asked questions throughout our discussion, Alyssa was very engaged. At the end of the discussion, I did not expect us to talk about statistics but

Alyssa brought up the topic and stated that she was learning about confidence intervals. Since she wanted to learn more about statistics, we talked about the statistics in the paper such as p-values. Our discussion went on a statistics tangent to learn about different types of statistical tests, both univariate and multivariate. I told her it all depends on the number of variables, groups for comparison (if applicable), and the assumptions of the data which help determine the appropriate test. On a lighter note, we ended up playing "guess the correlation" game on the internet in which we took turns guessing the R value for the scatterplot and we laughed. I asked her if she wanted to meet Dr. Diatom and she said she did, so I planned a meeting.

The next time we met (17th session), Alyssa, Margaret, and I worked on the abstract for the conference. We wrote sentences that corresponded to the poster sections that we individually worked on. After reading and writing for about thirty minutes, we did an interview. Alyssa stated that she felt good about her participation:

> I enjoy it too and I think it's a good balance of like, us being involved but you will still like take care of editing and help us with the format and I feel like we involve like, just the right amount and you help us with it.

The 18th session was exciting because Alyssa and I discussed the paper by Dr. Diatom and she agreed to join our Zoom session for a personal conversation. Alyssa asked Dr. Diatom how to obtain a job at her workplace, the challenges of doing research such as funding and sexism in science, what it is like to do research in quarantine, and how to figure out research ideas. I asked a few questions such as the relationship between her work and policy and what needs to change for science to be more attractive and inclusive to women. We ended the session on a really good note and Dr. Diatom even asked Alyssa about her aspirations and what she had been learning with me. Alyssa stated what she walked away with:

> I learned that the research she does goes into the policy department of [X organization]. Currently there seems to be like [meant to say lack] of funding (most likely from X person). Research for her usually isn't just what makes her curious like professors. Because it is taxpayer money, they have to research what Congress wants and what would benefit the taxpayers the most. With Covid-19, she can do a lot of her normal stuff. However people who do fieldwork or need special equipment are struggling a lot more than her.

For Alyssa's 19th and very last session, I originally planned on resuming diatom-turtle items. However, the turtle conference was not accepting abstracts as they were not sure about the status of the conference with COVID-19. This meant I had to rearrange the plan for the day and decided to do career preparation. I gave Alyssa and Merry work options and they decided to make resumes. We all took the time to work and then shared what we learned. We did our last interview together and Alyssa shared the following:

> I think like a mentor like teachers and stuff, but like good ones also guide you and help you find opportunities, and just like bring the best of you...You guided us, and like helped us find opportunities, and you basically made sure that we were like, as a mentor, you like made sure that we were involved and participated, and you gave us a lot of new skills and taught us new things...I guess for example, you gave us skills on like how to write abstracts, and how to do research, and how to read it, for me, like how to read and analyze some, and like how your just giving us like opportunities to present at a conference, and like you hooked us up with Dr. Diatom and all of that.

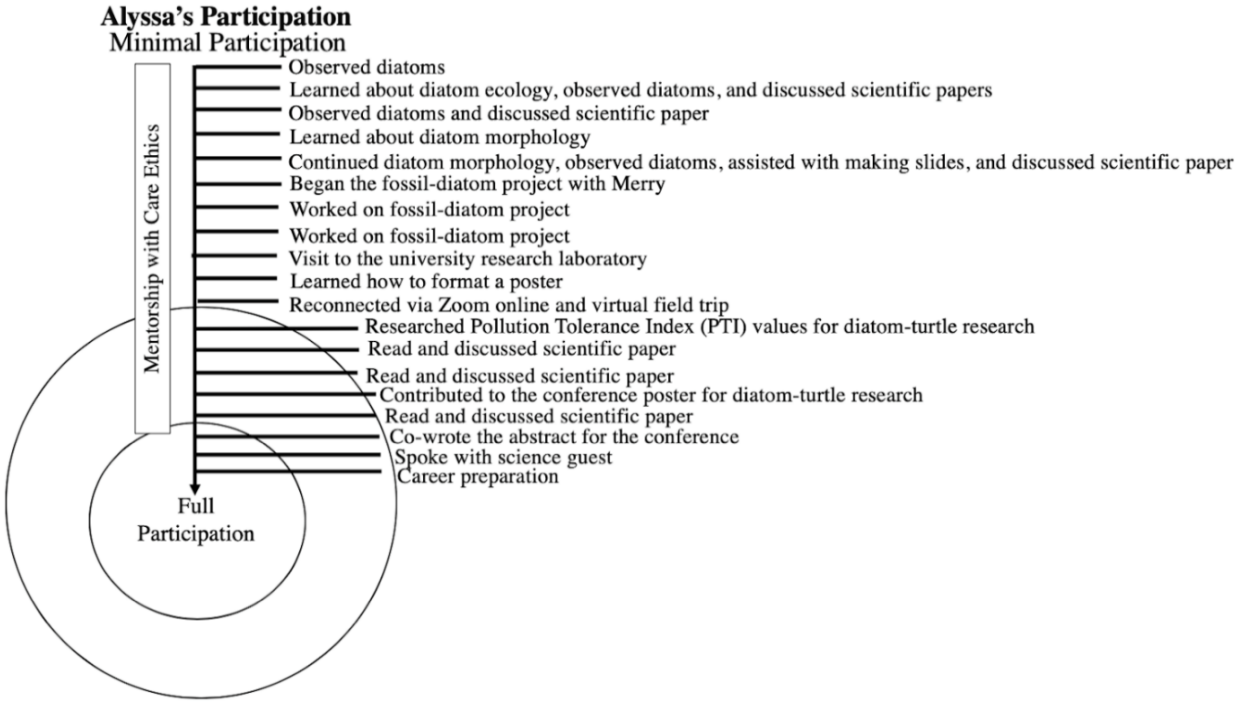
The interview also took an unexpected turn when they brought up a student from the turtle survey and told me a funny story which resulted in laughter. We also reminisced about good

people we had met. I was getting a little sad as this was our last session together and Alyssa made an impression on me when she expressed sincere gratitude.

Collectively, Alyssa's high engagement through the apprenticeship afforded her with the opportunities to shift from a newcomer in a community of practice to understanding the practices and norms in science (Figure 2). As she expressed her interests and took ownership of her learning, she was able to work on the fossil-diatom project in the physical environment. After we started meeting online, she still expressed her interests with reading papers. This allowed her to learn more about research and led to a discussion about Dr. Diatom's paper and career. She was also still engaged and highly involved with the completion of the diatom-poster project for the conference. Alyssa maximized the most of her apprenticeship experience by infusing her interests and participating consistently.

Figure 2

Alyssa's Participation Throughout the Apprenticeship



Merry

Merry was a Chinese American female student. At the recruitment meeting, she was sitting next to Alyssa. I felt ashamed that I asked Mr. Chelydra if they were siblings since they were both Asian-American and documented my bias in my notes. In our conversations during the apprenticeship, I learned that she is adopted from China by a single mother, has a sister in college in Ohio, is artistic, likes to dance, and is good friends with Alyssa as they are both involved in the science and political club.

At the very first turtle survey, Merry helped sample diatoms on turtles. As students helped sample at least one turtle, I learned that Merry and Alyssa knew each other since eighth grade, but did not become good friends until high school. I complimented her turtle necklace as I thought it was fitting for the turtle survey. For the rest of the day, Merry and Alyssa stayed with the other high school students so I did not get to know Merry and Alyssa more that day.

Merry's participation in the apprenticeship was moderate as she came for a total of thirteen times after school and virtually online after the pandemic. In the beginning of the apprenticeship, it took me some time to get to know Merry as she is introverted. She often came with Alyssa, as they were good friends. In my first session with Merry, she learned about the basics of diatoms including what they are, where they are found, and their ecological significance.

During her second session, four participants showed up. While we discussed the introductory diatom article, she was very quiet so I could not tell if she was shy, not interested, or both. To change the pace and make it more exciting, she worked with Margaret to look at diatoms under the microscope and identified diatoms together. Although they were both very quiet and there was initial awkwardness with who would look at specimens first and take turns,

they were very respectful to each other and worked as a team. They observed and identified several diatoms including *Nitzschia*, *Aulacoseira*, an araphid diatom, and *Navicula*. For the araphid diatom, they learned that diatom taxonomy can be messy for certain taxa, particularly *Ulnaria* and *Fragilaria*. They worked well together to make observations on the Diatoms of North America website and figure out identifications together.

For our third session, Merry and Alyssa worked together to make diatom morphology models. While they were learning, we had some personal conversations in which I learned that they were part of the "Students Politically United," a bipartisan club that was different from the "Young Republican Club" or "Young Democratic Club." We discussed politics, finding common ground, and the importance of people taking action. The conversation transitioned to the school issues I noticed in the school district and how student's needs were not always met. I also learned that Merry was adopted in China and has a sibling; the day ended with good conversation.

For session four, I anticipated that Merry and Alyssa would show up together so I could interview them together. However, Alyssa was extremely busy and told me she would not come for the day. I did my first interview with Merry and admit it felt awkward for various reasons. I wanted to interview in the science classroom but students were already doing something and I did not want to disturb them so we moved to the classroom next door which was noisy and Merry was shy during the interview. Because Alyssa was interested in turtle survey and the after-school apprenticeship, she thought the opportunity to do science sounded cool which influenced her involvement. She often gave short responses so it was hard to further ask her to expand on her responses. Merry stated that she was "learning a lot which is cool" but also revealed that sometimes she was a little confused on what was going on regarding the projects. I assured her it was alright not to know as we were figuring out their interests and would build it into a research

project that they would present at the mini-symposium at the end of the semester. After the interview, she helped process diatom samples on the hot plate and began to decorate her morphology model box.

Merry wanted to finish her diatom morphology model when she arrived for the fifth session but could not find it. I had no idea what happened to the model because it was not in the spot it should have been. I did not know if I accidentally misplaced it or someone took it. Regardless, I felt I should have done a better job securing her diatom model and felt bad about it. Merry and Alyssa began looking at a diatom-turtle sample that we finished processing and practiced how to take pictures of diatoms on their phones; Merry had to leave early.

The sixth session was an important turning point for Merry to get on-board with a research project. During the session, Alyssa and Margaret already expressed their interests, so they began planning and working on their projects. Since Merry had not specified her research interest yet, I thought I would give her time to work on diatom-turtle samples until she vocalized what she wanted to research. She began looking at diatoms from turtles. However, as Alyssa was looking at fossil diatom samples, Merry was curious to see what the fossil samples looked like. I saw a change in which she was actually much more fascinated by the fossil samples and started taking pictures with her phone, which she did not do with the diatom-turtle samples. Given that she was now excited, I mentioned that perhaps it could be a good idea for her and Alyssa to collaborate on the fossil project and she thought it was a good idea.

During the seventh session, Merry and Alyssa collaborated to take images of all the different fossil species in the sample. I introduced the idea of a diatom flora and their goal was to start compiling pictures to build a flora so we could use it later when we do diatom counts and community analysis. In her WID/WIL, she wrote:

What I did: I looked at diatoms from a fossil sample under a microscope and took pictures of what I found. What I learned: I learned about counting diatoms and also how to work the microscope. We found new diatoms and I learned about some of them.

At the eighth session, Merry and Alyssa were working independently to find more species, while I spent most of that session assisting Margaret with setting up her experiment since it required more work, whereas Merry and Alyssa's project was more descriptive and they worked well together.

I engaged with Merry two more times in the physical classroom environment before COVID-19 resulted in the school closure. In the ninth session, Margaret and Merry showed up. I think their group dynamic is different because they are both shy and do not know each other well. Merry was less talkative when her friend Alyssa was not present. During this time, I conducted the second interview with Merry. It was much better this time, as we were in a familiar classroom environment, and it felt more conversational as I did it while we were doing microscope work so there was less awkwardness. After the interview, we continued microscopy work and I learned that Merry was interested in studying engineering at a small school. She stated that over spring break, she planned on visiting New Orleans and I talked about my college experience there. During the 10th session, Merry arrived first so she began learning about poster formats and started a poster with the images she had captured. I mentioned that we wanted to start researching the diatoms in the samples to see any environmental inferences. Merry and Alyssa began working together but I did not expect that Alyssa had to leave so early. Merry continued consulting the diatom books to look for any information on the diatom taxa present in our samples. I think Merry did enjoy the work overall, but felt that the dynamic was a little

different when her friend Alyssa was not around. We still had good conversation and interacted with Ramon at the end of the session. In her WID/WIL, she wrote:

> What I did: I looked at another sample from New Zealand and took pictures of the different types of diatomes that were in the sample. What I learned: I learned that there are different species of diatomes in the New Zealand sample than the California sample. There are many that are the same though.

After the COVID-19 pandemic, Merry participated for three more times total and I wondered why she did not come as frequently as Alyssa and Margaret. For the 11th session when four of the students were present on the Zoom session, I noticed Merry did not share her webcam and also did not share her tour. She was not very talkative, so I hope that everything was going ok but could not tell and did not want to force her to talk if she was not interested.

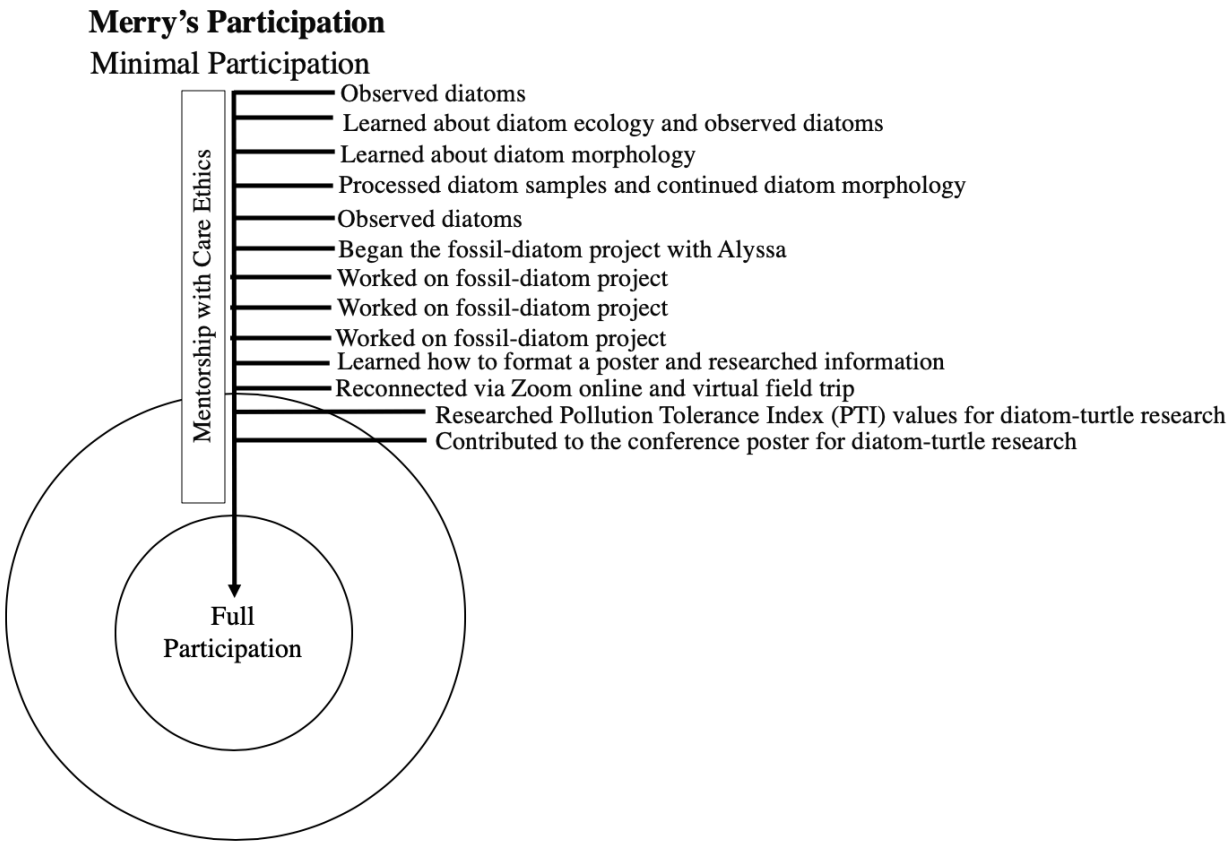
For the 12th session, Merry showed her video. She came in late to the session but did help collect some data. When we plotted our results on a graph and talked about it, I asked them to think about why the water quality was lower in Texas than Oklahoma. I felt bad because when I was trying to relate our findings to what we talked about earlier about oligotrophic compared to eutrophic lakes, I mentioned that Merry missed that part because she was late. I was not intentionally trying to call her out, but after that came out of my mouth, I realized it could have been taken the wrong way. Although Merry was quiet, I do not think she was disinterested as when I asked for the Pollution Tolerance Index (PTI) values, she was prepared to share what she had found. I had to learn over this apprenticeship that being quiet does not mean that a student is disinterested. For the following two sessions during the week of April 6-10th, Merry did not attend and was worried that I accidentally scared her away.

To my surprise, she joined our Zoom meeting for the last time on April 17th and assisted with compiling the poster. It was nice because her sister was on the webcam and we waved at her. As we all collaborated at the same time on a PowerPoint slide viewed via the Google slide, something happened where it would not save our work automatically. It got frustrating because we spent about an hour and it did not save our changes properly at the end. I extended the invitation for Merry to let me know if she wanted to learn anything Monday through Thursday that pertained to her particular interest since that was what Alyssa and Margaret were doing, and that was the last time I saw Merry during this apprenticeship.

Combining all of her experiences during this apprenticeship, mentorship with care ethics allowed Merry to begin the fossil diatom project with Alyssa and participate in the diatom-turtle research (Figure 3). In the beginning, she started on the periphery of being a newcomer but as she learned microscopy and diatoms, she got more involved in research. However, I always felt that Merry wanted to be a part of this mostly because of Alyssa (as she indicated in the first interview that she got into this apprenticeship because of Alyssa). I wonder what I could have done better to foster her individual interests but she did not vocalize anything specific, so it was hard for me to know how to help her. As she was shy, she was often quiet but still was engaged in the activities, so I had to give myself push-back and realize that being quiet does not necessarily mean students are not interested. I do not know what led her to be less involved after the pandemic but I know that the pandemic was a difficult time for everyone and wanted to be understanding and expected that participation would decline.

Figure 3

Merry's Participation Throughout the Apprenticeship



Grace

Grace, a white female student, was very enthusiastic about science and at the time of this research, was taking Mr. Chelydra's environmental class. At the recruitment meeting, her parents were not present but she was the most vocal about her interests in science, particularly with botany. Of all the students present, she made a striking impression on me. After the recruitment meeting, she was the only one that came up to me and engaged in further conversation about diatoms, botany, and possible research ideas, while everyone else left. Through our personal conversations during the apprenticeship, I learned that she worked at a local pizza shop, had a younger sister, her mother worked at the nearby university, and she was a little rebellious like me, and wanted to eventually go to college outside of Texas.

Grace participated the second least in the apprenticeship as she came for a total of six times after school and virtually online. From the very beginning, she was the most vocal and very passionate about science, so I naturally thought she was going to participate the most. Over time, she was less consistent in coming. Although I do not know the entire picture, she did explain on the very first day that she might miss some after school meetings due to meetings that were related to health. After COVID-19, I reached out to the group and learned that she lost her job. I wanted to be respectful of personal hardships that she might have been experiencing at the time and not further bother her. I still included her in texts and emails in case she was interested in participating.

At the first turtle survey, I observed that Grace was highly engaged as she helped me collect diatoms from turtles. She was the most inquisitive, asking questions such as "How are diatoms processed? Why do we sample at the sites that we do?" She also worked well with Margaret, ensuring that she had an equal opportunity to sample the diatoms and used teamwork. Towards the end of the turtle survey, I recall her mother showed up. During this time, Grace was helping newcomers learn about turtles, gently picking them up and educating people and described how we were sampling them for diatoms.

During the six times that Grace participated after school, she was engaged in learning and her love of botany was expressed frequently. In Grace's first visit, she arrived with Margaret. I wanted to engage them in diatoms, so they looked at dead diatom specimens under the microscope. Grace asked a lot of questions, such as what live diatoms look like, meaning of a biraphid diatom, and what the "µm" symbol meant. She wanted to ensure Margaret had an opportunity to use the nicer microscope, so they took turns. They also looked at a live sample and Grace got particularly excited when she saw *Navicula* moving around. As we were cleaning

up, Grace's love for botany was evident as removed some dead leaves from a plant in the classroom. We also noticed some fish in the classroom that were used for an experiment. We all put the fish back into the larger tank and left.

In the second visit, Grace was present with the other three students. During this session, I first held a discussion on the introductory diatom article. Grace was one of the most vocal in answering the questions that I posed to the group, such as answering my questions on how the diatoms developed on the clay pots submerged in the experiment. When it came time to work in pairs with the microscope, I felt there was an awkward dynamic because I let them select whom they wanted to work, and Grace stated that she wanted to work with Alyssa because she knew her more than Merry. Grace and Alyssa identified diatoms together while Margaret and Merry worked together.

In the third visit, Grace participated in the first interview with Margaret. During the interview, she commented that she wished she was more available after school because she enjoyed her participation:

> I feel like I have learned a lot about diatoms and turtles in general. Cause I wasn't, I didn't like Margaret, didn't really know diatoms existed…I think you have taught me a lot and helped us kind of figure out how to look at them and how to perceive the diatoms, and what we could possibly do in this project…I really like looking through the microscopes, trying to identify them, and I think that uh mentoring is guiding me through learning about this new field that we don't know about.

She did express that she wanted to get more into the research as she stated, "I would like to get like more into stuff about projects we can do and like start to diverge, now that we have a relatively stable base" and I appreciated her feedback. It was a little difficult to start the research

as we were still processing diatom samples (which take a while). We discussed ideas we could pursue once samples were processed or after we collected specific samples from the river. I gave Grace options and she stated that she wanted to write in her notebook. She opened her laptop and browsed the diatom website, wanting to learn the morphological groups. She was making notes and drawing in her notebook. During this time, we had personal conversations about our rebellious natures. Both of us got tattoos as a way to rebel against our moms. She showed her mushroom tattoo and I showed my diatom tattoo. We also talked about what she and Margaret were learning in their other classes such as Vygotsky and Piaget in their psychology class. After Margaret left, Grace was sharing her love of botany with me, telling me about orchids and ferns. As she was leaving, we talked about our siblings and I learned about her little sister being sassy, then she left.

At the next meeting (her fourth), I asked Grace if she wanted help figuring out her research idea, and she said she wanted some time to look up ideas on her computer. I admit that was not how I envisioned the development of the research plan and also worried about time since it was already past mid-February. I still wanted to respect her timeline and agency in the project, letting her know I was happy to help if needed. She helped Margaret cut pieces of cloth for her forensic experiment and contributed an idea for the setup which we implemented. Afterwards, Grace looked at samples of diatoms from aquatic plants under the microscope.

During Grace's fifth time participating in the apprenticeship, we visited a nearby university laboratory to learn about the scientists' research projects. Like the other participants, Grace gave her full attention to the scientists telling us about their work in the laboratory. She was most interested in the aquatic invasive plant present in the room. When we left the university

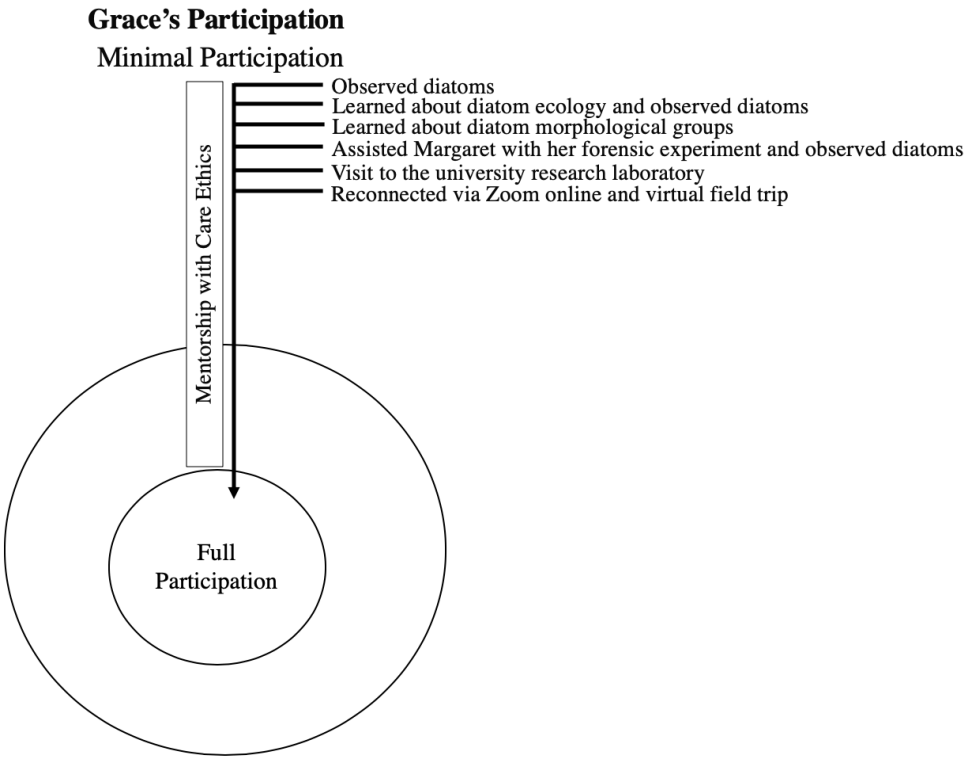
and headed back to school, Grace was telling me about hydrilla, and her interest in attending Washington College to study hydrilla in the Chesapeake Bay.

For the first virtual session that I held, we caught up on how we were doing since the school closures began due to the COVID-19 pandemic. I was surprised that Grace was the first one to arrive in the Zoom meeting. As we were catching up, she showed me all the different plants in her room, so I showed my bamboo plant too. She told me about the large bamboo plants she saw when she was visiting family in another state. As the virtual session proceeded, I wanted to ensure that there was a virtual place for participants to visit that aligned with their interest. Since Grace was interested in Botany, I found the Longwood Gardens and Morris Arboretum in Google Poly for her to explore. During our group session, she was very enthusiastic and wanted to share her tour. She told everyone that she actually had been to this place when she was visiting family in Maryland and was very excited to point out things in the garden such as the fernery and hydrangeas. She interacted well with the group, and this was the last I saw Grace.

Collectively, the mentorship with the enactment of care ethics allowed Grace to participate on the periphery of the apprenticeship as a newcomer (Figure 4). She learned about some diatom basics, microscopy, and a little about science research, but she did not get to the stage of developing a project like Alyssa, Merry, and Margaret. I did not get a full picture of what was going on in Grace's life, but know that she had a job and medical-related visits that limited her schedule. In my last interview with Alyssa and Margaret, both stated that they thought Grace was super interested in the apprenticeship, and we all wondered what happened. I am grateful for the times that Grace was able to come and was always enthusiastic about science.

Figure 4

Grace's Participation Throughout the Apprenticeship



Carla

Carla was a white female student who was very enthusiastic about science and at the time of this research, was taking Mr. Chelydra's environmental science class. She seemed to have supportive parents as her father came to the recruitment meeting. Through our personal conversations during the apprenticeship, I learned that her father is a real estate agent and her mother is a psychiatrist. Carla was involved in the school's band (playing the snare drum) and ran track. I also learned from Alyssa and Merry that she was also interested in politics.

Carla participated the least in the apprenticeship as she came for a total of two times after school. However, her participation does not appear to be due to lack of care ethics. She had expressed early on that she was more interested in learning about turtles than diatoms, so Mr. Chelydra was going to mentor her more closely more on turtle aspects of the research (his area of

expertise). During the first turtle survey together in January, I observed that she was proactive in catching turtles with a net, which is very rare for female students present at the survey. As she was busy helping catch turtles, I did not get to interact with her much that day.

For the two times that she came after school, she was very respectful about diatoms, even though she was more interested in turtles. The first time that Carla came on February 7th, she observed diatoms under the microscope and told me about an NPR podcast called Radio Lab, where she learned about diatoms. It was during this time I learned about her parent's occupations. As we continued making observations, I asked her if she wanted to keep going or try something different. To my surprise, she was curious about the algae present on the turtle in the classroom aquarium tank. I wanted her to pursue her interest safely so we approached the classroom tank and we carefully removed the turtle. Since it was a juvenile common snapping turtle, we used teamwork to safely handle the turtle and gently let her scrub the shell for algae. Carla seemed really happy in the moment and made a wet mount of the sample. She thought it was really cool to see rotifers in the sample. During this time, Alyssa and Merry showed up after school and Carla had a good group dynamic with them. As I wanted to give options, Alyssa and Merry worked on learning about diatom morphology while Carla continued looking through the microscope. At the end of the session, I wanted to show them a short National Geographic video on diatom art. I was trying to connect to the internet as a guest which was really slow, so Carla offered her login to get a faster connection. Once connected, I played the video which I have seen many times, but I never get tired of it. As the corny music was playing, they could see me slightly dancing and humming to it, and they all giggled. I recall feeling really happy in the moment to share my love of diatoms with the students.

Prior to Carla's second visit, Mr. Chelydra gave me a heads up that she was coming. I was not sure if she was coming because the last time I saw her was February 7th and this second visit was February 21st. I was a little skeptical if she would come, especially since her interests was more in turtles than diatoms so I was not sure what her motivations were. When Carla showed up, I still wanted to connect with her and give her options for the day. Carla decided she wanted to decorate a diatom morphology box and was interested in learning about the parts. As we discussed diatom morphology, she asked me great questions such as "are there diatoms living in the air?" Around this time, Mr. Chelydra told me that Carla was going to start a project looking at different rates of decomposing fish as turtle bait. Although I was skeptical at the start of the session that she was going to come, I had to challenge my own views and realize that Carla took the initiative to come. I was happy that she would be starting a project that aligned more with her interest with Mr. Chelydra soon. As the session was coming to an end, she wrote a WID/WIL entry:

> I learned about the different types of diatoms, including the cylindrical and more oval ones. When we looked on the slide we saw a "radioactive" diatom that looked like the radioactive symbol. When I decorated my box I learned the parts of the diatom including the epivalve and hypovalve.

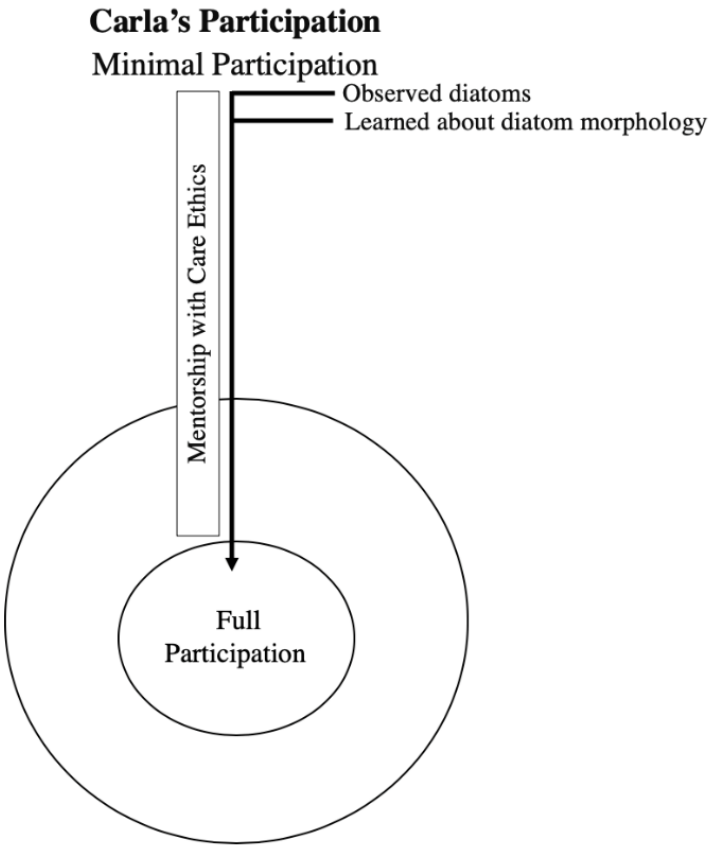
In a short amount of time, she did pick up on diatom basics. After she completed her WID/WIL entry, she waited for her father to pick her up. She told me about track practice and I shared stories about my high school days running track. This was the last time I engaged with Carla during the apprenticeship.

In thinking about the degree of mentorship with the enactment of care ethics, I did not mentor Carla on a project since it was decided early on that her interests aligned more with Mr.

Chelydra's expertise on turtles (Figure 5). This also meant that I did not get to develop a close relationship with Carla. However, for the two times that she participated, she still demonstrated interest in learning and was engaged the entire time, also having a good group dynamic with Alyssa and Merry. Although I was not able to get a full picture of what was going on in Carla's life, I had to challenge my own views on her participation and consider her time commitments with track and band which I learned about towards the end of my last session with her.

Figure 5

Carla's Participation Throughout the Apprenticeship



How Student Conceptions of Care Ethics Compared to my own Conceptions

In the section, cross-case analysis was used to describe similarities and differences between students' conception of care ethics in my own conception throughout this apprenticeship

experience to address the second research question (Table 2). This section is outlined in three subsection sections. The first subsection briefly describes conceptions of care ethics. There are both similarities and differences in how students conceived care ethics compared to my own view. I caution that the interpretation was incomplete, as participation in the apprenticeship was reduced after the pandemic; Alyssa and Margaret were the only students who consistently continued to participate after the pandemic and they were the only two students to corroborate the findings with member checks. Furthermore, Carla is excluded from the results due to minimal participation throughout the apprenticeship and was unable to capture her view of care ethics. The next two subsections following the conception of care ethics describe ways in which care ethics occurred and ways in which a lack of care ethics unfolded during the apprenticeship.

Views of Care Ethics

A similarity was that three of the students (Grace, Margaret, and Alyssa) thought that care ethics was about investing attention towards something in which you are interested. For instance, Alyssa stated:

> Ethics are like, our morals and our principles and define what we think is good and bad, and sort of like shapes how we see the world and how we interact with people and other living things, and I guess just like dictates a lot of our actions and I guess a lot of people don't agree with certain ethics and stuff, so I guess it's all subjective from like perspective...Caring ethics kind of means how you show that you care I guess, in like, so I guess like what you define as caring and like your view of it, if that makes sense.

As students conceived care ethics as investing time and effort into something you care about, they saw care ethics as doing the activities during the apprenticeship because they were interested in it. For instance, Margaret stated:

> I haven't seen caring not happening. And everyone has been [attending] pretty regularly, and stayed off their phones, and they have done stuff, and they have looked through the microscope and identified stuff. And if they didn't care, they wouldn't do that.

It appeared that their view was that care ethics was related to effort; caring was invested in activities that they cared about, and caring would not be invested if students did not care about it.

Another view of care ethics was considering other people's feelings. Merry stated that she saw this happening during the apprenticeship in which we would help each other if someone did not understand something, such as helping Margaret adjust the focus of the microscope. Merry stated how working with her peers helped her feel more comfortable with asking questions to gain help. Similar to Merry, I also observed students being considerate of each other's feelings asking each other how they were doing and observed how they practiced care as they assisted each other with activities.

Lastly, from my perspective of myself as an educator, my conception of care ethics was building centers of care through the curriculum. I designed the apprenticeship thinking about Noddings (2005) *the Challenge to Care in Schools* as a framework to facilitate students' individual interests. I also used this as a framework for building care in the educational research process using dialogue, confirmation, practice, and modeling to ensure that caring for students was prioritized. I found that Alyssa observed how I embedded care ethics in terms of the mentor-mentee relationship through our science activities. For example, she stated:

> I do see caring ethics in our science activities. I mean like I said, just the fact that you have all of our lessons prepared and then you let us be involved, and then like you edit

and stuff and you like guide us, and stuff. So I think the fact that you help like personal, I don't know, you just like always try to cater to our interest I think it shows care ethics.

She was the only student to explicitly communicate that she noticed that the activities were tailored to students' individual interests. Although I was doing my best to embed care ethics in the educational research process, none of the students mentioned their thoughts on educational research aspects of care.

Care Ethics during the Apprenticeship

This section describes how care ethics occurred during the apprenticeship and consists of three subsections. The first subsection includes the collective similarities between students and my own observations of how care ethics occurred through engagement in activities and assisting each other. The last two subsections describe a difference of how I personally observed students caring for the environment and how I experienced caring from community members.

Caring ethics through effort and helping each other

Students conceived that care ethics occurred by putting effort through showing up and being engaged in apprenticeship activities. Furthermore, care ethics was facilitated by being friendly, helping each other, or working collaboratively. For instance, during the first week of the apprenticeship, there was only one high resolution microscope and a lower resolution microscope. As Grace was using the high-resolution microscope, she wanted to take turns with Margaret to ensure she had an opportunity to view the diatoms better under the higher resolution microscope. During the third week of the apprenticeship when we began viewing diatom slides we made, Alyssa and Merry were learning how to take images of diatom specimens with their cell phones. They struggled to get their images in focus but were assisting each other. Another example was during week four, Margaret was beginning to set up her forensic experiment. Grace

took the initiative to contribute ideas for how to suspend the pieces of clothing in the pond and helped Margaret cut pieces of clothing for her forensic experiment. During week seven at the turtle survey, I observed Margaret work with another peer. As he was measuring the turtle carapace, Margaret made sure that the turtle would not bite her peer and helped record data. In our initial meeting after the pandemic, those who attended (Margaret, Alyssa, Merry, and Grace) confirmed care in each other by asking how everyone was doing and listening attentively if someone was sharing their virtual tour during our activities. Although participation decreased after the pandemic, Alyssa and Margaret continued to show caring ethics by putting effort to prepare for activities of their interest. For instance, when Alyssa and I discussed ecological papers of her interest, I could tell that she read the material in advance because when I asked questions about the paper, she was prepared to discuss the material. I also observed Margaret put care through her efforts to prepare for our Zoom sessions. I would email her a list of materials in advance and she always had all the materials prepared to do the activities when we met. I felt that the care was reciprocal because as I had prepared activities for them, they also took the time to be prepared. In summary, care ethics was confirmed by students being engaged in activities and assisting each other.

Caring ethics for the environment

Students did not explicitly state how they observed or were involved in care ethics for the environment; therefore, this section describes how I observed students demonstrate care ethics for the environment in ways that I anticipated and ways that I did not. At the turtle survey, I anticipated that caring would occur with the ways in which we worked with the turtles. I observed care ethics in the way that turtles were being handled to minimize harm. During the first turtle survey with all the participants, Margaret, Grace, Alyssa, and Merry helped me scrub

diatoms off the turtle shells. I noticed that all of them were gently scrubbing the shell to avoid hurting the turtle. Although I did not work with Carla much that day, I also noticed that when she was gathering turtle measurements, she was very excited to hold the turtles and carefully measured them. At the second turtle survey during spring break, Margaret was the only participant from the group to attend. I recall that we caught a razor-backed musk turtle. We happened to notice that the turtle had small pieces of paper stuck in its mouth. Margaret grabbed a toothbrush so that we could try to help brush the paper out of the mouth. At the end of the survey, she also helped place the turtles back in the river. Although Margaret never mentioned how she facilitated care ethics towards living organisms, she practiced care in trying to remove the paper waste from the turtle's mouth and placing the turtle back in their natural habitat.

There were ways that caring for the environment occurred in ways that I did not expect and were not part of the apprenticeship activities, but happened during the apprenticeship time together. First, there was a way of physically showing care for living organisms and I provide three examples for how this occurred. In the first week of the apprenticeship, Grace who loves botany proceeded to tell me fun facts about the plants in the classroom. There was one that felt fuzzy on the side of the purple leaves so with her recommendation, we got up out of our chairs to feel it. She noticed that there was a plant hanging from the ceiling and there were some dead leaves. Grace proceeded to stand on a chair and remove the dead leaves to make the plant more aesthetically appealing. On that same day, Mr. Chelydra's classes had engaged in some experiments with fish. It looked like some of the students during the last class period did not clean up, as there were some fish isolated in small plastic cups with water and sitting on some of the tables in the classroom. Margaret and Grace began wondering if we should do something. Margaret took the initiative to grab the cups and put the fish back in the tank in the back of the

classroom, which prompted Grace and me to do the same. We got a little sad because there was a fish that looked like it was about to die or already died. It was difficult to tell, but we wanted to put the fish back in the bigger tank to save them. In the second week of the apprenticeship, Carla who is more interested in turtles still decided to come. Unexpectedly, she asked if she could scrub the shell of the turtle in the classroom. We both tried to be gentle with the turtle and practice care towards the turtle and with each other as it was a juvenile common snapping turtle. I did not anticipate that she would want to study the microscopic organisms from the turtle, but felt it was demonstrating care in learning more about the turtle. In summary, these were two ways that I observed physically caring for living organisms during our time afterschool.

The students and I also demonstrated care ethics for living organisms through discussions that occurred during the apprenticeship. During the second week of the apprenticeship, Alyssa and I discussed a paper pertaining to diatoms and paleolimnology. We had a conversation about human settlement around the lakes, in which the diatom composition changed in response to human activities that decreased the water quality. The paper explained diatom reproduction strategies including sexual reproduction in relation to the water conditions. To help her imagine what would happen, I asked us both to close our eyes and pretend we were diatoms in the lake. We imagined that we were happy diatoms living in good water quality conditions, but then all of a sudden, our environment is changing for the worst and we are worried about surviving. We need to pass on our genes to ensure we increase our chances of survival. As corny as it was, I felt she appreciated this to gain a better understanding as we imagined what it would be like to be a diatom. We opened our eyes again and continued to hypothesize the impact of eutrophication on causing algal blooms. Although this was a complicated paper and she was new to diatoms, she was highly engaged in speculating the impacts of human activity on the diatoms. We discussed

another paper focused on the effects of amphetamine on aquatic organisms. I asked her about possible effects of amphetamine on organisms and she stated how there could be bioaccumulation in the food web. I agreed with her and talked about how drugs in aquatic systems could result in fish wandering off from a school of fish or negatively impacting a bird's diet. We continued summarizing the methods, results, and conclusions of the paper, in which she noticed that the data showed that the amphetamine changed the bacteria and algal communities.

Confirmation of care with community members

Students did not state how they observed or experienced care ethics with other members who were part of the community; therefore, this section describes how I personally observed care ethics in relation to others. I experienced care ethics in unexpected ways, particularly with interacting with community members at the school and turtle survey. At the school, I interacted with three members who confirmed caring towards me. The first community member to make a positive impression on me was the secretary. Whenever I walked through the front door and checked in with the secretary, she always greeted me in a friendly manner and learned my name. As I continued to show up frequently, we began talking more and she asked me about the turtle survey. She listened to me talk about the turtle survey and she stayed engaged in the conversation asking questions about what the students were learning with the diatoms on turtles and seemed fascinated. I felt that she was confirming care in the students and myself to ask about our experience. The second community member in which I experienced care ethics was my interactions with the janitor. As we conducted our apprenticeship activities after school, he would often come in and clean Mr. Chelydra's classroom. We waved at him and he always asked how we were doing. As he noticed that we were frequently working after school throughout the week, he asked what we were doing and listened to us talk about algae. There was even a

moment in which Alyssa showed the janitor a diatom under the microscope and he was surprised to learn how small diatoms can be. I felt that he confirmed caring in learning about our experience and Alyssa practicing care by describing what she learned. Lastly, Connie* (pseudonym) engaged with me in ways that I did not expect. Connie was the science laboratory coordinator who regularly worked with Mr. Chelydra and the other science teachers at the school. She often came into the classroom to get materials from the science closet. Connie always greeted me and was curious about what we were learning. Through her personal curiosity to learn more about diatoms, she took the initiative to help me centrifuge diatom samples and put coverslips on microscope slides.

At the turtle survey, I met strangers with whom I had pleasant interactions. I admit that I cannot remember their names, but one woman in particular confirmed caring. She attended the turtle survey during spring break. She was telling me that she studied at Tarleton, did an internship at Fossil Rim, and used to be a zookeeper at the same zoo with Mr. Chelydra. She was in the middle of transitioning in a career towards being an ultrasound professional. She listened to me discuss what I was doing with the students, my graduate student life, and my future goals as an educator. During the turtle survey, we came across a turtle with an unusual shell pattern, and Mr. Chelydra told us that this was a pet turtle that someone dumped in the river. We discussed invasive species and the need to educate the public to reduce the spread of invasive species. We continued to measure turtles and she helped scrub the turtle carapace for algae. When we interacted with the razor-back musk turtle and Margaret grabbed the brush to remove the paper out of the mouth, the woman also attempted to assist. In summary, there were people I had met as part of the greater community of this apprenticeship who contributed caring towards me in unexpected ways.

Lack of Care Ethics during the Apprenticeship

This section describes two subsections of how a lack of care ethics occurred (e.g., caring was not either confirmed, modeled, or practiced enough). The first subsection describes Margaret's specific observation of how some people did not help with doing the research on turtles. The second subsection describes my own perspective of how I did not promote caring ethics as I assumed too much prior knowledge and could have been more equitable in the researcher-participant relationship.

Not helping with turtle research

Margaret was the only participant to describe an event in which uncaring ethics occurred during the apprenticeship. Margaret stated that care ethics did not happen at the turtle survey as some people chose to help conduct research on the turtles while others did not. She described the ways in which she saw both care and lack of care ethics:

> I saw it happen by like people actually measure turtles, and going down to the river to catch, take them to the tables, and release them. And I did not see it happening because a lot of the time, the huge majority of the people would wander off with their friends and don't get much done.

Alyssa was surprised and said, "...I didn't know that like Margaret thought it was a problem that some people goof off at turtle survey." Margaret responded:

> Well, it's not a problem because if they were at the turtle survey, there would be overcrowding and you wouldn't be able to like work as well. So I don't really have a problem with it, I just think it's like a lot of people lacking in caring about actually doing the research on the turtles.

I thought it was an interesting perspective that I had not considered and thanked Margaret for being honest. I do recall that one time, a biologist and I were recording data for the turtles and we felt like people ditched us. Although this has happened on several occasions, I did not think about it as a lack of care ethics when they did not contribute to the research. I did not feel that it was any of the participants of this study that showed lack of care ethics as I recall seeing them highly engaged at the turtle survey, but recall seeing other high school students "wander off" as Margaret had mentioned. This was the only description from a student regarding their perspective on the lack of care ethics.

Mentoring and Research Aspects

As a researcher-educator mentoring students, I have to acknowledge the ways in which I created uncaring ethics in this apprenticeship, even though it was unintentional. First, a lack of care ethics occurred when I met Merry and Alyssa at the recruitment meeting. As I took a quick glance and noticed that they were both Asian American, I had asked Mr. Chelydra if they were siblings. I could tell that he had a confused look on his face, and I felt really embarrassed. As a researcher who identifies as Asian American and has been critical of people making assumptions about our race, I felt really ashamed of myself and realized that I had an implicit bias. After this, I wanted to work very hard to push back against my own views and get to know their personal identities.

The second way in which unintentional uncaring occurred was throughout the apprenticeship when I assumed too often that students had prior knowledge regarding laboratory experiences and academic language in science. For example, I had assumed that they knew how to use microscopes when they did not. I remember there were times maybe I did not provide enough direction, because I thought students knew how to focus a specimen on the microscope.

When I saw that they were struggling, I had to self-reflect and model for them how to use a microscope and then let them practice trying it themselves. Similarly, when it came to preparing different samples with Margaret, I had different pipettes, one for each sample. I made the assumption that she was already going to know to use a different pipette for different samples, but I noticed that there was a time that she used the same pipette for multiple samples, and then I had to catch her and tell her that we did not want to contaminate the samples. I can admit that I got a little frustrated, and I think that was a lack of care ethics for me to not explain this clearly. I felt like it was not fully aware that I was not thinking on the same page with the students until normal laboratory mistakes happened. Furthermore, I realized that I was not scaffolding their learning well enough. For example, when talking about diatom morphology, I was using complex terminology such as the raphe, and I could tell that students were looking a little lost, so that I had to use common language. To simplify my explanations, I grabbed my diatom box model and tried to point at different parts of the diatom and give analogies for what these parts represented. I think the same was true for when I discussed papers with Alyssa, there were times that the papers were complex and maybe I needed to do a better job of breaking down the information and tried to give her opportunities to ask questions about anything. In summary, I assumed too much at times and needed to adjust my instruction to ensure that I was helping students learn and not be excluded. To address my blind spot, I think it is important to use an ethic of care to see where students are at, ask them how they feel, promote dialogue, and ensure that my instruction accommodates their specific learning needs.

Lastly, during the educational research process, students completed a WID/WIL journal entry. Prior to the pandemic, students would complete it but I did not since this was the student-generated data source. While it is not typically expected that teachers or researchers complete

everything that students are doing, especially since this was the student-generated data source, I reflected and felt that I should have also completed the student-generated data source to show my willingness to share my experience. It honestly did not occur to me until after the pandemic. From a care ethics perspective, I was thinking that cared-fors could feel that I was not being open enough to share what I was also learning. When we shifted to learning online, I began completing the journal entries too. I felt this was important for students to know that I would be more vulnerable to make the research relationship feel more equitable.

Table 2

Cross-Case Analysis of Care Ethics in the Apprenticeship

Conceptions of Care Ethics During the Apprenticeship						
		Students				**Researcher**
		Margaret	**Alyssa**	**Merry**	**Grace**	**Shelly**
View of Care Ethics	Considering other people's feelings			**X**		**X**
	Put effort into something you care about	**X**	**X**		**X**	
	Reciprocal relationship in mentor-mentee and researcher-participant relationship; building care in the curriculum		**X**			**X**
Care Ethics during the apprenticeship	Help each other and being friendly	**X**	**X**	**X**		**X**
	People not on their phones constantly	**X**				

	Being engaged in activities	**X**	**X**			**X**
	Ensuring that everything is ok with the students	**X**	**X**			**X**
	Showing up to meetings	**X**				**X**
	Lessons prepared are catered to student interests		**X**			**X**
	People involved in the turtle survey are passionate about the subject				**X**	
	Caring for the environment					**X**
	Interactions with school community members					**X**
Lack of Care Ethics during the apprenticeship	People wandered off and did not help measure and study the turtles during the turtle survey	**X**				
	Implicit bias when I accidentally assumed Alyssa and Merry were siblings when I first met them					**X**
	Sometimes assuming too much prior knowledge					**X**

	Not completing "What I did/What I learned" (WID/WIL) journal entries with students until later in the apprenticeship					**X**

Note: Carla was not included because there was no data on her conceptions of care ethics.

CHAPTER 5: DISCUSSION

Question 1: How does mentoring with the enactment of care ethics shape participation in a science apprenticeship?

Mentorship with the enactment of care ethics shaped different degrees of participation. With the use of modeling, collaboration, and dialogue, I tried to promote inclusion and engagement. However, three participants did not fully participate for the duration of the apprenticeship while two students who remained involved were able to further explore their interests. A challenge in the mentorship was not fully knowing why attendance decreased, although two students did provide reasons. For instance, Carla stated upfront that she was more interested in learning about turtles. Grace mentioned early on that she would have meetings that were related to health and I did not want to ask further for respecting their privacy with care ethics in mind. However, I am unsure why Merry discontinued participation towards the end of the apprenticeship. Particularly after the COVID-19 pandemic began, participation was non-existent with Carla and infrequent with Grace and Merry. As Margaret and Alyssa were able to participate frequently, this afforded us time to develop the mentor-mentee relationship, tailor learning experiences to suit their interest, prepare a poster for a conference, and assist students with career preparation for the sciences.

I did not get to develop as close of a mentor-mentee relationship with Grace, Carla, and Merry and therefore, did not get to learn of their interests and guide the development of individualized projects with them. It is possible that early on, my mentorship style was unintentionally alienating. I was introducing students to the world of diatom which are often unknown to the general public because of their microscopic size (Conger, 1957). I started the apprenticeship with diatoms as a beginning point until they communicated a specific interest that

we could incorporate in their experience. It is possible that the scientific language and methods I introduced to them was a large learning curve. While I attempted to scaffold learning for students, there were times that I caught myself using diatom terminology that could have confused students and I had to correct myself. I realized that I could have made students feel overwhelmed and lose interest in science. Previous research has also identified challenges for students to navigate the unfamiliar culture of science including the language, discourse, and practices of science which can be perceived as difficult to learn and far-removed from their everyday lives (Aikenhead & Elliot, 2010; Aschbacher et al., 2010; Brickhouse et al., 2000; Lemke, 2004).

Another possibility was that I did not have realistic expectations. Although I mentioned that they can participate as often as they wanted during the week, I was hoping that they would at least come for half an hour because it takes time to learn scientific research. I made myself available on three days a week after school but it is possible these days were not flexible enough to accommodate their schedules. It is possible that participation was difficult due to additional responsibilities in their lives. Carla later revealed to me that she was involved in track and band and Grace had a job. I recognized that students had multiple obligations that could have made it difficult to participate. Ashbacher et al. (2010) also documented that high school interests who did not participate as much in science activities had competing interests such as sports or family care that limited their involvement in science.

For Margaret and Alyssa who participated frequently, this afforded us an opportunity to build a closer mentor-mentee relationship. The reciprocal dialogue and time spent together allowed them to contribute ideas and tailor the learning experiences for their specific, individual interests. Consistent participation also appeared to build continuity during the apprenticeship.

For example, a participant in my pilot study and Margaret in this dissertation study, both stated that when learning science in the classroom, a topic is often only presented in a class period and they move on to the next topic whereas the apprenticeship allows them to learn about a topic in more depth. It took time to build a reciprocal relationship to understand their preferences with learning, how they learned, and negotiate how to build their interests through the research tasks that they wanted to be involved in. Noddings (2005a) discussed that educators can build caring relationships in schools through a continuity of place, people, and a curriculum that accommodates students interests and capabilities. The continuity of caring for ideas in the apprenticeship was important for building the mentor-mentee relationship and tailoring the curriculum around their preferences. Alyssa stated how participation helped her learn about scientific skills such as doing research, writing an abstract, and preparing for a conference. Margaret stated in that addition to science, participation allowed her to learn more about life in general because she stated that previously, nobody talked about college preparation. It appeared that continuity was an important and necessary condition for building caring relationships with the students to get to know them and individualize the curriculum.

Mentorship with care ethics appears to be an important aspect of shaping outcomes for students learning scientific research. Although the studies below did not specifically study care ethics, they looked at aspects of caring. For example, Hsu and Roth (2010) studied high school students doing scientific research and found that in the beginning, students felt out of place but through positive interactions with technicians and scientists over time, they felt included in their contributions to the research. Similarly, Byars-Winston (2015) used existing data from an institution to study what aspects of mentorship were beneficial for undergraduates and found that students appreciated feedback from mentors, understood how their project fit into the larger

context of the research, mentors created inclusion, and appreciated their efforts to the research. Although the ideal aim is to build positive relationships, it is important to acknowledge that caring relationships exist on a spectrum and can be hard to build those relationships due to several reasons. For instance, Schwartz (2012) found that faculty valued the importance of mentoring minority students by fostering a sense of belonging and providing emotional support, but time spent mentoring students conflicted with professional and financial pressures from their institution. In addition, there can be aspects of mentorship that negatively shape mentees' research experiences such as advisor's absence, mismatch in advising style, abusing their power, and lack of support (Limeri et al., 2019). These studies highlight how the mentor-mentee relationship can shape student experiences and suggests that care ethics with mentorship is important for helping students actualize their potential.

First, mentorship with care ethics may inform several aspects of science education. Embedding care ethics in the mentorship process may facilitate authentic participation in scientific research. As newcomers are participating in an apprenticeship, they are confronted with a new culture to learn including the language, specific practices, and ways of engaging between members in the CoP (Lave & Wenger, 1991). As this might be a difficult transition, care ethics would allow mentors to understand how students learn from their perspective and guide them during the research process. For example, as care ethics includes the use of dialogue, this can be used to help students articulate and carry out their scientific research. Hsu and Espinosa (2018) found that scientists and high school students were using dialogue to help students refine their research projects, implement their ideas in a feasible manner, and foster a collegial environment.

Second, mentorship with care ethics can be expanded outside of apprenticeships and in the science classroom. In the teacher-student relationship, teachers could embed care ethics to improve learning outcomes as it pertains to NOS. For example, there is the common misconception of a singular, scientific method. As found in this study, Margaret used agency in designing her own aquatic forensic experiment. Noddings (2005a) describes that one aspect of care is caring for student ideas to foster their interest. Allowing students to design and conduct experiments with flexibility may help students recognize that there is no singular method and that science has a subjective element with human creativity. Another major misconception is that scientific knowledge is definitive, but students may not recognize that it is tentative but durable. With the use of care ethics during this apprenticeship, students were learning about diatom taxonomy, we worked together to identify diatoms. During this process, we discussed how diatom classifications have changed as scientists have made recent revisions and diatom classification is not always clear. The use of dialogue with care ethics could help students to learn that science can change in light of new evidence. Lastly, another idea of NOS is that sociocultural influences will impact what scientific research is done. With the use of care ethics, Alyssa had an open conversation with Dr. Diatom and learned that her research was guided by the interests of Congress and taxpayer funding. Through the use of caring dialogue, this allowed Alyssa to understand that there are societal and cultural impacts that guide what research is completed. Collectively, care ethics through the use of dialogue and practice in the teacher-student relationship could improve students' understanding of NOS.

Question 2: How do student conceptions of care ethics compare to my own conception of care ethics throughout the apprenticeship?

Margaret, Alyssa, Grace, and I viewed care ethics as putting effort into something you care about. However, Margaret stated that you would not put care into something that you are not interested in. Merry and I overlapped in our conception of care ethics in considering other people's feelings and Alyssa and I overlapped in our conception of care ethics in building care in the curriculum through student interest. Students mostly observed how care ethics occurred through placing effort into completing apprenticeship activities and assisting each other during their time together. In addition, I also observed care ethics occur by students helping each other during activities, taking action for the environment, and I personally received confirmation of care through community members. In contrast to a positive view of care ethics, Margaret stated that a lack of care ethics occurred when people did not help with turtle research at the turtle survey. Furthermore, in reflection of my own actions, I felt that I did not place enough emphasis on care ethics when I revealed my implicit bias, assumed too much prior knowledge, and was not equitable enough with sharing what I had learned with students.

Student conceptions of care ethics as placing effort towards things you care about might be explained by their views of natural caring. Noddings (2013) makes the distinction of natural caring as a "natural inclination" (p. 5) that one has to care towards another and recognizes that there are times in which people may not want to care about something. This differs from an ethic of care when someone adopts a mindset of "I must do something" (p. 14) to help care for others beyond personal motivations. Similar to the findings of this study, previous research that has largely focused on teacher education also reveals that participants have a view of natural caring. For instance, preservice or inservice teachers described caring as demonstrating emotional

aspects of care, building relationships with students, and using teaching strategies that promote student development including boundaries for caring (Barnes, 2018; Garza et al., 2014; Goldstein & Lake, 2000; Kemp & Reupert, 2012; Weinstein, 1998).

The findings may inform how students promote care in science education. First, peer collaboration with care ethics may be important in helping apprenticeship activities move forward productively. For example, as Margaret was creating an experimental design for her aquatic forensic experiment, Grace communicated ideas for how Margaret could suspend the pieces of clothing in the pond and assisted her with preparing standardized squares of clothing for the experiment. Student discussion and collaboration such as this were important to promote the progress of apprenticeship activities. Lave and Wenger (1991) stated that:

> Inside the shared practice, both forms of talk fulfill specific functions: engaging, focusing, and shifting attention, bringing about coordination, etc...For newcomers then the purpose is not to learn from talk as a substitute for legitimate peripheral participation; it is to learn to talk as a key legitimate peripheral participation. (p. 109)

This suggests that as students are jointly communicating, this helps them participate authentically in the apprenticeship. Collaboration may help students shift from the everyday worldview towards the specific, scientific view and Discourse of science (Gee, 2004). Such reciprocal relationships in doing scientific work parallel's Noddings (2013) ideas for how moral education is achieved through dialogue, practice, modeling, and confirmation. For instance, Quigley and Lyons (2017) studied high school students doing research together on the Aedes mosquito on their campus and developing better environmental solutions to manage their proliferation. The students in the study used dialogue to come up with their own possible ideas of other ways to reduce the mosquito population. Similarly, a study found that middle school

students demonstrated care for each other as they worked collaboratively and offered respectful feedback to improve their car designs (Chittum et al., 2017). The use of dialogue, dialogue, practice, modeling, and confirmation may help promote students' inclusion in the apprenticeship.

Second, the findings may inform how students demonstrate different degrees of care towards the environment. Students were able to use elements of Noddings' moral education, particularly practice and dialogue to demonstrate care for the environment such as through caring for organisms in the classroom, the turtles at the survey, or through our discussions related to the environment. A few other studies have also used care ethics as a framework to apply caring ethics towards the environment. Nazir and Pedretti (2017) found that educators enhanced children's environmental awareness at an outdoor center by helping students connect with nature, model care as they were respectful towards the environment and restored pathways on the ground. Similarly, in Schindel and Tolbert (2017), high school students did a restoration project planting trees and during the process, students developed relationships with each other. However, this dissertation study also found that through Margaret's lens, there was a lack of care ethics when people did not assist with the research at the turtle survey and wandered off. Through personal observation, I noticed a lot of students enjoyed socializing with each other and cautiously wondered if they were more interested in the social benefits and less with the research. It is also possible that students could have been fearful of interacting with the turtles. While there needs to be more research to confirm this, Bixler et al. (1994) surveyed interpreters as nature centers to identify children's fears during their visits and fears included touching animals in which one observation included turtles. It has also been suggested that people's attitudes towards reptiles depend on their cultural views and relationships with reptiles (Alves et

al., 2012). The lack of care might suggest the need to foster caring encounters and connection with the environment (Noddings, 2003). Chyleńska and Rybska (2019) implemented an intervention to study how it could change student conceptions on amphibians and reptiles; although there was no statistical difference, those that received the intervention were more curious about reptiles and amphibians and thought about ways to improve their local habitats. As human activities continue to pose a threat for the environment, this suggests the need for educators to facilitate care and citizenship for conserving the environment (Lyons et al., 2017; Noddings, 2005a,b).

Lastly, this research offers suggestions for how educators who are also positioned as researchers need to be more aware of their own biases and practice embedding care ethics throughout the entire research process. While my initial stance of not sharing what I had learned with the student does not pose an ethical challenge from an IRB perspective, I gave myself pushback from a care ethics perspective. Noddings (2005a) acknowledges that the teacher-student relationship is unequal, but it is still important to maintain trust and promote care. The same can be said for the researcher-participant relationship and felt that I should have used more dialogue to share what I had learned to be more vulnerable. Bergmark (2020) reflected on their positionality as a researcher working with teachers and recommended reducing asymmetry in the caring researcher-participant relationship through reflection and dialogue. Similarly, Lahman et al. (2010) advocate for using Culturally Responsive Relational Reflective Ethics (CRRRE) to critically evaluate dilemmas that arise, use reflection, and respond accordingly to enhance caring for participants.

Conclusion and Implications

The purpose was to integrate care ethics in a science research apprenticeship to understand how it shaped student participation and conceptions of care ethics. The first research question found that mentorship with the enactment of care ethics shaped student experiences differently on a spectrum from little to frequent participation, and therefore shaped the degree to which they learned scientific knowledge, skills, and developed their own ideas in the apprenticeship. The second research question revealed that student conceptions of care ethics focused on natural caring, but an ethic of caring occurred through students helping each other during the apprenticeship and caring for the environment. A lack of care ethics occurred when people did not assist with turtle research and I found my own biases as a researcher. Collectively, these findings conclude that care ethics may be important in shaping student participation and learning experiences in science education.

The first implication is that mentorship with care ethics may determine the degree to which students are able to participate in science. To gain entrance into a CoP, novices are expected to learn the norms of how the community operates. Lave and Wenger (1991) state, "The form that the legitimacy of participation takes is defining characteristic of ways of belonging, and is therefore not only a crucial condition of learning, but a constitutive element of its content" (p. 35). However learning scientific knowledge can be alienating to students (Aikenhead & Elliot, 2010). This suggests that mentors have the responsibility of using care ethics to introduce newcomers to the culture of science and bridge their understanding. The use of dialogue, modeling, practice, and confirmation of care with students in a reciprocal relationship could contribute to their growth in scientific knowledge and practices. Furthermore, as students gain these skills, they are able to become legitimate peripheral participants in a CoP

and this could spark their interest in pursuing a science career. As high school students who participated in research programs had a stronger desire to pursue a science career than those who did not participate in any science programs (Kitchen et al., 2018), we may need to critically examine how care ethics can be used to sustain student interest in the sciences.

The second implication of this study is that student conceptions of care ethics may impact the degree to which they care for each other and the environment. It may be necessary for educators to create opportunities for students to care for each other, as that caring can be extended towards preserving nature. Noddings (2005a) states, "Thinking of work, responsibility for ourselves and for others, and committing ourselves to a modern way of life are vitally connected to caring for the environment" (p. 138). It has been suggested that when students feel connected to a sense of place, this may help promote citizenship and environmental action to conserve the environment (Liefländer et al., 2013; Noddings, 2005b). Caring for the environment could be achieved through developing students personal interests in activities and research on environmental topics. Students can also engage in care-based citizen science projects to raise their environmental awareness and decision-making towards improving the environment (Lyons et al., 2017). Integrating care ethics with student relationships and the environment could promote environmental literacy and problem-solving towards environmental issues.

The third implication of this study is to consider if care ethics is possible in formal learning environments. Care ethics is difficult to implement in schools due to curriculum standards, pressures from testing, and societal expectations of academic achievement (Noddings, 2005a, 2007). While it is not possible to embed all aspects of care ethics that Noddings advocates for due to the existing power structures in education, it is possible to embed a few aspects of care ethics within the constraints of traditional schooling. One way to integrate care ethics is through

educators fostering student interest in learning. Xu et al. (2012) studied how eight, exceptional African American teachers promoted interest by connecting the content to students' experiences. For example, one teacher allowed students to create a rap song about the water cycle. Another teacher in the study was teaching about the human body systems and discussed health issues that impacted the community such as diabetes (Xu et al., 2012). This may be further supported by drawing upon students' funds of knowledge (Moll et al., 1992) in the science classroom. McLaughlin and Barton (2013) studied preservice teachers' understanding of funds of knowledge, and some perceived it as a means for sparking interest in a topic, helping students draw connections to the content, and allowing students to share their cultural knowledge with the class. On a larger scale across multiple disciplines, a literature review of studies on funds of knowledge for marginalized students found that interest was facilitated through various means such as student contributions to the curriculum or inclusion of popular culture (Llopart & Esteban-Guitart, 2018).

A second way to possibly embed care ethics within the boundaries of the formal curriculum can occur by providing students with epistemic agency, in which students have opportunities to make decisions as they generate scientific knowledge (Miller et al., 2018). For instance, Holmes et al. (2020) created a physics lab intervention in which students in the experimental group received opportunities for decision-making in the investigations and the control group completed confirmatory investigations. Students in the intervention group made more decisions, explored more inconclusive data, and were more likely to use the first person voice in the description of their methods compared to the control group (Holmes et al., 2020). In another example, Stroupe et al. (2018) collaborated with researchers, sixth grade students, and a teacher on moth research, in which students used epistemic agency to negotiate ideas and carry

out the research. However, the authors acknowledged that the adults experienced conflicts with the learning objectives and planning process (Stroupe et al., 2018).

Collectively, the ability to push back against formalized barriers in school and embed some aspects of care ethics depends on teachers' willingness to create opportunities for interest and agency. Stroupe (2014) studied how five science teachers and their students decided what information constituted scientific knowledge and found that teachers either promoted epistemic agency by valuing student perspectives or they focused on the "correctness" (p. 499) of student thinking. Similarly, McFadden and Fuselier (2020) describe how graduate teaching assistants in a biology lab demonstrated instances of facilitating epistemic agency with students' experimental designs, yet also directed student outcomes and efforts towards the expected, scientific knowledge. These findings have implications for how the degree of care ethics in the relationship between the teacher and student shape student agency and possibly, their understandings of NOS.

Limitations

There are several limitations to the study. The first limitation is that I only worked with participants from one high school, in particular, associated with one biology teacher. As I used a small sample size of five students with a qualitative case study approach, there is no generalizability. In the beginning of the study, the participants were already interested and motivated in science. I also have to acknowledge that myself and the participants were either white, Asian American, or half Asian American. The students and I already shared common interests in science at the beginning of this apprenticeship. I was also privileged to have built a relationship with the teacher for at least two years prior to the beginning of my dissertation study.

Another limitation is that it would be difficult for someone to replicate this study in terms of creating a diatom-turtle apprenticeship with care ethics. One consideration about the design of the apprenticeship was that I was positioned as a scientific researcher specialized in diatoms, but also as an educator who was able to mentor students with care ethics. Once when I was at a conference presenting this work, a researcher made a point about how recreating this apprenticeship experience is not feasible in the sense of another researcher having the same background in diatoms and science education training to replicate this study.

Related to the design of the apprenticeship, a third limitation was the duration of the apprenticeship which occurred after school over one semester. It is possible that one semester was not long enough to fully allow care ethics to develop and might be addressed with developing a more formal program that builds continuity in the after-school curriculum. Noddings (2005a) discusses how continuity in the curriculum could offer continuity with building relationships and caring for student ideas. To help design the program, it would be important to allow students to have agency in contributing ideas and help co-create the curriculum to tailor their learning experiences.

A fourth limitation was that because participation varied, not all of the data sources were collected as originally anticipated. For instance, even though some participants turned in their WID/WIL journal entries, others did not as their contributions were completely voluntary and if they also discontinued participation, I did not capture their responses in interviews. I have to acknowledge that although I tried my best to best care ethics in my relationships with the participants, there could be a possibility that from the students' perspectives that I did not foster care ethics which led some to stop participation. I could not confirm why participation stopped

despite efforts of communication with all participants. I tried to address missing data sources by using triangulation to still gain as much of a comprehensive understanding as possible.

Lastly, while the COVID-19 pandemic was an unanticipated occurrence and the event itself was not necessarily a limitation to the study, a consideration is that I do not know how this apprenticeship could have unfolded differently under normal circumstances. I have to acknowledge that when I began this study in January of 2020, I had designed this apprenticeship for meeting face-to-face afterschool. When the lockdown began here in March and the school closures occurred, I first had a difficult time re-envisioning what care ethics in a science apprenticeship will look like in an online environment without access to the normal science equipment we were using such as microscopes. As I had never done this before an online environment, I learned that I had to be flexible and adaptable to change, both in the way that the apprenticeship was conducted and the way that data sources were collected.

Future Areas of Research

One future area remains to study care ethics in science education with different student populations, particularly African American or Hispanic students with less equitable science opportunities. Such research could observe the role of care ethics in promoting inclusion in science research apprenticeships and in the classroom. It would be important to study their conceptions of care ethics and how it unfolds during science learning, given past critiques of White notions of caring (Antrop-González & Jesús, 2006) and the need to consider multiple voices. Understanding underserved students' perspectives could better inform educators with culturally responsive practices in caring for students during science education instruction.

A second suggestion is to study how care ethics unfolds in a variety of apprenticeship models. As this study was limited to a one-semester apprenticeship after school, the gaps remain

in how care ethics occurs in science apprenticeships in university-partnerships or technical programs in K-12 or community college level. This could contribute to our understanding of how care ethics is situated in specific science education contexts and how might improve learning outcomes such as understandings of NOS.

The last recommended area of research is studying how science educators foster care ethics online in light of a global pandemic. Although not part of my dissertation findings, a participation of my study stated that caring was created online when I made sure that her voice was heard; she also stated that one of her teachers created caring when he shared memes to make students laugh and showed videos. Given the challenges that this pandemic brought upon educators and students, future research could investigate the varied ways that practitioners design a teaching or research framework for care ethics in an online environment.

APPENDIX A: PARENT INFORMATION LETTER

Texas Christian University
Fort Worth, Texas

Dear Parent(s) or Guardian(s):

I am writing to ask your permission for your child to participate in a Texas Christian University research study **A Case Study of Mentoring High School Students with Care Ethics in a Science Research Apprenticeship**. This project will be conducted at Hoco High School* (pseudonym) School from January to May 2020. I am interested in implementing caring ethics in student experiences with extracurricular activities in the outdoors at the turtle survey and in the classroom learning scientific research in Mr. Chelydra's* (pseudonym) classroom. This project will help me understand how caring could be used to improve student interest in learning science.

Your child's participation in the study is completely voluntary. Participation in the study will include: 1) Laboratory learning in Mr. Chelydra's* (pseudonym) classroom for once a week after school for two hours or less. During this time, students will learn how to conduct scientific research of their interest. 2) Outdoors once a month at the turtle survey for four hours or less. During this time, students will learn how to study the turtles in the local river and collect scientific data. 3) Embedded during the science learning, students will be asked to participate in education data collection to share their experiences in the form of a) interviews, collecting a total of eight interviews (see Appendix E) and b) ownership of a data source (e.g. taking pictures, science notebook, or drawings) which they can record as often as they decide, followed by a discussion which should take an hour or less. Again, all participation in this study is completely voluntary and does not impact their ability to engage in the turtle survey if they chose not to participate in this study.

All your child's information will remain confidential and will not be shared with school staff at Hoco High School* (pseudonym) or TCU. The participants will be assigned a pseudonym to maintain confidentiality and files stored securely. Information from this study could be presented at conferences and published in science education journals. Only children who have parental permission, and who themselves agree to participate, will be involved in the study. Students and their parents may withdraw participants at any time during the study by indicating this decision verbally or via email to Shelly Wu (shelly.wu@tcu.edu) or Mr. Chelydra* (pseudonym). The anticipated risks to this study are no more than what could occur when students are in a typical lab or outdoor setting. The risks will be minimized by supervising students and training them on safety.

We would like to assure you that this study has been reviewed and approved by Institutional Review Board at TCU. However, participation is completely voluntary. If you have any concerns or comments resulting from your child's participation in this study, please contact Shelly Wu at shelly.wu@tcu.edu. If you have further questions about your child's rights as a study participant, contact: Dr. Dru Riddle, Chair, TCU Institutional Review Board, (817) 257-6811, d.riddle@tcu.edu or Dr. Floyd Wormley, Associate Provost of Research, research.tcu.edu. Thank you for your time.

Sincerely,
Shelly Wu

APPENDIX B: PARENTAL CONSENT TO CHILD'S PARTICIPATION IN RESEARCH

Texas Christian University
Fort Worth, Texas

Title of Research: A Case Study of Mentoring High School Students with Care Ethics in a Science Research Apprenticeship

Principal Investigator: Dr. Molly Weinburgh, Director of Andrews Institute of Mathematics and Science Education, TCU College of Education

Co-investigators: Shelly Wu, doctoral student in Science Education, TCU College of Education
Your child is invited to participate in a research study. In order to participate, your child must be a high school student attending Hoco High School* (pseudonym) and have an interest in the Turtle survey. Taking part in this research project is completely voluntary.

What is the purpose of the research?
The purpose of this study is to investigate how my implementation of caring shapes your child's experience as they participate in the local turtle survey in the outdoors and in the scientific research in the laboratory (classroom).

How many people will participate in this study?
If you decide to allow your child to be in this study, your child will be one of five participants in this research study.

What is my child's involvement for participating in this study?
Your child will be asked to do the following things**:**
1) Participate in the science experience once a week in the laboratory (classroom) for two hours or less and once a month outdoors at the turtle survey for four hours or less. 2) During the science activities, your child will also be asked to participate in the education research to share their experiences in the form of: a) interviews and b) ownership of a data source (e.g. taking pictures, science notebook, or drawings) followed by a discussion, which should take an hour or less.

How long is my child expected to be in this study for and how much of my child's time is required? Your child will be participating from January to May of 2020. For the laboratory portion, the number of visits will generally be once a week for two hours or less after with the exception of January and May which will have less visits to account for school starting late and graduation, respectively (see table below). For the outdoor learning at the turtle survey, this will occur once a month for four hours or less. Educational research activities will be embedded while we conduct the science and should take no more than an hour per visit. Below is a schedule of frequency of meetings each month.

Apprenticeship Meeting Frequency		
Month	**Number of times we meet and hours per month the classroom**	**Number of times we meet and hours per month at the turtle survey**
January	2 visits x 2 hours max = 4 hours	1 visit x 4 hours max = 4 hours
February	4 visits x 2 hours max = 8 hours	1 visit x 4 hours max = 4 hours
March	4 visits x 2 hours max = 8 hours	1 visit x 4 hours max = 4 hours
April	4 visits x 2 hours max = 8 hours	1 visit x 4 hours max = 4 hours
May	2 visits x 2 hours max = 4 hours	1 visit x 4 hours max = 4 hours
Total number of visits and hours for each location	**16 visits and 32 hours max**	**5 visits and 20 hours max**
Total number of visits and hours	**21 visits and 52 hours max**	

What are the risks to my child for participating in this study and how will they be minimized?
There are some risks your child might experience from being in this study. First, there are minimum anticipated risks with participating in the outdoors such as uneven ground. To minimize this risk, your child will be instructed to walk carefully with adult supervision and first aid kits will be available. Second, there are minimal anticipated risks associated with laboratory work such as using a microscope and viewing algae on a glass slide. To minimize this risk, your child will be trained on how to use a microscope. Third, there are psychological and social risks such as feeling anxious during the interview. If your child expresses discomfort or express they want to terminate the interview, they can verbally indicate this and the interview will be stopped. To minimize any risk, efforts will be made to build and maintain trust between the researcher and your child.

What are the benefits for participating in this study?
Your child might benefit from being in this study because they will have opportunities to conduct scientific research and could increase their scientific knowledge, laboratory skills, understanding of how science works, and gain career aspirations in science.

Will I be compensated for participating in this study? Your child will not be compensated for participating in this study.

What is an alternative procedure(s) for my child instead of participating in this study?
If your child chooses not to participate in the study, they can still participate in the turtle survey because it is an extracurricular activity and participation is voluntary and free.

How will my child's confidentiality be protected? Your child will be assigned a pseudonym and their identity will be confidential in everything from data collection to possible future presentations at a conference. All data will be secured on a password protected computer only accessed by the researcher.

What will happen to the information collected about me after the study is over?
The information collected will be analyzed for Shelly's dissertation, and could be presented to researchers in the form of a conference presentation and publication.

Is my child's participation voluntary? Yes, your child's participation is completely voluntary.

Who should I contact if I have questions regarding the study?
You can contact Shelly Wu at shelly.wu@tcu.edu with any questions that you have about the study.

Who should I contact if I have concerns regarding my rights as a study participant?
Dr. Dru Riddle, Chair, TCU Institutional Review Board, (817) 257-6811, d.riddle@tcu.edu; or Dr. Floyd Wormley, Associated Provost of Research, research@tcu.edu

By signing this document, you are agreeing to [your child's **OR** the person's named below] participation in this study. Make sure you understand what the study is about before you sign. I/We will give you a copy of this document for your records. I/We will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.
*I understand what the study is about and my questions so far have been answered. I agree for [my child **OR** the person named below] to take part in this study.*

_____
Printed Subject Name

_____
Printed Parent/Legally Authorized Representative Name and Relationship to Subject

_____
Signature Date

_____
Printed Parent Name and Relationship to Subject (when 2 signatures are required)

_____
Signature Date

APPENDIX C: PARTICIPANT'S ASSENT TO PARTICIPATE IN RESEARCH

Texas Christian University
Fort Worth, Texas

Title of Research: A Case Study of Mentoring High School Students with Care Ethics in a Science Research Apprenticeship

Principal Investigator: Dr. Molly Weinburgh, Director of Andrews Institute of Mathematics and Science Education, TCU College of Education

Co-investigators: Shelly Wu, doctoral student in Science Education, TCU College of Education

You are invited to participate in a research study. In order to participate, you must be a high school student attending Hoco High School* (pseudonym) and have an interest in the turtle survey. Taking part in this research project is completely voluntary.

What is the purpose of the research? The purpose of this study is to investigate how my implementation of caring shapes your experience as you participate in the local turtle survey in the outdoors and in the scientific research in the laboratory (classroom).

How many people will participate in this study? If you decide to be in this study, you will be one of five participants in this research study.

What is my involvement for participating in this study? If you agree to be in the study, we will ask you to do the following things**:** 1) Participate in the science experience once a week in the laboratory (classroom) for two hours or less and once a month outdoors at the turtle survey for four hours or less. 2) During the science activities, you will also be asked to participate in the education research to share your experiences in the form of: a) interviews and b) ownership of a data source (e.g. taking pictures, science notebook, or drawings) followed by a discussion which should take an hour or less.

How long am I expected to be in this study for and how much of my time is required? You will be participating from January to May of 2020. For the laboratory portion, the number of visits will generally be once a week for two hours or less after with the exception of January and May which will have less visits to account for school starting late and graduation, respectively (see table below). For the outdoor learning at the turtle survey, this will occur once a month for four hours or less. Educational research activities will be embedded while we conduct the science and should take no more than an hour per visit. Below is a schedule of frequency of meetings each month.

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April	4 visits x 2 hours max = 8 hours	1 visit x 4 hours max = 4 hours
May	2 visits x 2 hours max = 4 hours	1 visit x 4 hours max = 4 hours
Total number of visits and hours for each location	**16 visits and 32 hours max**	**5 visits and 20 hours max**
Total number of visits and hours	**21 visits and 52 hours max**	

What are the risks to me for participating in this study and how will they be minimized? First, there are minimum anticipated risks with participating in the outdoors such as uneven ground. To minimize this risk, you will be instructed to walk carefully with adult supervision and first aid kits will be available. Second, there are minimal anticipated risks associated with laboratory work such as using a microscope and viewing algae on a glass slide. To minimize this risk, you will be trained on how to use a microscope. Third, there are psychological and social risks such as feeling anxious during the interview. If you express discomfort or express you want to terminate the interview, you can verbally indicate this and the interview will be stopped. To minimize any risk, efforts will be made to build and maintain trust between the researcher and participants.

What are the benefits for participating in this study? You might benefit from being in this study because you will have opportunities to conduct scientific research and could increase your scientific knowledge, laboratory skills, understanding of how science works, and gain career aspirations in science.

Will I be compensated for participating in this study? You will not be compensated for participating in this study.

What is an alternative procedure(s) that I can choose instead of participating in this study? If you choose not to participate in the study, you can still participate in the turtle survey because it is an extracurricular activity and participation is voluntary and free.

How will my confidentiality be protected? You will be assigned a pseudonym and your identity will be confidential in everything from data collection to possible future presentations at a conference. All data will be secured on a password protected computer only accessed by the researcher.

What will happen to the information collected about me after the study is over? The information collected will be analyzed for Shelly's dissertation, and could be presented to researchers in the form of a conference presentation and publication.

Is my participation voluntary? Yes, your participation is completely voluntary.

Who should I contact if I have questions regarding the study? You can contact Shelly Wu at shelly.wu@tcu.edu with any questions that you have about the study.

Who should I contact if I have concerns regarding my rights as a study participant? Dr. Dru Riddle, Chair, TCU Institutional Review Board, (817) 257-6811, d.riddle@tcu.edu; or Dr. Floyd Wormley, Associate Provost of Research, research.tcu.edu

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. You will be given a copy of this document for your records. A copy also will be kept with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I understand what the study is about and my questions so far have been answered. I agree to take part in this study.

_____
Printed Subject Name

_____
Signature Date

_____
Printed Name of person obtaining consent

_____
Signature Date

APPENDIX D: MEDIA RECORDING RELEASE FORM

Texas Christian University

Title of Research: A Case Study of Mentoring High School Students with Care Ethics in a Science Research Apprenticeship

Study Investigators: Dr. Molly Weinburgh and Shelly Wu

Record types. As part of this study, the following types of media records will be made of you (or by you) during your participation in the research:

- Photographic Image taken by the researcher or by students. You will be credited for photos with your first name and last initial.
- Audio Recording taken by the researcher, in which your identity will remain anonymous.

Record uses. Please indicate what uses of the media records listed above you are willing to permit by initialing below and signing the form at the end. We will only use the media records in ways that you agree to.

- The media record(s) can be studied by the research team for use in this research project.
  Please initial: _____

- The media records(s) and/or their transcriptions can be used for scientific or scholarly publications.
  Please initial: _____

- The media records(s) and/or their transcriptions can be used at scholarly conferences, meeting, or workshops.
  Please initial: _____

- The media record(s) can be shown/played in public presentations.
  Please initial: _____

- The media record(s) can be shown/played on television, radio, or other broadcast media.
  Please initial: _____

I have read the above descriptions and give my consent for the use of the media recordings as indicated by my initials above.

Name: _____

Signature: _____ Date: _____

If you have concerns regarding your rights as a study participant, Dr. Dru Riddle, Chair, TCU Institutional Review Board, (817) 257-6811, d.riddle@tcu.edu; or Dr. Floyd Wormley, Associate Provost of Research, research@tcu.edu

APPENDIX E: INTERVIEW QUESTIONS

Thank you for taking the time to participate in this interview. I have a few questions about your involvement in this project and will be recording the interview. At any point you want to terminate this interview, please verbally indicate that you want to stop. Do you have any questions before we start?

1) **What have you been working on in the after-school experience?**

2) **How do you feel about your involvement in our after-school experience?**

3) **Has mentoring impacted your experience? Why or why not?**

4) **What does ethics mean to you?**

5) **If we put caring AND ethics together, what does "caring ethics" mean to you?**

6) **In what ways have you seen caring ethics happen and/or not happen during our experience?**

7) **What is working well?**

8) **What suggested improvements do you have?**

9) **What questions do you have for me?**

Thank you for your time today.

VITA

Personal	Shelly Wu
Background	Montebello, California
Education	Diploma, Salmen High School, Slidell, LA, 2009 Bachelor of Science, Loyola University New Orleans, New Orleans, 2013 Master of Science, University of Oklahoma, Norman, 2016 Doctor of Philosophy, Texas Christian University, Fort Worth, 2020
Experience	Graduate Teaching Assistant, University of Oklahoma, 2013-2016 Graduate Research Assistant, Texas Christian University, 2016-2020 Adjunct Instructor, Texas Christian University, 2018 Adjunct Instructor, Iowa Lakeside Laboratory, Summer 2017-2019 Instructor, Tarrant County College, 2020-present
Professional Memberships	Curriculum & Pedagogy School Science and Mathematics Association

ABSTRACT

A CASE STUDY OF MENTORING HIGH SCHOOL STUDENTS WITH CARE ETHICS IN A SCIENCE RESEARCH APPRENTICESHIP

By Shelly Wu, Ph.D., 2020
College of Education
Texas Christian University

Dissertation Project Advisor: Molly Weinburgh, Piper Professor and Director of the Andrews Institute of Mathematics and Science Education

To date, few studies have focused on the role of caring ethics in science education. The purpose of this study is to investigate how Nel Noddings' Caring Ethics in a science research apprenticeship shaped student participation and the collective conceptions of care ethics throughout the experience. A case study approach was used to embed caring ethics in a research apprenticeship at a high school with five students. The researcher was positioned as the mentor and educational researcher working in collaboration with students using Nodding's components of moral education. Laboratory activities were completed after school and outside at the turtle survey from January to March, 2020. After the COVID-19 pandemic began, the apprenticeship continued with online engagement and activities from March to May. The data sources collected were semi-structured interviews, "What I Did/What I learned" journal entries, and field notes. The first research question found that mentorship with the enactment of care ethics shaped student experiences differently regarding the degree to which they learned scientific knowledge, skills, and developed their own ideas in the apprenticeship. The second research question revealed that student conceptions of care ethics focused on natural caring, but an ethic of caring occurred through students helping each other and caring for the environment. A lack of care ethics occurred when people did not assist with turtle research and revealed the researcher's own

biases. This research has implications for the role of care ethics in shaping student participation in science apprenticeships and the science classroom.

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