A PASSION FOR TEACHING SCIENCE: A CASE STUDY OF FIVE SCIENCE TEACHERS

by

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ABSTRACT

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The modern psychological investigation of passion started with the study by Vallerand et al. (2003). The construct of passion has been applied to sports, gambling, and performing arts. The application of the construct of passion to the field of teaching has been very limited. This study uses Vallerand et al.'s definition of passion to consider the teaching of five science teachers. Using a case study methodology five teachers, who had been teaching for nine to sixteen years, were each interviewed twice, three of the five teachers provided a lesson plan that they had developed, about which they were passionate. I found that each of the participants was passionate about their craft, that each enjoyed being able to develop their own curricula, and that each participant valued peer collaboration and sharing of ideas as a means of professional development.

Chapter 1: Introduction

Statement of the Problem

According to the US Department of Education (2019), 43 states and Guam, Puerto Rico, and the US Virgin Islands all reported teacher shortages in some area of science for the 2019-2020 school year. Thus, finding and retaining good science teachers is in the interest of students, administrators and, frankly, everyone else in our society. Suarez and Wright (2019) report that secondary teachers in science and mathematics, when compared with teachers of other disciplines, are particularly hard to retain. They suggest that one cause of this difficulty might be high-stakes testing. It might be that the nature of preparing students for high-stakes tests does not allow teachers to find a love of, or passion for, teaching.

The problem of finding and retaining quality science teachers is not a new phenomenon; it has been, and continues to be, a topic of research in science education. For instance, Luft et al. (2019) write that, according to the National Science Board Report (2014), 25% of secondary mathematics and science teachers depart by the third year. Additionally, Ingersoll and May (2012) found that, according to the data collected from the National Schools Staffing Survey, schools have more difficulty hiring mathematics and science teachers than any other field. They attribute the greater need for new science and mathematics teachers to the relatively high teacher turnover rate of science and mathematics teachers. According to their research, mathematics and science teachers were more likely than other teachers to transfer into non-teaching, educational jobs, such as administration or curriculum development. They also speculate that one reason for the high turnover rate may be the possibility of lucrative, non-education jobs available to these teachers. Furthermore, Borman and Dowling (2008) conducted a meta-analysis of 34 studies. They found that, according to the reviewed studies, the odds of schools turning over "teachers with high-demand science and math degrees" (p. 396) are greater than the turn-over odds for

other teachers. According to their findings, teachers' working conditions were even more of a factor in teacher turn-over than previous studies had suggested. These working conditions include salaries, instructional resources, and student-body characteristics; troublingly, high poverty, high minority-populations had comparatively more difficulty retaining qualified teachers.

In light of this information, one important focus of science education research should be the fundamental question of how to attract great science teaching candidates who are proficient in a science and are interested in teaching that science to others. Even though exact definitions of great science teaching may vary from person to person and change with time, science education researchers should be interested in how to develop great science teachers — motivated teachers who can connect with students, increasing their job satisfaction and their effectiveness.

Luft et al. (2011), studying the recruitment and retention of science teachers, state that the shortage of science teacher recruits has forced administrators and science teacher educators to make tough, though perhaps necessary, decisions to increase the number of science teachers. These strategies, according to Luft et al., include enticing and accepting more students into science teacher education programs and providing opportunities for individuals to enter teaching as a "second career." While Luft et al. note that there is very little information in the literature regarding successful recruitment strategies and no longitudinal studies which might shed light on the long-term effectiveness of these strategies, they do posit that the recruitment strategy should be as carefully conceived as the preservice educational process.

The problem of finding teachers who are able and motivated to teach science has been studied with preservice elementary teachers. For instance, Jarrett (1999) found that if preservice teachers were taught science "little and poorly" (p. 55), those teachers would go forth to teach science "little and poorly." Jarrett's research showed that a preservice teacher's interest and

confidence can be increased by taking a "hands-on field-based methods class" (p. 56) in science. Similarly, Norris et al. (2018) found that, among elementary preservice teachers enrolled in a graduate diploma of education program, preservice teachers with a disinterested or fearful attitude toward science will have a lower sense of self-efficacy as a science teacher than those with an enthusiastic attitude toward science. They suggest that the lower science teaching self-efficacy could lead such teachers to devote less instructional time to science. These studies suggest that, if science education in elementary schools is to improve, designers of preservice training should study and emphasize effective techniques for developing a passion for science in preservice elementary teachers.

Therefore, one important question is, how can we recruit individuals who will make great science teachers? Another equally important question is, how can we retain individuals who *are* great science teachers? Is knowledge of a scientific subject area enough? Is it enough to enjoy working with students? Dewey, according to Simpson et al. (2005), believed that great teachers must possess the following loves: love of learning, love of students, and love of communicating knowledge with others, among others. This would seem to suggest that a great teacher or, more specifically, a great science teacher will be a person who has certain passions; indeed, the "loves," mentioned above, might also be called passions. Therefore, the purpose of this study was to investigate one aspect which may be instrumental in recruiting and retaining great science teachers: passion.

Significance of Study

This study is of significance to the field of science education and to school districts or other agencies concerned with attracting and retaining good science teachers. While the problem of teacher retention has been extensively studied (e.g., Doney, 2013; Goodpaster et al., 2012; Webb, 2018) and the concept of passion has been applied extensively to sports and other areas

outside of science education (e.g., Rousseau et al., 2002; Séguin-Levesque et al. 2003; Vallerand et al., 2003), and while there have been studies which looked at the importance of passion in educational settings, there is a lack of research connecting the concept of passion to the field of science education. Passion and factors that increase the passion of science educators may be an important part of attracting and promoting great science teachers; so being, passion may prove an important avenue of study for science education researchers. Therefore, in this investigation, I examined how science teachers define passion, investigated the ways science teachers believe their passion affects their students, and studied how science teachers believe their work environment affects their passion.

Research Questions

This research was an exploratory case study in which I began to examine how science teachers view passion for their work and if or why the teachers believe that passion is important. Related to passion and teaching science, I investigated the following research questions:

1. What job-related activities are science teachers most passionate about?
2. In what ways do science teachers believe their passion affects students?
3. In what ways do science teachers believe their environment affects their passion?

Definition of Terms

For the purposes of this research, the following definitions were used:

Environment. The environment of the science teacher refers to both the physical area in which the science instruction occurs and the interpersonal relationships which occur within this area. The physical environment included, from general to more specific, the neighborhood of the school, the school itself, the classroom within the school, and the equipment and hardware of the classroom. The interpersonal environment included the relationship of the teacher with the parents, the relationship with certain administrators, and the relationship with fellow teachers.

Passion. As defined by Vallerand et al. (2003), “passion is defined as a strong inclination toward and activity that people like, that they find important, and in which they invest time and energy” (p. 757).

Science Teacher. A science teacher is any teacher who teaches exclusively or primarily any science. The teacher may teach any grade level from kindergarten to grade 12. Specific subjects include, but are not limited to, physics, biology, chemistry, environmental science, physical science, life science, or forensic science.

Chapter 2: Literature Review

Dewey (1964), writing about the method of education, states that the "method is ultimately reducible to the question of the order of development of the child's powers and interests" (p. 435). If then, the most appropriate metric of an educational experience lies in the students' experiences, what differentiates a good or great educational experience from a less than ideal or bad educational experience? What role does the teacher play in this experience? It is necessary then to investigate the factors that attract effective would-be teachers to the profession, what factors allow teachers to grow in their profession, and what factors keep effective teachers in the profession.

Theoretical Framework

I was most interested in exploring how teachers view and interpret their teaching in relation to their ideas about passion(s). As stated by Lincoln and Guba (2013), "sense making… does not result in objective truth, but only in sets of symbols and meanings defined and applied by humans to enhance their ability to deal with the surround, to survive, cope, and prosper" (p. 46). Additionally, and perhaps more importantly, Lincoln and Guba posit that "it is rarely the raw physical reality which shapes our behavior and our response to the physical environment. It is, rather, the meanings we associate with any given tangible reality or social interaction which determines how we respond" (p. 12). Given that the most important factors for determining the behavior of a teacher are the constructs they develop to make sense of their world, the theoretical lens used in this study was constructivism as envisioned by Lincoln and Guba.

I view social constructivism to be appropriate for this study for the following reasons: Our self-concepts are not constructed in an isolating vacuum; rather, they develop as we interact with others, and those interactions shape those self-concepts. Indeed, in studying the nature of the developments of passions Vallerand et al. (2003) note the importance of this social interaction,

positing that it is the controlling factor which determines whether a harmonious or an obsessive passion develops. Additionally, writing about the role of other people in an individual's cognition, Bredo (1994), summarizing the works of Dewey, Lave, and Wenger, among others, wrote that thinking "is the result of a dialogue, a way of relating or mutually modulating activity, in which person and environment (ideally) modify each other so as to create an integral performance" (p. 29).

Using a constructivist lens means that the findings of this study are not necessarily generalizable to other environments, other times, or other individuals. Guba and Lincoln (1989), writing about generalizability in the axioms of a constructivist approach, posited that, according to a constructivist point of view, "phenomena can only be understood within the context in which they are studied; findings from one context cannot be generalized to another" (p. 45).

Furthermore, staying true to a constructivist lens in the writing of this study, participants were considered stakeholders in the ultimate product of this research. As such, I presented the findings of the study to the participants and solicited their opinions of those findings.

Lastly, I was not only interested in how the teachers defined passion at the time of the interview but was also interested in how their passion and perhaps their definition of passion has changed with time. Patton (2015) pointed out: "attending to the social construction of reality, then points us not only to what is constructed but how it is constructed" (p. 127). So, I asked the participants questions about how their passion has evolved with time and what factors have been important in that evolution.

Review of Research

The concept of passion passed from a subject of philosophers to a subject of scientific interest relatively recently. Psychologists took up the subject of passion starting in 2003 (Vallerand et al., 2003). Some educational researchers took up the case of passion in 2004 (Day, 2004). This new and important field is now rapidly expanding and evolving.

Passion in the field of psychology. The study of passion in psychology is closely related to the topics of intrinsic and extrinsic motivation which were the primary emphases of self-determination theory (Vallerand et al., 2003). Self-determination theory is a line of research within the field of positive psychology which researchers investigate how intrinsic and extrinsic motivations develop and affect an individual's relationship with a task, such as teaching or running. Deci and Ryan (1980) posited that intrinsic motivation can be affected by two processes, namely a "*change in perceived locus of causality*" (p.40) and a "*change in perceived competence*" (p. 40). Writing about the first, Deci and Ryan stated,

> When one perceives the locus of causality (deCharms, 1968; Heider, 1958) to be more internal and feels more self-determining, one will be more intrinsically motivated; when one perceives the locus of causality for one's behavior to be external, and feels less self-determining, one will be less intrinsically motivated. When behaving in the presence of salient control structures and extrinsic rewards, one will tend to perceive the locus of causality to be external and to feel less self-determining; when behaving in the relative absence of strong external controls and rewards, one will tend to perceive the locus of causality to be internal and to feel more self-determining. (p. 40)

Regarding perceived competence, Deci and Ryan posited that "when an experience leaves one feeling and perceiving oneself to be more competent, one will be more intrinsically motivated. When experiences leave one feeling and perceiving oneself to be less competent, one

will be less intrinsically motivated" (p. 40). So, to make the development of an in intrinsic motivation toward a certain task more likely, an individual would have to perceive autonomy in how the behavior associated with the task is acquired, and the individual would also have to perceive that they are getting better at the task.

A task for which an individual has a strong intrinsic motivation may well be called a passion of that individual. Vallerand et al. (2003) defined passion "as a strong inclination toward an activity that people like, that they find important, and in which they invest time and energy" (p. 757). They also distinguished passion from other internal sources of motivation by positing that a "passionate activity is internalized into one's core self or identity" (p. 757). Individuals with passion, as opposed to motivated individuals without this passion, may identify themselves using the task which has become a passion; they do not just love running; they are runners, for instance.

In their scientific introduction of passion Vallerand et al. (2003) proposed what they call a "dualistic approach on passion" (p. 757). Passion, they argued, comes in two different types, namely harmonious and obsessive. Describing harmonious passion (HP) Vallerand et al. wrote,

> Harmonious passion (HP) results from an autonomous internalization of the activity into the person's identity. An autonomous internalization occurs when individuals have freely accepted the activity as important for them without any contingencies attached to it. This type of internalization produces a motivational force to engage in the activity willingly and engenders a sense of volition and personal endorsement about pursuing the activity. Individuals are not compelled to do the activity but rather they freely choose to do so. (p. 757).

Development of HP has been shown to have many positive effects on the life of the individual. For instance, HP for religious beliefs has been positively linked to lower stress levels, greater life

satisfaction, and decreased rates of alcohol problems (Tomkins et al., 2019). Additionally, HP has been associated with lower levels of burnout among college students (Saville et al., 2018). Numerous other studies have linked HP to positive outcomes (e.g., St-Louis, 2018; Orosz et al., 2016; Yeh & Chu, 2018). From the research conducted it is clear that a HP is beneficial to the individual who possesses the passion. HP, it seems, leads to greater life satisfaction, both while performing the task and after the task is performed. Furthermore, HP was hypothesized by Vallerand et al. to lead to greater creativity on the part of the individual engaged in the task associated with the passion.

In contrast to HP, Vallerand et al. (2003) describe the way in which obsessive passion (OP) develops and the characteristic of OP as follows:

> Obsessive passion (OP), by contrast, results from a controlled internalization of the activity into one's identity. Such an internalization originates from intrapersonal and/or interpersonal pressure either because certain contingencies are attached to the activity such as feelings of social acceptance or self-esteem, or because the sense of excitement derived from activity engagement becomes uncontrollable. Thus, although individuals like the activity, they feel compelled to engage in it because of these internal contingencies that come to control them. (p. 757)

From the definitions, the main difference between HP and OP is the amount of control an individual has over their passion. According to their research, individuals with an OP reported an external locus of control with respect to the object of their passion; individuals with HP report an internal locus of control. According to Vallerand et al., OP is suggested to lead to more rigid (less creative) forms of behavior associated with the passion.

Research using the dualistic model of passion began with the application of passion to activities such as sports, music, reading, and painting (Vallerand et al., 2003). Passion has been

studied in the context of gambling (e.g., Philippe & Vallerand, 2007; Ratelle et al., 2004). Passion's role in sport has been extensively studied since Vallerand et al.'s (2003) seminal study (e.g., Amiot et al., 2006; Donahue et al., 2009; Vallerand, et al., 2006;). Passion has also been studied in musicians (e.g., Bonneville-Roussy et al., 2011; Bonneville-Roussy et al., 2013;). Finally, there has been a recent body of work relating the dualistic model of passion to the concept of "grit," as defined by Duckworth et al. (2007) (e.g., Duckworth & Gross, 2014; Jordan et al., 2019; Lee & Sohn, 2017; Malin et al., 2017). Duckworth and Gross (2014) reported that "newer literature has begun to explore the consequences of pursuing a passionate interest with determination and effort over the course of years" (p. 320). Duckworth and Gross later posited that HP is a predictor of deliberate practice and, therefore, success. Perhaps conducting studies such as these within the field of science education will provide insights into factors that affect teachers' willingness to continue to experiment with and improve their teaching skills. Clearly the concept of passion has been recognized within the psychology community and beyond as a critical factor in a happy and productive human life and an important domain of research.

More recently Schellenberg et al. (2019), instead of the dualistic model proposed above, proposed what they refer to as a "quadripartite approach" (p. 163) approach to passion. Citing existing literature on passion, they report a positive correlation between HP and OP, meaning that, to some extent, the presence of HP for an activity may also indicate OP for that activity. Additionally, they posited that there is evidence that approximately one fifth of the participants of previous research studies are not passionate about any activity whatsoever. Due to this coexistence of HP and OP for an activity in the same individual and the existence of individuals who display no evidence of passion, Schellenberg et al. propose four, instead of two, subtypes of passion, namely Pure HP, Pure OP, Mixed Passion, and Non-Passion. Testing undergraduates and video gamers, they tested the new passion sub-types for differences in general health,

psychological well-being, and academic burnout. They concluded that individuals with Pure HP have more positive outcomes in the tested dimensions of well-being. The results suggested that individuals who are closer to Non-Passion may fare better than individuals with Pure OP. Finally, Schellenberg et al. suggested that future research into passion adopt the quadripartite approach as opposed to the dualistic model.

Passion applied to the field of education. It is difficult to imagine a *good* science teacher who would not have one or more passions related to teaching science, a passion for students, a passion for biology, or a passion for women in science, to give just a few examples. The educational researcher Christopher Day has devoted his career to studying "the continuing development of teachers, teachers' work, lives and effectiveness, teacher identity, commitment and resilience" (Christopher Day, n.d., Research). In 2004 Day wrote the book, *A Passion for Teaching*, in which he made the argument from his own research and the research of others that passion is an integral part of teaching to be ranked with other more commonly acknowledged metrics of teacher quality such as testing data. Going further, Day (2004) exclaimed, "passion is not a luxury, a frill or a quality possessed by just a few teachers. It is essential to all good teaching" (p. 11). Passion may affect everything from ability to communicate with and inspire students to career longevity. Day (2012) identified six so-called "professional life phases" (PLP's) (p.11) of teachers. The PLP's described by Day are stages of a teacher's career in which the teacher is faced with a challenge than can be successfully met or not, much like the stage of personality development posited by Erik Erikson. Day posited that passion is a crucial element in a teacher's ability to maintain a commitment to teaching for the benefit of their students and ends with an appeal to educational researchers to investigate passion within the field of education.

Ruiz-Alfonso and León (2016) writing about passion in the field of education note, "bearing… in mind the benefits of passion, it is quite clear the need to know how to promote it… [and] 'what variables ignite passion?'" (p. 175). Additionally, Noddings (1984), writing about the nature of being a teacher, wrote, "'Mother' is not a role; 'teacher' is not a role. When I became a mother, I entered a very special relation…. When I became a teacher, I also entered a very special – and more specialized- caring relation" (p. 175). Clearly, many have considered the importance of passion in the field of education, even if efforts to scientifically study it have been thus far limited.

The concept of passion has not yet been widely applied to the field of education, but studies researching passion in the field of education have been conducted. Ruiz-Alfonso and León (2016) conducted a literature review of all articles pertaining to passion and education. They found, after a winnowing of results, 13 articles about passion and education.

Studies on passion in students. Of the 13 articles, eight specifically deal with the subject of student passion (e.g., Bonneville-Roussy et al., 2013; Coleman, & Guo, 2013; Stoeber et al., 2011). Of the eight dealing with student passion, one considered passion in middle school students (Coleman & Guo, 2013), two considered high school students (Fredricks et al., 2010; Oliver & Venville, 2011), and the other five considered university students to young adults.

The studies of student passion have yielded some interesting results. For instance, Bonneville-Roussy et al. (2011) found that, for the expert musicians they studied, 99% tested positive for a passion for playing their instrument, suggesting, perhaps, that passion is a necessary part of high achievement in music. Stoeber et al. (2011) found that, for the university students they sampled, both HP and OP were positively related to aspects of engagement such as vigor, dedication, and absorption and negatively related to aspects of burnout, such as cynicism and feelings of inefficacy. Luh and Lu (2012) found, with the undergraduate students they

surveyed, that HP was a mediating factor between an innovative cognitive style and creativity. In other words, Luh and Lu found that students with an innovative cognitive style who did not have HP were less likely than those who had both an innovative cognitive style and HP to be creative. Bonneville-Roussy et al. (2013) found that, with the music students they studied, helping students become autonomous learners led to greater numbers of students with HP and lower levels of students with OP. Moreover, HP alone seemed to be associated with persistence or what we might now call grit.

Yet, some of the most interesting conclusions had to do with the difference in the types of goals that motivated individuals with HP as opposed to the types of goals that motivated individuals with OP. Specifically, individuals with HP were shown to be more interested in mastery goals or performing the task in a better way (Bonneville-Roussy et al., 2011). Alternatively, individuals with OP were shown to be more interested in performance-oriented goals, that is, getting high marks or receiving some other external validation for performing the task (Bonneville-Roussy et al., 2011; Fredricks et al., 2010; Vallerand et al., 2007). Pursuit of performance-oriented goals was also shown to lead to performance anxiety, which would lead to performance avoidance (e.g., Bonneville-Roussy et al., 2011; Vallerand et al., 2007). To clarify, students with an OP were more likely to be chiefly interested in performing, rather than on getting better in their craft. Additionally, Fredricks et al. (2010) and Oliver and Venville (2011) found that the gifted students they studied were primarily concerned with getting good grades and being seen as a good or smart student (performance goals); the gifted students did not seem to have a passion for the science classes they were in.

In conclusion, these studies revealed that teachers, parents, and administrators should pay close attention to what their students are passionate about. A passion merely for performance has

been shown to lead to increased anxiety and performance avoidance in the long-term (Vallerand et al., 2007)

Studies on passion in teachers. The research of passion in teachers is much thinner. Carbonneau et al. (2008), conducted a large study of 494 teachers in French-Canadian schools. The study included 373 women, 119 men, and 2 participants who did not identify their genders. Three-hundred and six participants were elementary school teachers, 120 were high school teachers, 20 were adult education instructors, 46 were teachers in vocational and technical education, and 2 did not identify their school level. The participants had an average teaching experience of about 16 years and ranged in age from 23 to 64 years. In this study Carbonneau et al. found that both teachers with HP and teachers with OP had a positive effect on students in the classroom. They suggested that this may be due to the students' inability to differentiate between teachers with OP and teachers with HP based solely on classroom-behavior. Additionally, they found that HP in teachers may lead to an "upward spiral" (p. 983), or positive feedback loop, in which "positive affect leads to higher levels of subjective well-being that lead to subsequent experiences of positive affect" (p. 983). Carbonneau et al. suggested that this may lead to a decrease in teacher burn-out symptoms over time. On a final note, they commented on the prevalence of passion in participant teachers. "Indeed, 93.1% of the [494] teachers in the present sample met the criteria for at least a moderate level of passion toward teaching" (Carbonneau et al., 2008, p. 984). Also investigating the similarities and differences between teachers with HP and teachers with OP, Moè (2016), studying 379 teachers, across 11 Italian schools, found that HP is associated with job satisfaction, self-efficacy, and innovative teaching techniques, while OP is not. These studies may indicate that passion is a key feature in an effective teacher.

In further research on teacher passion, Clark (2012) sent out 50 surveys to early childhood teachers in New Zealand; only nine of the 50 surveys were returned. Clark found, for

the nine teaching participants studied, five ranked passion as very important in being a good teacher. Clark then asked the nine respondents to define what passion meant to them; in summary, the participants referred to passion as an enduring force that kept them interested in their subject and their students. Hobbs (2012) conducted a small study involving three teachers from two different secondary schools; two of the teachers were faculty at a co-educational, grades 7-12, government school near Victoria, Australia, and the third teacher was from another government, grades 7-12, school outside of Melbourne. The schools had enrollments of 1300 and 900 students, respectively. Hobbs was interested in exploring the relationship between teacher knowledge, identity, and passion. As Hobbs states that "the issue of teaching out of field was not the focus for the study, however, it emerged when asking teachers to reflection subject commitments" (p. 721). Hobbs found that teachers who teach outside of their subject area lack and aesthetic sense of the subject which they teach; as such, they found it difficult to be passionate about those subjects.

To continue, Phelps and Benson (2012) conducted a phenomenological study using open-ended interviews with 13 teachers, asking how long they had been teaching, what they enjoy about teaching, and what advice they would give to new teachers and colleagues about maintaining an enthusiasm for teaching. The 13 teachers were from seven different rural or suburban schools from a county in a southeastern state of the United States. The teachers were all experienced teachers, with experience ranging from 11 to 31 years. They were from a range of academic disciplines, including music, science, math, foreign language, reading, and social studies. The participants were also from a range academic levels, including elementary, intermediate, middle, and high school. All teachers were identified by their principals as being experienced and passionate about teaching. Phelps and Benson found that the chance to make a difference to students, job variety, and challenge all helped them maintain their passion for

teaching. They also found, perhaps unsurprisingly, that paperwork, time pressures, and parent-expectations were reported as barriers to the maintenance of passion.

Finally, Yukhymenko-Lescroart and Sharma (2019) studied the relationship between type of passion (OP or HP), sense of purpose, life satisfaction, and happiness among 177 faculty members at a California public university. They concluded that faculty members with more HP for their work "are likely to experience higher life satisfaction and subjective happiness" (p. 875). This finding is consistent with the findings of Vallerand et al. (2003). Yukhymenko-Lescroart and Sharma also found that a HP for work was positively correlated to life satisfaction, subjective happiness, awareness of purpose, and altruistic purpose; OP, on the other hand, was correlated to awareness of purpose, altruistic purpose, and what Yukhymenko-Lescroart and Sharma called awakening to purpose, which they define as "'actively engaging in the process of exploring one's purpose in life and formulating long-term goals'" (p. 865). They suggest "people who experience obsessive passion toward their work might experience a sense of longing for a larger purpose in life and thus actively explore the bigger existential question of their overarching purpose in life" (p. 876).

In conclusion, passion has been acknowledged as an important part of the human experience. It is entwined with issues of identity and purpose. Furthermore, the importance of passion in students and teachers has been recognized and studied, but there is much more work to do. Evaluating the nature, types, and factors that affect passion is an important avenue of research.

Chapter 3: Methodology

Introduction

The goal of this study was to investigate passion that science teachers have for their jobs. The principal foci of the study were to investigate and to describe how individual science teachers define passion for themselves, how they believed their passion affected their students, and how the teachers felt their passion affected and was affected by their environment. As a working definition of passion, in this study I used Vallerand et al.'s (2003) definition: "Passion is defined as a strong inclination toward an activity that people like, that they find important, and in which they invest time and energy" (p. 757). Furthermore, Vallerand et al.'s distinction between two types of passion, harmonious and obsessive, informed the analysis portion of this study.

However, in contrast to Vallerand et al.'s (2003) study and other subsequent studies of passion (e.g., Philippe & Vallerand, 2007; Ratelle et al., 2004), this study did not seek to quantify passion or discover the type of passion the participants had. This study used qualitative techniques for data collection and analysis. The definitions and descriptions from Vallerand et al. informed the precise interview protocols used.

Research Design

For this study I used a case study research design. Creswell (2013) posited that one of the possible goals of a case study is to understand a specific issue, which was my primary goal for this study. Moreover, Creswell stated that one key characteristic of a case study is that it presents "an in-depth understanding of the case" (p. 98). My goal for this research was to take an in-depth look at five science teachers and describe how passion has played a role in their teaching and how their environments have shaped their passion for teaching science. For the study, from each participant I collected data from two interviews conducted using Zoom. The interviews ranged from 30 to 53 minutes. I also asked each teacher for a lesson plan, test, or other artifact which

they had created that they thought exemplified their passion for teaching. I lesson plans for three teachers and one teacher shared YouTube "virtual field trip" videos they had made for their students. I then attempted to weave them into a coherent description of the participants and of how passion has played a role in how they teach science.

Special note. Due to the spread of Covid-19 during the implementation of this study the original research design was curtailed. The original design specified visiting the participant in their schools and observing their classes. Those aspects of the procedure were removed, and all data were required to be collected remotely.

Research Questions

Related to passion and teaching science, the I was interested in investigating the following research questions:

1. What job-related activities are science teachers most passionate about?
2. In what ways do science teachers believe their passion affects students?
3. In what ways do science teachers believe their environment affects their passion?

Choosing Setting and Recruiting Participants

For this study I was only interested in studying science teachers who considered themselves to be passionate about their teaching. So, purposeful sampling was used to recruit participants for the study.

Contacting science teachers. Middle-school or high school science teachers were identified by school websites which are open to the public. Additionally, a list of science teachers who have connections with the university was used. From the schools' websites, I obtained the email addresses of science teachers to be the possible participants in my study. My first contact with the potential participants was by email (see Appendix A). My goal was to recruit up to five science teachers who considered themselves to be passionate about teaching

science to be participants in my study. All teachers contacted taught at schools that were part of an urban public-school district in a mid-sized city in the southwest. I sent emails to sixty-five teachers from 11 different middle and high schools. Nine of the sixty teachers returned my emails and expressed interest. One of the nine later dropped out, citing time pressures induced by virtual instruction due to the Covid-19 pandemic. Once consent documents were returned by five of the participants, the remaining respondents were sent an email thanking them for their interest and telling them that their participation would not be required.

The final five participants were from five different schools. Three participants were currently teaching science at the high school level; two of the high schools had student populations of approximately 2000 students, while the student population of the third was approximately 2500 students. One teacher was teaching at a dedicated sixth-grade school with a population of about 500 students. The other teacher was from a grades 6-8 middle school with a population of about 750 students.

Collaborating with participant to agree upon a schedule. Once a participant signed the informed consent document and media release form, I scheduled the interviews with the participant. I conducted the two interviews more than one week apart so that I had time to think about and process the first interview and develop follow-up questions to topics discussed in the first interview.

Description of participants and settings. There were five participants in this study. Two were male and three were female. The participants were given the pseudonyms Julia, Paul, Charles, Eva, and Colette. All participants taught at schools in the same large, urban public school district in the southwest United States (see Appendix D).

Julia, who has taught for 12 years, teaches at a 6th grade center with 473 students. In the 2018-2019 school year 97.4% of the students qualified for free or reduced lunch according to the

National center for education statistics, common core of data (n.d.). Julia's school is struggling according to the numbers released by Txschools.gov (n.d.). The school received an overall rating of F by the state for the 2019-2020 school year, with a score of 57 out of 100. Demographically, the student population was majority students of color, with 89.0% Hispanic and 5.7% African American (Txschools.gov). The student population was 3.4% students who were white.

Paul's school was a little different. Paul taught 8th grade at a grades 6-8 middle school. Txschools.gov (n.d.) gave Paul's school an overall grade of B (82 out of 100) for the 2018-2019 school year, so, according to the state, this school was faring better than Julia's for the time periods. Paul's school is also majority students of color, with 59.8% Hispanic students, 24.2% White students, and 12.9% African American students (Txschools.gov). According to National center for education statistics, common core of data (n.d.), 73.4% of the student population qualified to receive free and reduced lunch in the 2018-2019 school year.

Charles, who has been teaching for 13 years, teaches AP Environmental Science and Environmental Systems at a high school within the same district. Txschools.gov (n.d.) gave Charles's school an overall grade of B (83 out of 100) for the 2018-2019 school year. Again, the student population at Charles's school is majority students of color—63.1% Hispanic, 27.2% White, and 6.0% African American. National center for education statistics, common core of data (n.d.) reports that in the 2018-2019 school year 64.9% of the student population qualified for free or reduced-price lunch. So, Charles's school is facing similar challenges to those of Paul and Julia.

Eva, according to Txschools.gov (n.d.), also teaches at a school with many students in economic hardship—91.2% classified as economically disadvantaged by the state. Additionally, National center for education statistics, common core of data (n.d.) reports that 94.3% of the students qualified for free or reduced-price lunch during the 2018-2019 school year. The student

population was 86.7% Hispanic, 9.2% African American, and 2.6% White as reported by Txschools.gov. Needless to say, this is a school with many challenges; the school received an overall rating by the state of C (74 out of 100) for the 2018-2019 school year.

Finally, Colette, who has taught for 9 years, was teaching at a high school which also received an overall rating of C (79 out of 100) by the state according to Txschools.gov (n.d.). It is also majority student of color—51.1%, 23.6% White, and 21.9% African American. The National center for education statistics, common core of data (n.d.) states that 69.7% of the students qualified for free or reduced-price lunch in the 2018-2019 school year.

From the above descriptions each of the participants must face a number of challenges in their teaching life. These challenges make the fact that they have maintained passion for their subjects and for teaching even more impressive.

Initial briefing of participants and obtaining informed consent. After a teacher agreed to become a participant in my study, I provided them with the informed consent document and media release form as an attachment to an email and asked each participant to read, sign, and return the forms via email (see Appendices D & E).

Study Procedures

With each of the participants I conducted two interviews. The interviews were conducted over Zoom and ranged from 30 minutes to as long as 53 minutes. At the end of the first interview, I asked each participant to share with me a lesson plan or something else that they had created that they were passionate about. Four of the five participants shared lessons with me. Julia never sent a document, but during the interviews we did discuss what she most enjoys teaching and how she feels when she is teaching that subject.

The first interview. The first interview was modeled after Patton's (2015) "standardized open-ended interview" (p. 438) approach, and the core questions of the interview were the same

for each participant (see Appendix E). Follow-up questions which depended on responses to the core questions were not be the same for each interview.

The purpose of the first interview. In the first interview the I tried to determine the participants' views on passion in science teaching, the extent of their passion for the science subject they teach, their definition of passion, the parts of their job about which the participant was the most passionate, and what job-related activities what most likely to be so engaging as to produce a flow state. I also tried to determine how the participant thought their passions and interests affected their students. Since all participants answered the same core questions, the responses of the individual participants were compared allowing better "cross-case item analysis" (Patton, 2015, p. 263).

Procedure for the first interview. On the day before the interview, I sent an email to the participant reminding them of the time of the interview. The interview was conducted online over Zoom. At the beginning of the interview, I started a 55-minute timer and began asking the questions. Audio and video for the interviews was recorded. The interview was concluded when the participant had no more to share regarding the questions. No interview lasted the entire 55 minutes. In the last minutes of this interview, I asked the participant to share a lesson plan or lab procedure, developed by the participant, which indicates the participant's passion for their work. By viewing a document that the participant had created I hoped to observe evidence of passion either in the amount of time for creation indicated by the item or by the language used in the document.

The Second Interview. The second interview occurred at least one week after the first interview to allow time for me to review the transcript from the first interview. If the time for the second interview had not already been established, the participant and I established a time by email correspondence. I used the second interview to investigate the evolution of the

participant's passion over the course their career, to clarify responses from the first interview, and to ask any remaining questions (see Appendix F). Again, I sent an email on the day before the interview reminding the participant of the time of the interview. At the start of the interview, I started a 55-minute timer; all interviews concluded before the timer went off. I began each second interview by asking the participants specific questions about the items that they shared with me between the interviews.

Research Journal. Throughout the research process I kept a journal in which I wrote most of the times that I worked on this study. I used the research journal to brainstorm about emerging themes and to document what I had accomplished during that work-session. With this data source I hoped to maintain a thread that began with the commencement of the study and ran through the entire progression of the research. This allowed me to look back and to see how my thoughts had changed or remained constant through the work. This helped me to see some of the commonalities in the participants' responses.

Data Analysis

Most importantly, all data analysis for this study was qualitative. The method of analysis was informed by the case study data analysis strategies described by Patton (2015) and Creswell (2013). The primary goal was to provide "thick, rich description" (Patton, 2015, p. 533) of the individual cases so that they could be compared and so that other researchers will be able to judge whether the data from this study applies elsewhere. First, all interviews were transcribed and read multiple times to look for emerging themes. Second, these emerging themes were then shared with participants to ensure that they accurately reflected the opinions and ideas of the participants.

Analysis of the individual cases. For the purposes of this study a case is defined to be the individual teacher. When I considered the individual participant, I was interested in topics

that came up repeatedly and/or spontaneously. As I read through the interviews, I began to categorize parts of the responses by theme. I constructed a spreadsheet in Google Sheets in which I started to make sense of the interview responses (see Appendix G). In the spreadsheet the theme was noted as well as examples of responses that fit the theme from the participants' interviews. The interview number and time stamp were recorded so that the examples could readily be found later. Some emerging themes ballooned with many examples, like the theme of labs and projects, while other themes gained very few subsequent examples, such as the theme of extracurricular clubs. As more and more evidence began to emerge for certain themes, ideas for what was important to each teacher individually began to emerge. Additionally, I began to see themes that occurred across the individual cases, for instance multiple participants reported that planning lesson was a job-related activity about which they would get very passionate. These common themes would form the basis for my cross-case analysis.

The different items that I collected were also analyzed for evidence of passion and objects of passion. I obtained three lesson plans which teachers had developed (see Appendices H, I, K, and L) and one video virtual field trip (see Appendix J). These were viewed in between the interview and formed the basis of some of the first questions in the second interview. Additionally, since the submitted samples represented a substantial amount of time and effort on the part of the participant, each sample was used as evidence for the types of activities about which the participants were passionate.

Cross-case analysis. Additionally, the case study design allowed for what Patton (2015) calls "cross-case item analysis" (p. 263) where data from multiple individual participants were compared to look for themes of passion. Yin (2003) suggests comparing different individual cases to look for similarities and differences. This approach allowed for what Creswell (2007) calls "naturalistic generalizations" (p. 163) or general lessons which could be abstracted from the

individual cases. This method of analysis could prove very elucidating and was a real strength of the case study design. I was able to identify several commonalities among the participants of the study, such as the appreciation of being able to collaborate with fellow teachers about how to best teach subjects or the dislike of top-down initiatives from the school district. Indeed, there were quite a few commonalities shared by the participants. This type of analysis provided one more piece of information about how environmental factors affect a teacher's passion and suggested possible avenues for future work.

Risks

The primary risks to participants were the loss of time due to correspondence with the me, participation in interviews, document retrieval, and member checking. To mitigate the risk of loss of time I made every effort to be respectful of participants' time and not take more than was necessary to collect the data for the study. Correspondence with the participants was kept to a minimum. All interviews were conducted in 50 minutes of less to minimize the participants' loss of time.

To maintain confidentiality, audio files from the study were stored on password-protected computers and on a password-protected Google drive. Electronic transcripts from interviews were also stored on password-protected computers and on a password-protected Google drive. All participants were given pseudonyms to protect their identities. Only I knew the real names of the participants. Likewise, the names of the schools were not used in the research report, and the city where the research was conducted was described only by approximate population, region of the country, and other general characteristics; the name of the city was not given in the report.

Additionally, participants were also informed that they were free to withdraw from the study at any time. Participants were informed that they could withdraw from the study by contacting me by email or phone and asking to withdraw. If any of the participants had opted to

withdraw from the study, all data obtained from the withdrawing participant, which has not been analyzed at the point of withdrawal notification, would have been removed from the study and destroyed.

Trustworthiness

Lincoln and Guba (2013) describe the trustworthiness of the research as referring to "whether the findings and interpretations made are an outcome of a systematic process, and whether the findings and interpretations can be trusted (Lincoln & Guba, 1985)" (p. 103). I used Lincoln and Guba's "criteria for trustworthiness, authenticity, and catalyst for action" (p. 103) to judge the trustworthiness of this research. Strategies which I employed to increase the trustworthiness of my research included providing a detailed description of the settings in which the participants worked. While I was not able to visit the sites, I provided what information I could from state and national data bases. I also used a spreadsheet to begin forming my ideas about themes that I was witnessing. This allowed me to easily add more examples of the theme as I read additional responses, providing some amount of triangulation within one participant's response and between the responses of different participants. Finally, after each participant's individual section was finished, the section was sent to the participant for member checking so that they could verify its accuracy.

Credibility. According to Lincoln and Guba (2013) credibility in qualitative research is closely related to the internal validity of qualitative research. Lincoln and Guba suggest "triangulation of sources [and] methods… and member checks" (p. 104) as techniques for assuring credibility. I used triangulation within participants responses by observing how frequently they mentioned a topic and how long they talked about a topic. I was also able to see in the original conducting of the interview and in viewing the video of the interview how passionate the participant was about a topic. Checking one participant's responses to other

participants' responses provided another form of triangulation and comparing responses to results of previous research was one more method of data triangulation used.

Finally, I made use of member checking to ensure validity of any "proto-conclusions." I submitted to the participants the parts of the study in which I had written about the participant and asked the participant if statements and conclusions were accurate. Three participants declared the representations accurate, one participant never responded, and one made small revisions to clarify their points.

Transferability. Lincoln and Guba (2013) largely recommend leaving the generalizability or transferability of qualitative research findings to readers of the research. To aid readers of the research, Lincoln and Guba recommend that researchers provide "enough descriptions of the context so that the reader can determine whether the findings apply to his or her context" (p. 105). Due to Covid-19 research protocols, a detailed first-hand description of the environment was not possible. However, state and national databases were used to provide information about the settings in which the participants were working. This information gives the findings some context which will allow others to assess the transferability of conclusions to other environments.

Dependability. According to Lincoln and Guba (2013) the dependability criterion "addresses how the findings and interpretations could be determined to be an outcome of a consistent and dependable process" (p.105). I increased the dependability of the study by using well-accepted qualitative research practices. As a start, I used purposeful sampling as described by Patton (2015). I used open-ended interview questions as advocated by Patton to allow participants to independently recall subjects and activities about which they are passionate. I used triangulation within each case and then between cases, and, finally, member checking was

employed. By using these strategies, it can be said that my findings were the result of a "consistent and dependable process" and so should be dependable.

Confirmability. Lincoln and Guba (2013) state that confirmability refers to "how the findings and interpretations are a result of a dependable process of inquiry as well as data collection" (p. 105). I used triangulation between the responses of the different participants to look for confirmation of emerging themes. Additionally, the responses of a single participant were scrutinized to confirm whether a possible theme was accurate. If the participant mentioned similar items, such as field trips, multiple time or spend an inordinate amount of time talking about field trips this was taken as strong evidence that field trips were important to the participant.

Authenticity/Ethical Criterion. Lincoln and Guba (2013) posit that qualitative researchers should, through their research, help participants learn something new about themselves or their social condition, help stakeholders (teachers, administrators) learn about each other, seek to be an impetus for social change or action, and educate stakeholders in how to bring about social change. To this end, I shared the preliminary findings with participants in the process of member checking.

Limitations

Patton (2015) discusses the difference between "emic and etic perspectives" (p. 337). One potential limitation of the study was the fact that the I was approaching participants and gathering data from at etic, or outsider, perspective. Being an outsider, I expected the behavior of the observed to be affected for the purposes of interviews or observations. This was unavoidable and every attempt, through triangulation and other means, was made to mitigate the effects endemic to an etic perspective.

Of course, there was the fact that this was a very small-scale study in terms of numbers of participants, which affects the generalizability of the results. However, I was not concerned by the generalizability of this study. The results of this study provide additional insights into the role of passion in the teaching of science. The results may help to awaken questions in other researchers who will wish to conduct studies with large numbers of participants, but that is not the goal of the present study.

There was also the issue of positionality to be considered (Ardis, 1992). I am a white male who is also a high school science teacher, and this probably affects the way people relate to me. I have numerous other physical and behavioral characteristics; any of which could affect how the participants related to me. There was no way to eliminate this consideration; so, when the data were reviewed, I kept the idea that all my interactions could have been affected by the self which was present in the interactions. Additionally, this positionality statement is an attempt to describe who I am so that the reader will be able to make judgements about potential biases in the final report.

Conclusion

This study was conceptualized as a preliminary look at passion in the context of particular science teachers. As a preliminary look into passion, I aimed to clarify how science teachers themselves define and manifest passion. With this study, I was seeking to get an initial look at a new way to evaluate and consider science teaching. All decisions were made with this goal in mind.

Chapter 4: Results

The responses of five participant teachers were analyzed for answers to the following research questions:

1. What job-related activities are science teachers most passionate about?
2. In what ways do science teachers believe their passion affects students?
3. In what ways do science teachers believe their environment affects their passion?

The participants for this study were five science teachers who have taught for 12 to 16 years. For reporting, each teacher was first considered as a case and analyzed for each research question. Cross-case analysis was then conducted for common themes.

Julia

"I am very passionate about the fact that I refuse to let my students tell me they're not going to college because they can't afford it" (J2). As a first-generation college graduate, Julia sees it as her mission to keep college in the minds of the sixth-grade students she teaches. Julia has taught sixth grade at a stand-alone sixth grade center for 12 years; it is the only school at which Julia has ever taught.

She teaches students for a year; after which, they move to a separate, unattached campus. Her desire to see the sixth-grade students successfully complete high school and matriculate at a college or university continues after her students have graduated from the sixth-grade center and moved on to middle school and high school. "I tell them every year, 'when you get to high school, if you need help filling out [applications for] scholarships, send me an email'" (J2).

Julia, who can personally relate to many of the students she teaches, uses the example of her own life to motivate her students.

> I am a Hispanic woman, and I have a college degree, and I feel like, 'Boy, my young men and my young women need to see that.' There's more to it than just what society says,

> and so I'm a science teacher, you know. Science isn't a girly subject. So, I'm like, 'Yeah, let's do it!' (J2)

What Julia wants most is for her students to know that they could have a place in a science-related career. "I want them to have that feeling of 'I could do so much with science'" (J1).

Julia started as a mathematics teacher— "But the problem I had was I was constantly trying to bring the science into it" (J2). She reports that the students who come to her have not had much exposure to science. "And so, I've kind of made it a mission of mine to just make kids love it, and I just want then to see that everything leads back to science" (J1). "I want kids to understand that everything has to do with science, and I just want them to feel it" (J1). For Julia, passion about science or science teaching is more than just words: "You have to show it, and you have to feel it" (J1).

What job-related activities is Julia the most excited about? Julia's favorite teaching-related activity is planning and then delivering lessons that produce "Aha!" moments in her students. She feels very passionate about designing project-based learning opportunities for students as they provide a venue for the "Aha!" moment.

> My favorite parts of teaching science are developing not just lessons but units, I guess. So, I'm really big in project-based learning. And so, developing those and creating opportunities for the "Aha!" moment. And then, of course, the "Aha!" moment. (J1)

For Julia, creating project-based learning is a passion.

> I feel like we do a great disservice by sending kids to different classes because you don't walk into a grocery store and turn off your reading brain and turn on your math brain, and our kids tend to feel very compartmentalized when we do that, you know. And we're like, oh, so go to reading class now, or they come into science class, and they're like, "But we're doing math," like, "This isn't math class." And so, I feel we should be teaching

them a lot more across the board, like project-based learning. Which is why I do so much project-based learning because you can kind of wrap everything into it. (J2)

When asked if she was given much freedom to design her own curriculum at her school Julia replied that, due to her seniority, she was afforded the freedom to control her curriculum. She also mentioned the lack of end-of-term tests in her subject area.

> I have been teaching on this campus for nine years; I've been teaching science on this campus for nine years. And I was the teaching chair last year… Our district does give us an outline, and it follows the TEKS [Texas Essential Knowledge and Skills], and then, being a sixth-grade campus and teaching sixth grade, our kids aren't tested in science. So as long as I'm teaching the TEKS, I have a little leeway to kind of do what I want with it. But I will say that at the beginning it was nice to have that tool of the district's curriculum, but I have a tendency to kind of go a little rogue. (J1)

In what ways does Julia believe her passion affects her students? Julia reports feeling as if her passion for her subject or aspects of her subject is directly conveyed to her students.

> I feel like I am trying every day I go to work to instill that passion in the kids; so, I feel like if I'm passionate about it. Then I'm going to build little passions, little passions, you know? Like, have those kids that build up that passion. (J1)

Additionally, Julia's passion and the students' passion form a learning feedback loop.

> When I start talking about [outer] space, and then they start asking questions. I just want to get into it more because they enjoy it so much. When they start asking questions and the questions are, you know, questions we all have, but it's just kind of nice to hear that they actually want to speak up… So, I hope by then I fostered that sense of community to where they feel comfortable asking those questions. (J1)

Julia also stated that the parts of her curriculum about which she is more passionate are more well developed that other areas of her curriculum.

> I really like the astronomy part…. So, I have a lot of units that I have built because I have such a stronger understanding because I like the astronomy unit. The biology unit where I'm not as strong on it, it's a little harder for me, and, so… those units aren't as strong… I think that we tend to kind of portray our understanding and our beliefs and our feelings towards the subject to the kids. (J1)

Julia feels as if it is a challenge to move on from areas about which she is passionate because she enjoys them so much, she feels that there is too much information to share in the limited amount of time. "Excitement builds and I just want to share it" (J1).

How does Julia think her environment affects her passion? When asked about how her school environment negatively affected her passion for teaching science, the aspects of the job that Julia mentioned were the paperwork and meetings.

> Probably the hardest part… is definitely all the other stuff we have to do that isn't teaching. You know, the paperwork, the meetings…. When I tell somebody I'm a teacher, I don't ever think about those kinds of things. I think about standing in front of the kids and, you know, doing all of that. But the stuff that really gets me down is… the paperwork and the lesson plans and all of the stuff that takes my time away from just spending time and giving knowledge. (J2)
>
> It's irritating, and yeah like you know… all of the things that take my time away from just building some like "bomb" lessons that I could do with the kids, you know. (J2)

It might be predictable that someone who has a passion for teaching science would not find these aspects of teaching to be compelling or exciting.

When asked about how her school environment positively affected her passion for teaching science, Julia mentioned feeling supported by the administration of her school. She also reported that her school took her teaching ideas seriously.

> My school is my canvas… My campus is very good about providing opportunities for us. So, if I tell them I want to do this lab, and I'm going to need every kid to have 30 Starbursts; so, I'm going to need 1500 Starbursts, they say, "Okay, when do you need them?" (J2)

Julia attributes her waxing interest in teaching science to a friend group that started at a teach training offered by the district.

> When I switched over to science, I actually did a training with TQ, what you called the teacher quality, and it was a group of other teachers in the district where I was just able to get together and talk science. And so, it definitely was an experience that I definitely think helped kind of propel me forward on that because I got to meet other science teachers, and we created a small little group. Like they're some of my greatest friends now. Just from this training… and what I appreciate about it is, we're from all over the district, but it was training we actually needed. Like our district doesn't tend to give us trainings. We need trainings… And so, this was training we needed and our teacher quality, you know, we could go in and we could ask questions, and they were like, "Okay, this is what you need, like, let us help you do that." So, it was definitely that first year of that just built this cohort of some of, like I said, some of my greatest friends and some of my greatest resources, like I could definitely call any one of them right now about a problem I'm having in class and they've got ideas or things that we can like bounce off of each other. (J2)

The valuable part of the training that Julia mentions is the forming of a friend group that has helped Julia to solve problems that have occurred during her career. Julia has found her tribe.

Julia's shared items. Julia never shared a document which she had created with my, but during the interviews we did discuss her love of astronomy and the excitement that she feels when she is teaching it to the students.

Paul

When Paul begins the lab where his students mix calcium chloride, water, and baking soda, he sets his timer at the front of the classroom. Paul knows that when he starts this lab, he will lose all track of time and might not remember to wrap up the lab with enough time remaining in the class period. Paul rates his passion for teaching science as an eight on a scale of one to ten. "It has to do with… I'm not bonkers-crazy. I have a life outside of teaching. Of the time I'm here, I spend my time fully engaged" (P1).

Paul has taught middle school biology and chemistry for 16 years. He has taught so long that he surprises himself when preparing copies of lesson plans. "I can't believe I used to do that, you know, I just forgot" (P2). Yet, Paul still has a passion for teaching science.

Paul defines a passionate teacher as a teacher who will think about the job and how to do it better, at all times of the day, during any activity; or, in Paul's words, "like when you're out at a show or, you know, with my family swimming in the backyard, planting… gardening" (P1). Paul has a life that he really enjoys, frequently camping with family and friends and biking, but Paul's brain is never completely separated from his teaching.

What job-related activities is Paul the most excited about?

I like the creative part of it, the planning the lesson. I like the actual delivery, and then, you know, the kids. So, out of those three, which one is my favorite?... I like the kids to

> be honest; I just… you know, that's the reason why we're here, but I mean, if I'm talking about it, planning or delivery, planning is more important. (P1)

It seems evident from Paul's response that he is hard pressed to say whether he enjoys the actual delivery or the planning of the lesson more. Paul is evidently passionate about both areas of teaching.

In terms of subject materials that Paul is passionate about, he enjoys introducing the students to chemistry.

> I like teaching chemistry. I like to be the first guy that talks to them about the periodic table and shows them all the chemicals, that type of thing…. because it's immediate; there's no hemming and hawing around; it's right there in front of them, and if there's a 'wow-factor' as well. (P1)

The specific chemistry experience that Paul enjoys sharing with the students is adding $CuCl_2$ and adding aluminum.

> One of my favorites is taking copper-chloride-two and putting it into solution and then adding aluminum to make aluminum chloride, you know. See, what you get is you get decomposition; you get heat; you get an exothermic reaction; you get a production of gas. So, in that one reaction you get pretty much the whole gamut of evidence that the reaction has occurred. So, I think that one's my favorite… because to me very, wow! (P1)

He also enjoys showing the students how to extract visible DNA from strawberries. When Paul is recounting classroom experiences involving these investigations, it is apparent that he is enthused and that the students were enthused when they were in the classroom.

In what ways does Paul believe his passion affects his students? "It's of the utmost importance my attitude towards whatever it is I'm doing translates directly to [student] outcome" (P1). From conversations with Paul, it is evident that he sees his passion and the passion of the students as a sort of feedback loop. Sharing a lab more than 12 times with students stays engaging for Paul because he is introducing it to a new group of students whose excitement motivates Paul (P2). In turn, Paul's excitement keeps his students engaged.

When asked what parts of the job are the most critical for being a good science teacher, Paul responded,

> The most critical? Passion. You've got to be into it…. I think anybody can learn this stuff if their passionate. Prior knowledge, it can be learned. So, it has to be the subjects you enjoy… That's how you become good at this. Because everything else will fall into place. (P1)

How does Paul think his environment affects his passion? Paul does not find all district-wide teacher trainings to be valuable, but he does find training in which teacher share ideas with other teachers to be helpful.

> The district, our district used to do some cool trainings… So, I always do that… Those used to be really good. Lately, they have not been that great. But there were periods of times where the admin would tap people in the district that were passionate and interested in things… in certain subjects or ideas, and they would share it with us and we [would] go on Saturdays and get that. (P2)
>
> So, I like AVID right… Okay, so that's one of the things that I like; I like AVID; I like the way it works. So, it motivates me because the way in which AVID treats the lesson cycle. Yeah, and that the, I'd say tricks… But anyways, that they have these little ways in which you to get them to learn at a higher level…. The underlying theme is note-taking,

> right… So, they want to be able to process the information, and then, when we're finished taking the notes, either chunk things, so that so once they're finished taking them [the notes], they instantly want to do some sort of activity to substantiate that information. So, I think AVID does that for me… It creates this simplistic way to look at lesson planning and to look at the lesson cycle. So that you can chunk the information and then put it into a format where they can learn it quickly. I'd say AVID the added strategies are the things that motivate me because from there, then you start to think that way. So, then you start to come up with your own way to look at how to substantiate the ideas. (P2)

Paul's lesson on plate-tectonics. Paul shared with me a plate-tectonic project that he did with the students during the month of January (see Appendix H). The students have to use materials of their choice to model the layers of the earth and demonstrate different phenomena as well as relating the phenomena to all three of Newton's Laws of Motion. The project was complex and had to include at least 2 moving parts. At the culmination of the project the Paul and the students did a "gallery walk" in which each group would be able to explain and demonstrate their model to the rest of the class. Pictures of some examples of student work were included (see Appendix I). The information conveyed by the items Paul choose to share with me seem to fit nicely with what Paul had said about his enjoyment of doing group work with his students to encourage their passion and excitement for science.

Charles

On a cot under the stars near a river in Texas, Charles is having trouble sleeping because of a curious feral hog who keeps coming within feet of his cot. Eventually, Charles resigns himself to sleeping in his car for the rest of the night. The next morning Charles awakes to find several other pickup trucks parked near the river next to his pickup truck. Several of his fellow

pickup-truck-campers, who had parked under the bridge in the night, awoke to find that their trucks were stuck in the mud and sand by the side of the river. Charles spent the first part of his morning helping extricate his unlucky neighbors. Just the previous morning, other fisherman and campers had helped Charles pull his own truck out of the sand by another section of river. Charles is there, by himself, to set turtle traps for a turtle survey, a research project he does with groups of students from school.

Charles has always loved wildlife, working for the local zoo for six and a half years before deciding to become a high school teacher with the local public school district. He has taught at the same public high school for 14 years.

Early in his career as a teacher, Charles taught a student who was "one of those legit genius kids." This student lead Charles's Biology Academic Competition team to state and national championships. The team was even awarded "all-expense paid trips to DC." These experiences helped to fuel Charles's initial passion for academic competitions. Over the years this passion for competitions has waned. "I liked the competitions, and I like, you know, knowing all that stuff, but, in general, I think it's not very useful information…. Whereas environmental science, it's all actual, you know, important stuff for students to know, water quality and that kind of thing." Now, Charles enjoys conducting field work with his students and publishing research studies in journals with his students as coauthors.

> If you're passionate about teaching, you spend a lot of your personal time, you know, working on your craft and working toward the season. You don't have clear… this nine to five, where the minimum work" (Ch1) is all you are doing.

What job-related activities is Charles the most excited about? Charles related at length many examples of his love of conducting field studies with his students.

> Definitely field work. I like to get the students out in the field as much as possible, field trips as well. I go to the botanic gardens…. View a wastewater treatment plant. I think that's a really good one to connect with, you know, the Trinity [River], wherever we actually drink from it, and everything we do goes back into it. And, then of course the lab; in class when kids are having fun learning. (Ch1)

> I think getting outside of the classroom and learning science through hands-on activities like the turtle survey or going on a field trip gives them a connection. [The students] will start to care about it [the subject] a little more. We just read it in a book, you know, you read about water pollution. It's a lot different than when you go to the Trinity and see all the trash in the Trinity and, you know, realize that if you put trash on [the school campus], when it rains, it goes to the storm drain, goes to the Trinity, and then it goes all the way to the ocean if it makes it that far. (Ch1)

Charles's favorite subject is ecology. Without hesitation, he launched into an explanation of how fun ecology can be.

> Definitely ecology, that's what I enjoy the most, and natural history. I like teaching the students, you know about the plants and animals and how they interact with each other, like the mimicry and that kind of stuff. I was showing them some pictures today, like persimmons are ripe right now. A lot of students don't realize you can eat them, they're native, 'course you've got to wait 'til the right time. Or, like, the dragonfly, eastern pond hawk, the females, they're green and the males are blue. So, most students think they're a different species, but they're the same species. Or, different types of cool fungi and insects, that's the kind of stuff that I really like to teach about. (Ch1)

In what ways does Charles believe his passion affects his students? Charles's passion for his students and the subject that he teaches spurs him to outside of the classroom and this, according to him, makes a big educational difference for his students.

> I think getting outside of the classroom and learning science through hands-on activities like the turtle survey or going on a field trip gives them a connection. [The students] will start to care about it [the environment] a little more. We just read it in a book, you know, you read about water pollution. It's a lot different than when you go to the Trinity and see all the trash in the Trinity and, you know, realize that if you put trash on the school campus, when it rains, it goes to the storm drain, goes to the Trinity, and then it goes all the way to the ocean if it makes it that far. (Ch1)

How does Charles think his environment affects his passion? When asked in what ways his teaching environment negatively affected his passion, Charles reported that top-down directives from the administration and student disciplinary issues were the primary concerns.

> Just in general, all the, you know, the things that the administration puts on you, that you know they're doing to make themselves look better. But as far as the students are concerned, it's not helping them at all. And that's just extra busy work. Which, to be honest, a lot of times I just kind of blow off and don't do because I know I don't really have to. It's not part of the job. I try to focus, you know. But I'd say that's the biggest drawback. And discipline is also a problem. Because they don't discipline, for the most part, because there's a lot of pressure to have, you know, like the administration is judged by the amount of suspensions. So, they want to have less suspensions than the previous year or than the previous principal. So, we don't really suspend students much anymore. Like, I've had students getting physical altercations and, you know, come right back to class. (Ch2)

Being a well-respected teacher who has been at the school for some time, Charles is probably more able than a novice teacher to ignore directives from school administration.

When asked what, in his history as a teacher, has had a positive effect, Charles immediately, recalled a colleague, now retired.

> Definitely, Ms. Brenda Song who just retired here at [my school], but she was one of the senior teachers here. She definitely helped me a lot and inspired me, the way she taught her classes and interacted with their students, you know, and developed relationships that she's still friends with lots of our students and they're always keeping in contact and stuff like that.
>
> *Interviewer: Do you still keep in contact with her?*
>
> Yeah, I've got text messages right now on my phone from her….
>
> She taught anatomy and physiology. That was her main subject area. But she also taught Medical micro [biology] and pathophysiology, or something like that, basically students that were destined for med school.
>
> *Interviewer: Okay, now, now would you ever take her on any of your trips, or on the turtle surveys?*
>
> You know, she's always invited, but she is a little bit older. (P2)

When asked if there were other people or experiences that helped to further his passion, Charles recalled two professors and a student.

> I really enjoy all the field trips that I've gone on since the beginning. I think that really helped a lot. And then when I was at [my college] getting my masters. My advisor George McGregor, he was really good and helped me understand teaching. Also, Oscar Drake, I'm not sure if you knew him, but I got to teach a class with Oscar and he really, you know, opens your mind about different things and how to teach and stuff. (Ch2)

When asked specifically about a school practice that helped to further his passion Charles discussed practices that are intended to bolster school pride.

> I'm not exactly sure about for science, but just all of the football games and the athletics and, you know, singing the fight song and that kind of stuff, all that gets me excited about teaching in general, you know, and being a part of the community and not, you know, just a job thing. Like I was at a football game last year and a student came up that I hadn't seen in a long time. And now he works for Bell Helicopter and had his own kid with him, you know, his wife and stuff. It was really neat. He told me how much he enjoyed AP Bio when I taught him… I was actually getting an award for the most spirited teacher, something like that, because I had gone to football games and stuff. Yeah, they announced it over the loudspeaker. So, he knew I was there. So, then he found me. (Ch2)

When asked if there were any other instances where a student had helped to further his passion, he recounted a student who was very interested in birds.

> Yeah, I had a student…. He was really special kid he. I'm not sure if he had Asperger's, or whether he was just really, really socially awkward some sort of autism or whatnot, like he when he would tuck his shirt like halfway and, you know, and he was just a bizarre student, but he was really into birds so me and him hit it off over birds, he would stay after school and talk to me for, you know, an hour more about different birds and the ecology behind the birds and interesting facts I didn't know, and it really got me more and more. And, when he left, he had to go back to China… I gave him a pair of binoculars as a going away gift, and yeah, I was really close with him and his mother. He was here when his mother was at the seminary, I think.

Charles's virtual field trips. Charles shared with me two links to YouTube videos he had made for his students in environmental science (see Appendix J). The videos are seven and ten minutes long and take his students on virtual field trips to places that are driving distance from the school. He films the location and gives the students some information, pausing frequently to say, "so my question to you is…" The students watch the films and have to turn in their answers to the questions. The making of these films indicates a Charles had a great passion for his work; he must not only drive to the locations and film, but then there is the substantial task of editing the videos. Charles would much rather take his students to these locations, but failing that, this is good substitute, and may encourage his students to go to these locations themselves.

Eva

It was the months before the August 2017 solar eclipse. Eva was working at a district school designed for newly arrived international students. The eclipse would come at the very beginning of the school year. Many of the students would have just arrived in the United States and would not be able to speak or understand English. Nevertheless, Eva was determined, as their science teacher, to take them out to show them the eclipse. However, Eva's principal, worried about safety, was on the verge of not allowing the students to observe the eclipse, worried about the numerous safety concerns.

"I had to present all my safety issues, and I was in tears because I was just like, 'she better not.' I better be able to do this because we don't get to see a solar eclipse that often."

Eva typed up every safety concern that she would go over with the students. She was fully aware of potential communication issues. "I didn't want any issues with someone who didn't understand on the first day of school when you don't speak any English." Eva developed

and wrote extensive safety protocols that would minimize the risk to students who would be new to the school, new to the country, and new to the language.

Eva's principal, despite her concerns, agreed to let the students go outside with Eva and her colleagues after Eva pleaded her case and provided evidence for the safety protocols she and her fellow teachers would follow. "It was just like you're in another world." "And, they saw the solar eclipse, and for that whole year the kids bought in the entire time. We were engaged."

Eva began her path toward science teaching as a zookeeper after graduating from college. Eva did not initially consider teaching science; in Eva's own words, "I wasn't going to go into education, but education found me" (E1). Eva began by working as an education specialist while still a zookeeper. Eva has been teaching science for 16 years and has spent the last three of her summers working with professors at a local university to teach students at a science day-camp run by professors at the university. Eva considers this to be a lot of fun because it does not involve preparing the students in the camps for an end-of-course test, which is her normal, school-year experience. She appreciates being able to linger on topics for a bit more time instead of quickly moving on to other subjects.

During Eva's 16 years of teaching, she has worked at three different schools, all schools in the local public-school system. Eva has taught at a middle school for nine years, then a school specifically for students who have just arrived in the United States from other countries for five year. Most recently, Eva is teaching in currently teaching high school science. Eva really likes the fact that the subjects she currently teaches are not tested by end of the course tests; as a result, Eva can spend more time on subjects when the students are engaged and working (E1)

Eva would rank herself as a 10 out of 10 on a scale of passion. She defines this as considering her job to be "twenty-four, seven, three-hundred and sixty-five" (E1). Eva is never able to completely turn her brain off teaching science. She is thinks about how to engage

students on weekends and during the summers. Eva tries to shut her brain off and get some sleep but finds herself waking up at three in the morning with a great idea for a lesson, hoping that she will remember her flash of creativity in the morning.

Eva does try, for a week or two during winter break or summer break, to completely shut off her brain and not think about school at all,

> You know, there's a lot of times that we do PD, and I go to the PD, not for what they're delivering but the collaboration with other science teachers from other schools to learn what their what's working for them. And can you help me. You know, it's a collaboration. I will. I tried this and did that help you or you know kind of sharing resources and collaborating and talking not formally but more informally. (E1)

What job-related activities is Eva the most excited about? For Eva, the ability to develop the lessons that she teaches is very important. Indeed, she will work many hours outside of the traditional school day to design quality lessons for her students.

> Right now, in this virtual world. I spent a lot of time learning all this technology, and right now I'm having an absolute blast developing lesson plans that incorporate the technology. Because everything pretty much has to be linked to something because there's no paper, and I probably will never go back to paper now. Your options are endless. It's [something] you haven't created, and you have to develop it. And then put it in a structure that the students can be successful at. Plus, I'm not teaching a tested subject area. (E1)

Teaching an untested subject area, Eva is freer to teach what she believes is important to her students. Eva sees data collection as a crucial part of science education.

> So, this year we just did something on climate change, and I did it from the standpoint of, really, I wanted them to create analyze data. I didn't say what is climate change. I said,

> Let's analyze the data. Let's create questions. And then we're going to watch people's opinion of it, and then you can agree, or you can disagree; I'm fine with it… Being able to do that and spend a couple of days on it because I'm not tested. I'm having more fun with it. Yeah, I'm hoping that I am engaging the students and maybe changing the, you know, modify the way they're thinking or modeling that process of analyzing data. (E1)

When developing lessons, Eva can easily lose track of time. She spends many hours but is happy and proud to relate the effort; she is like an artist working on a project.

> Quite often if I'm really developing a lesson and really in depth. So, this is where like this summer I learned hyper-docs, and so I had done a carbon and nitrogen cycle lesson; I did it in hyper-docs and Google Forms. I had found the Flip It website where they could do a card sort or create their model. I probably spent 25 hours easily, 25, 30 hours developing this lesson and took it to the twelfth degree. Like, if you don't know the carbon and nitrogen cycle now. But I was interested in, how can I make this technology- savvy for students to do this on their own and then get it in a repetitive nature to where they can master it without me having to give step by step in the process. So, I have since learned that was way too much; Walk it back some, but you know? That's the science of education, and you don't know until you try something and then you walk it back. (E1)

At times it can be difficult for Eva to break out of the creative fervor. Eva finds it difficult to turn off or distract her thoughts when she is in the midst of creation.

> At three o'clock in the morning I'm now coming up with four other things… You know? So, you do lose time. I've spent two hours. I need to get up and walk around, I need to move. Thank God my dogs need out, because otherwise…. Don't bother me because I'm creating this, and I'm in that brain…. I tried to go to bed and not think about it, but then it creeps in and then I wake up at three o'clock in the morning and then bam, bam, bam,

bam, bam, and then I gotta go over it. That's a genius idea! Please let me remember that it the morning. Let me repeat it three times so I will remember it in the morning. (E1)

In what ways does Eva believe her passion affects her students? When Eva thinks about how her passion affects students, what comes to her mind is the transference of excitement to her students, but what also comes to her mind is the idea that students know she cares about them.

> Well, I think there's a relationship part of it with students. And so, when they know that I'm for them and that I'm into it and I'm helping them problem solve. I think that kind of fuels them and brings them into the process, you know? Whether they're successful or not I view things as, it's a process.… We're all in this process together. Some of you may get there faster than others, but it's a process. So, I just think, I don't know. If I'm excited about it, I mean, just think about going into a classroom. If you go in and someone's excited to be there or welcomes you in, then you're more than likely to complete any assignment that you're going to be asked to do. And I think that's the important part of teaching is you've got to the kids got to know that you're there for them and that you're excited about what you're doing. (E1)

Wanting those students to really get engaged into the science. Just really wanting them to share my excitement. (E1)

How does Eva think her environment affects her passion? Sometimes Eva's environment challenges her passion for teaching. While she still loves teaching, she acknowledges that at times it can be "crazy."

> Well, it's kind of like one of these things where sometimes you feel really great, and then sometimes you're just like, "What am I doing?" But I don't know if it's that's teaching science or just all the stuff that comes with educating students. Not, not what you're doing

> in your classroom, not what the students are doing, but all the top [down] stuff coming at you and changing every, you know, they just changed how we're doing attendance. They change the bell-schedule, and you just want to go, "You're paid the big bucks. Why didn't you plan better? That really is your job." Yeah, and so that's probably what influences me as a teacher, more than anything, it's not always the students. It's not always what you're teaching it is all the craziness that goes behind it. (E2)

At other times, Eva's circumstances have helped to encourage her passion for teaching science.

> I've been fortunate that the principals that I've had support whatever craziness that comes in mind because they know that I'm going to keep the kids safe, and I'm going to engage the kids, and that there is a higher purpose of what I'm doing. I'm more of one who comes in and says, "This is what I want to do. This is how I'm going to do it; can you support me on this?" Or I'm one who kind of shapes what's going on… not necessarily a procedure that they're telling me that I have to do. I'm telling me what I have to do. I have to, I have to buy in. If I think it is worth it and there is a bigger purpose, then I will do it…. I've never been that type of person. Now, if it's science related, I'm all aboard. (E2)

When it comes to implementing new educational initiatives, Eva likes to know the theory behind the initiatives.

> What I found was effective was me getting my masters in Curriculum and Instruction finding resources like STEM Scopes, for me, helped me. On my own, I would go and find the resources; I will do my own work. Once I… understood the pet the theory behind it. Then I began to buy in… You can't hand me something and say, "Here, do it." You've got to explain to me why and show me and prove it to me and maybe that's just me being in a district that… that's… So, most of things from the district are not effective for me. (E2)

Lesson plan about the reintroduction of wolves to Yellowstone. Eva shared with me was a Yellowstone Wolf project that she modified from a lesson plan presented by PBS Learning Media (see Appendix K). The lesson is a group project in which the students examine the impact of the reintroduction of wolves to Yellowstone National Park. Evident in lesson is the love that Eva has not only for the subject, but also for her students. Within the project Eva had built in a number of choices for her students to make that could customize the project to the interests of the students each group. Eva's lesson walks the students through a very long project with frequent personal checks for completion—students must mark an "x" when they have completed a certain section. It is evident from this lesson plan that Eva wants her students to succeed and to learn about the subject.

Colette

"I still have this amazing amount of wonder with the natural world, and I think that what drives my passion for science teaching is just the natural world that's around us and how you can take those examples for kids and make something that feels really relevant" (Co1). Colette, in addition to teaching, build has a business building backyard chicken coops and gardens. "Yeah, so we'll help you build gardens and chicken coops or whatever your thing is. I have worms! I do vermicomposting in a huge garden." (Co1)

Colette really appreciates it when she is teaching a course that does not have an end-of-course exam. This gives her the freedom to create her own materials and to cover topics that she and her students find interesting. Colette's passion for teaching science stems from the fact that she has an enduring interest in the natural world. Colette is an AVID-trained teacher and uses her training to help her students think meta-cognitively and find their own learning style.

Colette has taught for nine years, and has taught environmental science, forensics, and biology; she prefers biology. When asked about her level of passion for teaching science, Colette

referred to herself as a "t-shirt kind of teacher," and ranked her passion for teaching science as an eight on a scale from one to 10. Even though she teaches high school, not grade school, she occasionally wears Ms. Frizzle dresses while teaching and even wore the dress to a union-backed teacher protest because in high school "it still has to be fun… a soft place to learn; it's not college yet" (Co1).

What job-related activities is Colette the most excited about? "Oh, my gosh, I really enjoy planning!... It's like buying a present for someone, you're like, 'how are they going to use this?'" (Co1). Colette is most passionate about planning lessons. Because of her AVID training Colette tries to plan lesson in which all her students, with their different learning styles will be successful.

> I love using AVID techniques. I'm AVID-trained, and so I love getting the students to do meta-cognitive activities and thinking about themselves and how they learn best. I really try to give them a lot of choice and especially now that we are virtual, choice is even easier. Everyone has so much access. It's just up to me being creative enough to, like, keep them busy. But I love teaching seniors, and I also like teaching freshman, I love biology! It's my passion subject like I've never forensiced [*sic*] is it in real life. (Co1)

She likes introducing students to the contributions that women have made to the field of science, but, more than just teaching the history of science, Colette likes to walk the students through the science, by having them recreate historical methods, such as the methods of Alphonse Bertillon, the French police officer who created a database of physical metrics that could be used in law enforcement. Colette has each student get measured in one pairing. She then takes those measurements and switches the students' pairing. In the new pairing the students get measured again. They then must match the new measurements to the previous measurements, which are "on file." She enjoys seeing how frustrated the students get when they try to match

the two sets of measurements. It forces them to think about the challenges of and flaws of such databases. It is learning the lesson by walking in the footsteps of the pioneers of the science.

In terms of the subject areas about which Colette is most passionate, Colette really enjoys teaching the students about the scientific study of fingerprint analysis.

> So, I really love teaching fingerprint evidence because it's something that… you've always had fingerprints. They've always been exactly the same, but you probably never really looked at them and after just a little bit of practice, you get really good at that. It's one of those things that makes them feel really smart. So, fingerprints, I really enjoy that. (Co1)

In what ways does Colette believe her passion affects her students? Colette feels that when she begins a new unit and is personally very excited about the unit that the students respond to her enthusiasm with their own enthusiasm.

> We do some meta cognitive stuff where we think about our learning styles, and I reference back to those learning styles all year long. And especially when it comes to student choice. I'll say, well, so remember, those of you who are reader writers, you don't have to. You can use this thing. Those of you who are more visual, you can feel free to watch this video, it's going to give you the exact same information. So, I'll give them more than one way. And I think when I'm planning, I really try to think about how do my students learn, and how can I give them different activities to try to hit everyone's learning style. So yeah, that's how my passion for planning goes into that I really try to do. (Co1)

How does Colette think her environment affects her passion? When asked to describe a person or experience that has helped to further her passion, Colette's reply was all about fellow teachers.

> Oh gosh, so many, so many, but they're all teachers; right? It's all other teachers and their passion for and the way that they taught that really inspired me to also want to provide that. So, I super-duper loved my high school biology teacher, and I ended up taking two years with her and I would… I was like her office assistant my senior year. And I can remember at one point she had a freshman class, and I was well past the point of being in the freshman class, and there was something. They were talking about crawfish; this was back when we did dissections, right? And she was explaining something and then, for whatever, probably because I'm a "Lucy," like a bossy [person], and I talked too much. I felt like I had something to add to the discussion, and she let me do that. And she let me kind of teach that bit. And this was like, well… if I would have never wanted to be a teacher in high school, right? (E2)

When asked if there were any parts of her job that she thought challenged her passion, Colette replied that she enjoyed the rhythm of teaching.

> No, I love the… nice rhythm… but every day is different, and every class is different, you know. I love that! I don't mind teaching the exact same things, year after year, right? If the audience is different, you're buying the gift that's different every time; so, I really like… I like the schedule. I like my job. I generally, usually like my job. Oh, yeah, a lot. I don't often think about becoming a long-haul truck driver. (E2)

There is one part of her school's procedure that Colette does find challenging, a practice known as attendance recovery.

> It is attendance recovery…. Students must be in class ninety percent of the time and at whatever point you are absent more than ten percent of the days then you lose credit due to attendance…. You have a student for an entire year. It's a huge pain… and then they come back the following fall and they say, "Hey, will you give me some work for attendance recovery? I have to go this Saturday." And you say, "But, darling. You're not even my student." And they say, "No, it's for your class. I'm doing attendance recovery for your class." …. But there's actually no relevance or benefit, other than to the school, getting the funding for that student having made up their hours. (E2)

Another positive aspect of Colette's job about which she remarked is that "it's nice to teach an untested subject." (Co1)

Colette's fingerprint analysis lesson plan. The item that Colette chose to share with me was a fingerprint lab that she conducts with her students (see Appendix L). What Colette really likes about this lesson is how difficult it is for the students to identify "suspects" based on fingerprints. The contrast between the difficulty of the lab the portrayal of ease on television shows leads to many teachable moments. As with the items shared by Eva and Paul it is a group project. Eva enjoys watching her students learn science collaboratively.

Common Themes

Each of the five participants studied had their own way of teaching science and had unique preference, but there were many commonalities in their responses.

Freedom to develop your own lessons. Each of the participants in this study reported enjoying planning lessons. Colette replied, "Oh my gosh, I really love planning!" (Co1) immediately when asked what job-related activities she most enjoys. Julia discussed trying to design lesson that would provoke the "Aha" movement in her students. Paul has found that the planning was the creative part of the job that occupied his mind on summer vacations, while

gardening, or anywhere. Charles spends many hours of his personal time by rivers, making video clips for his students, collecting specimens for his students. After his time by the river, he spends more hours editing all the video he has collected. Eva, as well, reported enjoying planning hands-on lesson for her students. Their enjoyment of planning was either an object of their overall passion for teaching science or a consequence of their passion for teaching science.

Sharing the science with students, not dictating science to students. The way four of the participants speak about teaching students is also interesting. Julia, Paul, Eva, and Colette, all speak of *sharing* knowledge with students. From Julia, "Excitement builds, and I just want to share it" (J1). Paul, writing about teachers teaching on Saturdays, remembered fondly, "they would share it with us, and we go on Saturdays and get that. OK." Eva confides, "Wanting those students to really get engaged into the science. Just really wanting them to share my excitement" (E1)." Colette in her interview states, "Yeah, being true having really great teachers that then trust you to kind of share what you know has really inspired me and given me confidence."

Active learning for students—field trips or hands-on activities. All participants enjoyed having the students active and engaged. Eva wants to take her students on as many field trips as possible. Julia loves designing project-based learning experiences for her students. Charles loves taking his students down to the river to research turtle populations. Paul loves conducting chemistry labs with his students, and Colette enjoys leading her students through history-based forensics labs. Perhaps there is something in the activity related to passion.

Continuing education. Two of the participants, Charles, and Eva, brought up the importance of earning their master's degree. Charles talks about his advisors really opening his mind when he was getting his master's degree. "My advisor George McGregor, he was really good and helped me understand teaching. Also, Oscar Drake, I'm not sure if you knew him, but I got to teach a class with Oscar and he really, you know, opens your mind about different things and how to teach and stuff" (Ch2). Eva also talked about getting her master's degree when asked about factors that encouraged passion. "What I found was effective was me getting my masters in curriculum instruction finding resources like stem scopes. For me, helped me" (E1).

Professional development by peer collaboration. Another commonality among four of the five participants was how much they valued peer collaboration as a way of developing as teachers. Paul only valued the district-wide professional development when the district staff picked a teacher who was excited about some part of their teaching, and that teacher was able to share their ideas. "They [other teachers] would share it with us and we [would] go on Saturdays and get that" (P2). Charles spoke of important peer role models from his early days of teaching. "She definitely helped me a lot and inspired me, the way she taught her classes and interacted with her students" (Ch2). Eva, as well, only enjoys professional development when there is informal collaboration with other educators. "It's all related to making connections with other educators" (E2). Finally, Colette only remembers being inspired by other teachers. "It's all other teachers and their passion for and the way that they taught, really inspired me to also want to provide that" (E2).

Preparation for an end-of-course test (ECT). Having or not having to prepare for end-of-course exams also came up in with three of the five interviews. Eva shared that she was happy because she could" spend a couple days on [climate change] because I'm not tested. I'm having more fun with it" (E2). Eva mentioned ECTs spontaneously several other times. Julia also mentioned without prompting, "our kids aren't tested in science. So as long as I'm teaching the TEKS I have a little leeway to kind of do what I want with it" (J1). Colette enthusiastically exclaimed, "I've got the best gig ever. I'm teaching all untested elective sciences" (Co1).

Chapter 5: Discussion

Why should anyone care about whether science teachers are passionate about the subjects they teach or whether or not they are passionate about teaching? Does it make any difference to student outcomes? Does it make any difference to the teachers themselves? The results of this study would suggest that researchers and policy makers should care about whether science teachers develop a passion for science and for teaching, that it will make a difference for students in those science teachers' classes, and that a passion for teaching will make the life a science teacher more enjoyable and will make the teacher more likely to continue teaching.

Ryff's Six Aspects of Positive Psychological Functioning as it relates to the Participants

Carol Ryff (1989) posited six aspects of a person with positive psychological functioning, namely self-acceptance, positive relations with others, autonomy, environmental mastery, purpose in life, and personal growth. There is evidence for each of the six characteristics among the participants. Demonstrating of self-acceptance, Colette proudly exclaims that she wears science-themed t-shirts and "Ms. Frizzle dresses" and loves being a science teacher. Julia's primary social group is tied to her identity as a teacher, and she proudly proclaims that she is a first-generation, Hispanic college graduate. Charles maintains strong ties with former colleagues and students, and, again, Julia loves hanging out with her group of teacher friends; they are willing to call one anther when they are having personal or professional difficulties, indicating strong positive relations. Demonstrating autonomy, Eva independently pushes to take her students out to observe eclipses or go on field trips, and Paul indicates that he makes up his own mind with the mixed reviews of in-service trainings from his district.

Paul also indicates environmental mastery by his strong knowledge of the subject that he teaches. Mastering both the subject knowledge and motivation of students, Charles publishes studies with his students. Julia, as a Hispanic woman, feels a strong sense of purpose in seeing

her student successfully navigate high school and go to college. Eva tries to instill in her students an excitement for science and learning about the natural world. Finally, the willingness of each of the participants to grow in their careers through continuing education, collaboration with peers, and independent study of new technologies indicates a proclivity for personal growth. So, there is evidence that these five participants, according to Ryff's measures, have found a way to maintain positive psychological functioning and to grow successfully in their careers. This positive psychological functioning should indicate teachers who will remain in their careers and continue to grow.

Evidence for Intrinsic Motivation among the Participants

The sheer longevity participants' careers, in which the participants remain engaged, innovative, and effective, would seem to suggest an intrinsic motivation. Deci and Ryan (1980) posited that intrinsically motivated individuals will believe that their future is in their own hands, while those who feel more extrinsically motivated will perceive their destiny to be more out of their control. The responses of the teachers indicates that, when they were more excited about activities, they had chosen those activities for themselves. Without prompting from administrators, Eva works until the wee hours of the morning perfecting lessons, Charles drives hours and hours, camps out by the sides of rivers, and Paul and Colette use the AVID techniques they have learned to individualize curriculum for their students. Finally, Julia asks her former students to call her for help getting into college, an activity not mandated by any district-wide initiative. There is strong evidence that the participants of this study are intrinsically motivated in their careers; Charles drives long hours to make interesting lessons for his students, Eva stay up until the wee hours of the morning making lessons perfect, and Julia tries to maintain contact with her students long after they have left her campus. All of this is done with no hope of extra pay—public school teacher pay scales are published and do not depend on going above and

beyond what is strictly required. Strong intrinsic motivation should make the participants more likely in the future to independently seek out opportunities for career and personal growth.

Evidence for Passion among Participants

Vallerand et al. (2003) defined passion "as a strong inclination toward an activity that people like, that they find important, and in which they invest time and energy" (p. 757). Beyond being intrinsically motivated, there is strong evidence that all five study participants are passionate about teaching science. They have all taught for considerable amount of time and all seemed to spend a lot of their time perfecting their craft. After all the years teaching science, all participants ranked their passion as eight out of ten or higher. Vallerand et al. also posited that a "passionate activity is internalized into one's core self or identity" (p. 757). Again, evidence suggests that all five of the participants possess this characteristic. "I'm a science t-shirt kind of teacher" (Co1). So, of the two types of passion posited by Vallerand et al., which best describes the participants of this study?

Harmonious passion (HP). It would seem intuitive that harmonious passion would be important in order to have a teacher who will stay in the profession for an extended period of time and stay active and engaged. The participants have all been educators for nine or more years. So, if it is true that a harmonious passion is important for staying active and invested in your career, then we might expect to find evidence of harmonious passion. The most explicit example of harmonious passion among the participants was Paul's reason for ranking himself as an eight on a one to ten scale of passion, "I'm not bonkers-crazy. I have a life outside of teaching. Of the time I'm here, I spend my time fully engaged" (P1).

Obsessive passion (OP). There is also some evidence of OP among the participants. The most explicit statement of OP being Eva's. "I wake up at three o'clock in the morning and then bam, bam, bam, bam, bam, and then I gotta go over it. That's a genius idea! Please let me

remember that it the morning" (E1). Eva must also spend hours planning the field trips that she loves to organize for her students. It must take Charles a great number of hours to drive to locations, to collect samples, to shoot videos, and then to edit those videos, not to mention the hours spent applying for field trips so that his students can experience water treatment plants and the like. Possibly more in-depth study might reveal some of the negative effects of OP. However, perhaps there are better ways to conceptualize the passion of the science teachers.

Quadripartite approach to passion. Schellenberg et al. (2019) advocated for the use of what they call a quadripartite view of passion with four subtypes, namely pure HP, pure OP, mixed passion, and non-passion. With this framing of the construct of passion, Paul, who is not "bonkers" (P1) might rank high for pure HP, while Colette may rank highest in the mixed passion with period where she expresses OP. This might mean that she could spend most of her time exhibiting HP and therefore avoid the deleterious effects of OP, such as burnout and stress.

The role of the interplay between environment and person – a new way to frame passion? I suggest that no analysis of the participants with the above conceptualizations would be satisfactory. Furthermore, I posit that the existing studies on passion place too great an emphasis on the person and do not concentrate enough on the environment. There is evidence from this study that some of the participants have ordered their environment so that what might be called OP does not have the accompanying negative effects.

For instance, Julia formed a friend group at one of her early teacher trainings. As a result, when Julia is relaxing, she may also be working and thinking of lessons. However, Julia has all the positive effects of her tribe while she is becoming a better and better teacher. Charles, who must spend countless hours devoted to finding better ways to teach science, is fully immersed in the culture of the school. He loves going to the football games. He keeps up with former colleagues and students. Some of the time that Julia and Charles spend working is offset by the

fact that they are simultaneously meeting their other emotional needs. There may be truth to the saying attributed to Confucius that if you "choose a job you love, and you will never have to work a day in your life." Perhaps individuals who find a job related to their passion and construct the right social environment, friends who are connected to your area of passion, can display higher levels of OP while avoiding the negative consequences of OP.

Teacher Passion and Quality Education

It is likely that the students of all five participants benefit from their passion. It is the participants' passionate approach to teaching that drives them to develop new and interesting lessons. The participants are not the types of teachers to simply pull the same worksheet out of a filing cabinet year after year. They are excited by new technology and new challenges. Eva even expressed excitement about retooling her class for the Covid-19 protocols. Additionally, it may be that passion is what has allowed these teachers to stay in their careers for nine, twelve, and sixteen years. This experience coupled with their passion means that their students are very fortunate to be in their classes.

Implications

The results of this study suggest implications for the way in which school districts and states should implement teacher trainings, development of curricula, and end-of-course tests.

Quality science teacher retention. The results of this study suggest that, if schools and school district wish to retain teachers who will be invested in education and invested in their students, those schools and school districts should pay attention to factors that may encourage or develop a passion in their teachers. A high-functioning, intrinsically motivated, and passionate teacher should continue to seek out new and better ways to teach students. Such a teacher, according to Duckworth et al. (2007), might be more able, than a non-passionate teacher, to weather adversities in their career.

Teacher trainings. The study participants most valued trainings that were teacher to teacher. Paul enjoyed it when the district would allow a teacher to share their practice with other teachers of the district. Charles, when asked what factors in his career had been important for developing his passion, listed former colleagues and professors, but professor with whom he had worked collaboratively, more as peers. Julia's memory of her first teacher training was the friend group that she developed and has since maintained. Districts, universities, and schools developing teacher training should place strong emphasis on providing opportunities for teacher collaboration.

Curriculum development. Far from being burdensome, the participants of this study expressed joy for planning lessons. "It's like buying a present for someone" (Co1), remarked Colette. Two of the participants, Paul, and Colette, expressed an appreciation for training in how to develop a curriculum for diverse learning styles, AVID. In light of this information, science curriculum developers should construct broad curricula with freedom to customize built in, perhaps even freedom to choose between large sections of material, for instance a teacher may be able to cover the physics of waves and leave out thermodynamics if it fits the interests of teacher or the needs of the school.

End-of-course tests. Since three of the five participants expressed relief that their students did not have to take an end-of-course test, perhaps we should look at the value of the end-of-course tests. What are the goals for those tests? If the goal is to measure the quality of education in a particular school, is there a better way to measure that. Are they meeting the goals? Do the tests help to improve undesirable educational outcomes? At what cost? What are the "side-effects" of the testing? Are teachers less invested in how and what they teach; do they add to student stress levels; do teachers stop emphasizing the big ideas in favor of an emphasis on how to answer test questions correctly?

Conversations with all possible stakeholders, students, parents, and teachers, would be beneficial. With good-faith discussions about testing we may be able to move to a way testing that is kinder and better meets the needs of the students.

Ethics and passion. Nodding's (1984) compared the role of teacher to the role of mother. As such the role of teacher, as that of mother, must be internalized and incorporated into one's identity. This, according to Vallerand (2003), is the difference between a passion and merely a strong interest. Day (2012), in writing about quality teaching and teachers, connected passion to empathy.

> Good teaching is recognized by its combination of technical and personal competencies, deep subject knowledge and empathy with the learners (Hargreaves 1998, 2001; Palmer, 1998). Teachers as people (the person in the professional, the being within the action) cannot be separated from teachers as professionals (Nias, 1989a). Teachers invest themselves in their work. Teaching at its best, in other words, is a passionate affair (Day, 2004). (pp. 18-19)

There has not been enough research conducted into the link between passion and its subtypes and empathy, but Day might be suggesting that there is such a link. If this is so, then a passionate teacher may be important not just for student achievement but also for a kinder and more humane educational system.

One final aspect of ethics must be considered; we must consider how administrations and districts and school policies treat these highly passionate and invested teachers. Firstly, teacher pay is not commensurate with the effort that these individuals put into their jobs. It never will be, but a real appreciation of this fact could go a long way toward a new ethos toward teachers. Secondly, related to the first point, within schools moving from teaching to administration is seen as a "promotion." That is not what it is; if Yo-Yo Ma put down his cello and moved from

performing to managing musicians it would be regarded as insane, not a "promotion." Similarly, it should also be seen as insane if a highly passionate, highly effective teacher leaves teaching to move into school administration. Yet, this is incentivized by the pay structures that exist in schools today. Administration is another job, an important job, but a different job. It should not be seen as a promotion. Pay scales should be changed to stop incentivizing this behavior.

Suggestions for Further Research

This study does suggest some possible future avenues of research. First, in the field of science education research the concept of passion needs to be considered. Passion has been identified as an important part of effective teaching; it should be studied more extensively in the field of science education and in education in general. Secondly, more studies on passion and subtypes should focus on the interplay between environment and passion. Can individuals with the right environment and social groups exhibit high levels of OP and still maintain a balanced life? The link between empathy and passion would also provide a fruitful area of research. Is a science teacher who is more passionate about education or about science more empathetic toward their students?

Conclusion

Passion plays a critical role in good teaching. To quote Day (2004) again, "passion is not a luxury, a frill or a quality possessed by just a few teachers. It is essential to all good teaching" (p. 11). Passion may allow teachers to do a tremendous amount of work without any additional monetary compensation. It may help teachers to stay in their careers until they have enough experience to truly effective with their students. The five participants of this study have stayed in their careers and are still willing to stay up very late planning lessons, drive many miles to collect samples, and pursue personal educational experience that will help them to become better

teachers. There is ample evidence that they are passionate about teaching and science. This passion may have compelled them to become the teachers they are today.

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Appendix A

Email to Science Teachers

Dear [Name]:

My name is John Cordell. I am a Science Education PhD candidate at Texas Christian University (TCU) studying the role of passion in teaching science. I am looking for science teachers who consider themselves to be passionate about teaching science. If you would describe yourself as passionate about teaching science, I would like you to be a participant in my study.

The active part of the study will involve two 45–60-minute (maximum two hours) interviews which will occur over the course of two months or less. I would also collect a lesson, lab, or similar document which you created. If you are willing to participate, I would like to meet with you over Zoom or Google Meet, to give you more information about the study.

Please let me know if you are willing to take part in my study, and we can set up a time to talk about it. john.a.cordell@tcu.edu; phone # 817-614-6389. I would appreciate a reply by [date].

Sincerely,

John Cordell

Ph.D. candidate in Science Education

Texas Christian University

Appendix B

Informed Consent Document

Texas Christian University

Fort Worth, Texas

CONSENT TO PARTICIPATE IN RESEARCH

Title of Research: Passion in Science Teaching

Principal Investigator: Dr. Molly Weinburgh, Ph.D.

Co-investigators*:* John Cordell, Ph.D. candidate in Science Education

You are invited to participate in a research study. In order to participate, you must be a current science teacher and consider yourself to be passionate about teaching science. Taking part in this research project is voluntary.

A summary of things you should know:

- This is a research study involving human subjects that has been approved by TCU Institutional Review Board.
- The purpose of the study is to investigate the role of passion in science teaching. If you choose to participate, you will be asked to participate in the following.
    - Engaging in two 45-60-minute, audio-recorded interviews at a time and place agreed upon by you and the researcher.
    - Providing a lesson, lab, or similar document of your own creation about which you are proud.

- Reviewing summaries of information taken from you and conclusions based on this information.

It is estimated that this will take a total of approximately four (4) hours of your time mostly over the course of two months with a final check of the researcher's work which may occur outside of the two-month time frame.

- Risks or discomforts from this research are minimal and may include loss of time due to the interviews and interaction with the researcher.
- Reflecting on practices that make you passionate about teaching science could benefit you and your teaching practices.
- Taking part in this research project is voluntary. You do not have to participate, and you can stop at any time by informing the researcher.

Please take time to read this entire form and ask questions before deciding whether to take part in this research project.]

What is the purpose of the research?

The purpose of this study is to investigate the how science teachers view passion for their work and if or why the teachers believe that passion is important.

How many people will participate in this study?

If you decide to be in this study, you will be one of up to five participants in this research study.

What is my involvement for participating in this study?

If you agree to be in the study, I will ask you to do the following things**:**

- Participate in two video-recorded interviews on Zoom or similar platform, lasting no more than 60 minutes each.
- Share with the researcher an item related to your teaching (such as a lab, a lesson, or a test) which you have developed, and which illustrates what you are passionate about.

- Review the researcher's conclusions regarding your information to ensure the correctness of those conclusions.

We expect your participation to take place for about four (4) hours over the course of two months, with a total of two hours for the interviews, approximately one hour collecting data sources, and an hour for reviewing the researcher's conclusion. The estimated total time of involvement is four hours.

How long am I expected to be in this study for and how much of my time is required?

You will be expected to be actively involved in this study for no more than two months and the study will occupy no more than four total hours of your time. The one aspect of the study which will occur outside of the two-month time frame will be reading the researcher's conclusions and commenting on the correctness of his representation of data provided by you.

What are the risks to me for participating in this study and how will they be minimized?

The primary risks of this study include loss of time due to your participation. To minimize the loss of time, the researcher's interviews will not last longer than 60 minutes each. Finally, communications, by email and phone, will be kept to a minimum.

What are the benefits for participating in this study?

This study will potentially benefit you by providing an opportunity to be reflexive about your practice of teaching. Additionally, your participation could result in other teachers and educational researchers growing in knowledge; knowing that you helped this cause could be a source of pride for you.

Will I be compensated for participating in this study?

You will not be compensated for your participation in this study. You will not be responsible for any costs to participate in this study.

How will my confidentiality be protected?

All data (interview transcripts and documents) will be kept on password protected websites and computers. Hard copies of materials will be kept in locked offices. In the reports of this study, your name and the school's name will be replaced with pseudonyms.

What will happen to the information collected about me after the study is over?

I will keep research data to use for possible future research. Your name and other information that can directly identify you will be deleted from the research data collected as part of the project.

Is my participation voluntary?

It is totally up to you to decide to be in this research study. Participating in this study is voluntary. Even if you decide to be part of the study now, you may change your mind and stop at any time. You do not have to answer any questions you do not want to answer. If you decide to withdraw before this study is completed, please contact John Cordell at the email or cell phone number given below or Dr. Weinburgh at m.weinburgh@tcu.edu or 817.257.6115. Upon withdrawal from the study, the researcher will destroy any data provided by you that has not yet been analyzed.

Who should I contact if I have questions regarding the study?

You can contact John Cordell at john.a.cordell@tcu.edu or cell: 817-614-6389 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

Consent to be video recorded.

I agree to be audio recorded. Yes _____ No _____

_____

Signature Date

Appendix C

Media Release Form

TEXAS CHRISTIAN UNIVERSITY

Media Recording Release Form

Title of Research: Passion in Science Teaching

Study Investigators: Molly Weinburgh, PhD and John Cordell, PhD candidate in science education

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

- Video Recording
- Audio Recording

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.

- _____ initial

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

Participant and Setting Information

Participant	Gender	Ethnicity	Teaching Experience (years)	Grade Level	Subjects Taught	Type of School	Total School Enrollment in 2019-2020 School Year*	General School Performance for 2018-2019 according to State Education Agency*	Student to Full Time Teacher Ratio in 2019-2020*	Percent of Students Eligible for Free or Reduced Price Lunch in 2018-2019**	Enrollment by Type in 2019-2020*	School Demographics in the 2019-2020 School Year*
Julia	F	Hispanic	12	6	General Science (Physics, Astronomy, Ecology, Biology)	6th Grade Center	473	F (57 out of 100)	15.9	97.4%	95.6% Economically Disadvantaged, 55.6% English Language Learner, 7.2% Students Receiving Special education Services	89.0% Hispanic, 5.7% African American, 3.4% White, 0.6% Asian, 0.6% American Indian
Paul	M	White	16	8	Biology and Physical Science	Middle School	722	B (82 out of 100)	16	73.4%	66.3% Economically Disadvantaged, 15.7% English Language Learner, 11.2% Students Receiving Special education Services	59.3% Hispanic, 24.2% White, 12.9% African American, 1.1% Asian, 0.3% American Indian
Charles	M	White	13	12	AP Environmental Science and Environmental Systems	High School	2401	B (83 out 100)	16.5	64.9%	62.0% Economically Disadvantaged, 13.0% English Language Learner, 6.5% Students Receiving Special education Services	63.1% Hispanic, 27.2% White, 6.0% African American, 2.0% Asian, 0.2% Pacific Islander
Eva	F	White	16	9, 10, 11	Chemistry, Physical Science, and Biology	High School	1873	C (74 out of 100)	14.5	94.3%	91.2% Economically Disadvantaged, 27.7% English Language Learner, 7.6% Students Receiving Special education Services	86.7% Hispanic, 9.2% African American, 2.6% White, 0.7% Asian
Colette	F	White	9	11, 12	Forensics and Environmental Systems	High School	1866	C (79 out of 100)	16.3	69.7%	70.3% Economically Disadvantaged, 12.6% English Language Learner, 8.6% Students Receiving Special education Services	51.1% Hispanic, 23.6% White, 21.9% African American, 0.8% Asian, and 0.3% American Indian

* Data were obtained from the state education agency. Categories for enrollment were defined by the state education agency at https://txschools.gov/schools

** Data were obtained from Common Core Data at https://nces.ed.gov/ccd

Appendix E

Interview Protocol for First Interview

1. On a scale of 1 to 10, with 10 being high, how passionate are you about teaching science?
2. How do you define passion in teaching? Can you give examples of passion for teaching science?
3. The practice of teaching involves curriculum developing, lesson planning, teaching lessons, and developing assessments among other activities. What are your favorite parts of teaching science? What makes those activities enjoyable?
4. With regards to doing the work just described, how do you feel your passion for the activity affects your students and their development as students of science?
5. What topics in the science you teach are you the most passionate about teaching? Why?
6. With regards to teaching this area of the curriculum, how do you feel your passion for the activity affects your students and their development as students of science?
7. Please describe an instance of working on your favorite part of teaching and how you felt while you were doing that work.

   Can you describe another instance…?
8. Describe an instance in which you were doing something job related, and you completely lost track of time or spent too much time on a particular task because you were enjoying yourself so much.

   Can you describe another instance…?
9. What parts of the job do you feel are the most critical in order to be a great teacher? Why?
10. Is it necessary for a teacher to have passions in order to be a good teacher? Please explain.

11. In your experience teaching students, how do you feel your passion affects the students you teach?
12. Is there anything else, not already described, about which you are passionate when it comes to teaching science?
13. You have shared with me a lesson plan/lab/activity which you have developed yourself. How did you come up with the idea for this lesson plan/lab/activity? Why do you think this lesson plan/lab/activity is important? What are you most passionate about when you present this lesson plan/lab/activity to your students? How do your students respond when they participate in this lesson plan/lab/activity?

Appendix F

Interview Protocol for Second Interview

1. In your career or education so far, describe a person, experience, or item that has helped you to develop your passion for teaching science?
2. Can you describe another person, experience, or item that has helped you to develop your passion for teaching science?
3. What is one school procedure, practice, or tradition that encourages your passion for teaching science?
4. Describe an instance where your students have helped to foster a passion in you for something you teach.
5. How has what excites you about teaching science changed with time?
6. What events have been important in how your passion for teaching science has developed?
7. How has your passion for teaching science evolved over the course of your teaching career so far?
8. Describe one aspect of your job that poses a threat to maintaining your passions for teaching science?
9. Can you describe another aspect of your job that makes it difficult to maintain one or more of your passions?
10. Do you have any thoughts, not covered so far, about passion and its role in teaching or education?

Appendix G

Image of Spreadsheet with Participants' Responses Grouped by Theme

Possible Themes in Participant Responses

Question Number	Question	Possible Themes	Evidence	Participant
1	What job-related activities are science teachers most passionate about?	Curriculum Development/Lesson Planning	Eva relates in the first interview, starting at time 17:37, her unwillingness to devote as much time as the curriculum demanded for ninth grade students to the biology topic of transcription, translation, and replication; instead, wanting to spend more time on topics which could be made more hands-on for the students.	Eva
			"I have the freedom now because I'm not tested this year" Eva 21:39.	Eva
			Describing a "flow state" when developing a lesson, Eva1 relates losing all track of time in making her lesson, with hyper-docs and Google Docs, just perfect. Eva1 mentions staying up until three o'clock in the morning, planning lessons. Eva1 36:07-38:24.	Eva
			Charles1 (15:15-15:29) "Sometimes I'm thinking about cool projects so much that I forget where I'm driving to and end up missing exits"	Charles
			Charles1 (16:30-16:41) "When I'm thinking up a new project or new adventure or whatnot, then that's when I'll get, you know, obsessed with it for a while."	Charles
			Paul1 (04:24- 04:28) "I like the creative part of it, the planning the lesson"	Paul
			Paul1 (04:44-04:52) "If we're talking about it, planning or deliver, which is more important... It's more intrinsically rewarding	Paul
			Paul1 (04:55-05:00) "Delivery is the cake; planning is the baking."	Paul
			Colette1 (16:30-16:35) In response to what are you favorite parts of teaching, Colette responds, "O my gosh. So, I really enjoy planning."	Colette
			Colette1 (18:03-18:12) "So, I really liked the planning aspect and the way I do that. Now, the way I do instruction is to give them the resources"	Colette
			Colette1 (18:36-18:37) "Planning. I like planning."	Colette
			Colette1 (18:48-18:54) "It's like buying a present for someone, you're like, "how are they going to use this."' - What lesson planning is like for Colette.	Colette
			Julia1 (09:43-09:59) Her favorite part of teaching science is "developing not just lessons but units, I guess. So I'm really big in project-based learning. And so, developing those and creating opportunities for the "aha" moments."	Julia
		Extracurricular Clubs	Charles1 04:02-04:17 shares being in charge of clubs like "Under the bank" Club and Recycling Club.	Charles
		Sharing science with students	Eva enjoys sharing biology and ecology with the students because that is the area of her scientific training, and so she has a very deep knowledge of this area of science. (Eva1 25:49)	Eva
			"I want to really get students interested in science that's supporting that passion so science itself is more than teaching" Eva1 09:21	Eva
			Eva relating taking non-English speaking students out to view the solar eclipse of August 2017 and having to convince the principal of the school to allow her to take the students outside. (Eva1 31:03-34:18). "The principal was on the verge of saying we can't go do it… I had to present all my safety issues and I was in tears because I was just like, "she better not." I better be avle to do this because we don't get to see a solar eclipse that often… I could not handle a no" Eva1 33:36.	Eva
			"I'd like to get the students out in the field as much as possible" Charles1 06:31. Charles takes students to the botanic gardens, the wastewater treatment center.	Charles
			Julia1(07:51-08:03) "I want kids to understand that everything has to do with science. And I just, I just want them to feel it."	Julia
			Julia1(08:39-08:55) "I want them (students) to have that feeling of like, oh, I could do so much with science"	Julia
		Field Trips	"Getting kids usually with field trips" Eva 25.	Eva
			"I think getting outside of the classroom and learning science through hands-on activities like the trutle survey or going on a field trip give them a connection where they will start to care about a little bit more than if we just read it in a book" Charles1 08:30.	Charles
		Labs/Projects	Charles1 (6:56), in reponse to the question, "what are the parts of teaching about which you are the most passionate?", responds that he likes doing labs with the students.	Charles
			Paul1 (15:51-16:05) Regarding the "flow state" question, Hiett answers, "it happens during labs... When the kids are engaged."	Paul
			Paul1 (17:16) Paul describing what it's like to supervise the cabbage juice 'pop' lab says that from the time he starts to the time he finishes it's "dream-world." Describes those experience as enjoyable.	Paul
			Paul1 - When asked to share an item that illustrated their passion for teaching science, Scott shared with me a plate-techtonics project that he has his students complete. He mentioned that it was open-ended and the students liked it.	Paul
			Colette1 (10:22-10:42) In response to a question about the favorite parts of teaching, Emily brings up a forensics lab in which students measure different body parts. They then switch partners the next day and try to figure out which measurements match the measurements of their new partner.	Colette
		Continuing Education	"I got my masters in curriculum instruction" Eva 58.	Eva
			"What I found was effective was me getting my masters in curriculum instruction finding resources like stem scopes. For me, helped me" Eva 66.	Eva
		Natural World	Colette1 (09:14-09:33) In response to what part of the job are you the most passionate about Colette responded, "I still have this amazing amount of wonder with the natural world, and I think that's what drives my passion for science teaching is just the natural world that's around us and how you can take those examples for kids and make something that's theoretical feel really relevant."	Colette
		Women in Science	Colette1 (09:55-) "Especially love places where women played a role in science, but they might not have gotten as much recognition. I love bringing things like that up."	Colette
		Peer Collaboration	"It's all related to making connections with other educators"(Eva 23).	Eva
			"Supportive, collaborative educators" Eva 29.	Eva
			"but it has to be a good collaboration" Eva 187.	Eva

			"You know, there's a lot of times that we do PD and I go to the PD, not for what they're delivering but the collaboration with other science teachers from other schools to learn what their what's working for them. And can you help me. You know, it's a collaboration. I will. I tried this and did that help you or you know kind of sharing resources and collaborating and talking not formally but more informally" Eva 172&173.	Eva
			Veteren teachers learning from new teachers about technology Eva 178.	Eva
		Ecology	Charles likes ecology the most (10:24)	Charles
		Life-Long Passions	Charles1 (11:29-11:58) "Yeah, I've been interested in a long time. I grew up next o a natue ceter, I was always there, and I went ot Michigan State University for a zoology degree, and then I worked at the Fort Worth Zoo for seven years, and I got my masters at TCU doing field work... So, I've been a student of ecology for as long as I can remember"	Charles
		AVID Teaching	Colette1 (01:18-01:30) "I love using the AVID techniques and I'm AVID trained and so I love getting the students to do meta cognitive activities adn thinking about themselves and hwo they learn best. I really try to give them a lot of choices.?	Colette
			Hiett expresse and interest and passion for AVID during the second interview Paul2 (Time?)	Paul
			Colette1 (19:16-19:30) "At the beginning of the year we do some meta-cognitive stuff where we think about our learning styles, and I reference back to those learning styles."	Colette
		Lesson Delivery	Paul1 (04:28) - "I like the actual delivery and of course, the kids; so, which out of those three is my favorite... I like the kids to be honest. That's the reason why we're here."	Paul
		Chemistry	Paul1 (06:52-07:00) "I like chemistry... I like to be the first guy that talks to them about the periodic table."	Paul
			Paul1 (07:43-08:20) "One of my favorites is taking copper-chloride 2, putting it in solution, and adding aluminum... In that one reaction you get pretty much the whole gamet of evidence that the reaction has occurred... It is very, "wow."	Paul
		History of the Subject	Paul1 (21:09-21:33) "When we talk about the periodic table, we talk about Mendelev... why was he so cool."	Paul
		Working with students	Julia1 (04:15-04:20) "I tell them all teh time that I don't like adults and the kids are the only thing that makes my job worth it"	Julia
2	In what ways do science teachers believe their passion affects students?	Transmission of their passion to the student	"I think there's a relationship with students, and so when they know that I'm for them and that I'm into it, and I'm helping them problem solve. I think that kind of fules them and brings them into the process" Eva1 23:54.	Eva
			Eva1 sharing the effects of teachers without passion says, "it shows in the class, in the enthusiasm that the kids have" Eva1 40:56.	Eva
			Talking about teaching student the environment effects of personal choices, Charles1 says, "I think just making them care about, making them feel connected like that, it impacts what they're doing at home, envirnonmental science, you know, when they run their washing machine because I know that there can be phosphate free because that can't be taken out at the treatment plant" (09:27-09:49).	Charles
			Charles1 (12:22), "Obviously depends on the students."	Charles
			Charles1 (12:30-12:48) after their online class "one girl that styed on for an extra 15 to 20 minutes who wanted to show me some cool rock that she had found, a fossil amonite."	Charles
			Paul1(06:30-06:42) "My attitude towards whatever it is I'm doing translates directly to outcome."	Paul
			(19:59-20:30) "Passion! You've got to be into it. If you aren't into it, it doesn't translate. Anybody can learn this stuff, if they're passionate. Prior knowledge it can be learned. It has to be, 'you enjoy the subject. That's how you become good at this. Everything else will fall into place"	Paul
			Colette1(08:41-09:04) "But when you start a new unit and it's something that you're like, "you guys are gonna love this. Like, you're gonna love this. It's goint to be so cool. An, by the end you're going to be so smart; you're going to do this and this and this and you really hype it up"	Colette
		Willingness to get additional training and certifications	Charles1 (05:53-06:05) relates the process of getting permits from the Texas Parks and Wildlife Department to be able to trap and study turtles in the watershed of the local river.	Charles
		Goals for students	"If you can get them to a college campus before they go into high school, the more than likely to move on to college and I'm being that most of the kids that I'm dealing with are low social and economic" Eva 35.	Eva
			Referring to planting seeds of knowledge, "Let me sprinkle enough to get kids perked up into it to where maybe in high school, they invest more time in it or they hav a good foundation to where they don't get lost in the process, and maybe they become engineers or they become biologists or ecologists, or maybe they just have a really good foundation and can apply those critical thinking skills to real-life scenarios" Eva1 10:22	Eva
			"I'm driven by wanting those students to really get engaged into the science just really wanting them to and share my excitement. Like, I found this really cool thing, and let me show you" Eva1 13:53.	Eva
			Charles1 (13:00-13:11), "I've had a lot of students go on to study environmental science and they told me it's partly because of my class, so hopefully I get them passionate about it and they'll want to learn about it more."	Charles
			Charles1 (13:41-13:53) The turtle survey, we just had eight different students present academic posters at a conference; I couldn't be more proud."	Charles
		Desire to be a better teacher	"It's the kind of a work that's 24 seven, 365 days, you know, I worked every summer multiple doinn multiple things like I always did. The math and sciene camp at the same time I would help write curriculum to support teachers in Fort Worth." Eva1 11:06	Eva
			"On the weekends, you know I'm always looking for ways to engage students. Or how about hinging abou this way, and even this virtual environment" Eva1 11:37	Eva
			"I really don't ever stop working" Eva1 12:11.	Eva
		Sharing their learning with the students	"I take experiences and thinkn how can I apply those into teaching students in class. Like how do I that math and science camp every summer is how can I take some of those things and then put it into my classroom" Eva1 13:06.	Eva
			Charles1 (18:18-18:35) "If you're not passionat about your subject you're teaching, they are not going to want to even be in class or teaching them is going to be pretty difficult.... They see a teacher cares about what they're teaching and they're exited about coming to class."	Charles
		Willingness to do more than is strictly required	"On the weekends, you know I'm always looking for ways to engage students. Or how about hinging abou this way, and even this virtual environment" Eva1 11:37	Eva
			"I really don't ever stop working" Eva1 12:11.	Eva
Question 3	In what ways do	Positive Feedback from	"Aha moments" Colette <<Time?>>.	Colette

science teachers believe their environment affects their passion?	Students	“In class when kids are having fun learning” Charles1 06:58.	Charles
		Paul1 (07:43-08:20) "One of my favorites is taking copper-chloride 2, putting it in solution, and adding aluminum... In that one reaction you get pretty much the whole gamet of evidence that the reaction has occurred... It is very, "wow."	Paul
		Paul1 (09:12-09:55) "I make cabbage juice, the phenol comes out of it... and if you use a small plastic bag... 'boom'... they go bonkers."	Paul
		Paul1 (10:34-10:38) "DNA. Doing the DNA one, where you isolate DNA from strawberrys."	Paul
	Top-Down Initiatives	“The things that Fort Worth gives me directly from Fort Worth don't work and are not effective pedagogy” Eva 57.	Eva
		In response to being asked to think of a school policy or practice that encourages her passion: “I'm pretty much I don't think of any. I cannot honestly think of anything that the school.” Eva 44.	Eva
		“But I don't know if it's that's teaching science or just all the stuff that comes with educating students, not, not what you're doing in your classroom, not what the students are doing, but all the the top stuff coming at you and changing every, you know, they just changed how we're doing attendance. They change the bell Bell schedule” Eva 148&149.	Eva
	Preparation for End-of-Course Exams	“It’s the pressure of , we got to move on an not having the advantage of just staying a little bit longer to get a little bit more” Eva1 05:36.	Eva
		Eva, in her first interview at 15:44, relates that she is feeling better about the upcoming school year because she is not teaching a tested subject area.	Eva
		“I have the freedom now because I’m not tested this year” Eva 21:39.	Eva
		“I want to enjoy the teaching part of it. I want to be away fom the test at pat I want to enjoy the science because that’s what makes me, fuels me as a teache. You give me science, let me do science and then that’s going to give me energy to work with students” Eva1 23:02.	Eva
		Colette1 (00:17-00:21) "I've got the best gig ever, I'm teaching all untested, elective sciences."	Colette
		Colette1(00:42-00:47) "no one's watching me because it's an elective" - about teaching forensics.	
	Effects of School Administration	“And I'm going to engage the kids and that there is a higher purpose of what I'm doing but I don't. I'm more of one who comes in and says, This is what I want to do. This is how I'm going to do it, can you support me on this” Eva 46.	Eva
	Need to help Colleagues	“Can I help other teachers can they help me that type of that type of situation” Eva 142.	Eva
		In reference to organizing field trips for fellow teachers and students:	Eva
		“So having a great group of teachers who will come aboard Sarber’s gravy train” Eva 26.	Eva
	Need for change	“When I get bored my enthusiasm decreases. So what I mean by that is, that's why I decided to move into high school was” Eva 133 & 134.	Eva
		“You know how many ways can you do this lab when I mean it's a great lab, but I'm losing the enthusiasm about it. So I need to do something different. And when you have to cover certain topics” Eva 136.	Eva
	Challenging Students	Paul2 (Time? - toward the end)	Paul

Appendix H

Paul's Plate Tectonic Project

Plate Tectonics Project

This project will use your skills in creation and application. You will create a model of the layers of the earth involved in plate tectonics. The material is of your choice. You will create a working model of how plate boundaries work and how the features at those plate boundaries form. You will need to use the vocabulary provided to label and highlight how each phenomenon works. You will show how the formations are created and clearly show the type of boundary that is present. Your product will also show how this phenomenon is related to Newton's Laws of Motion (all three). How are the concepts related to weather and fluid motion? This grade will be a lab grade. This project will be finished by Friday Jan. 17th for a gallery walk.

Your model needs to be easy to understand…

3-dimensional

At least 4 colors

Have at least two working/moving parts.

Must show all vocabulary words by labeling the parts of the model.

You have shown all plate boundaries- Convergent, Divergent, Transform	At least four colors
You have shown and given examples of all of the crustal features found at each boundary-	At least two moving parts
You have some way to show motion at each boundary.	All vocabulary present
People that view this model can easily understand what it is showing	Clever idea…
There is an example of each of Newton's Laws somewhere on the model.	
You have related some of what you know about fluid movement to this project.	

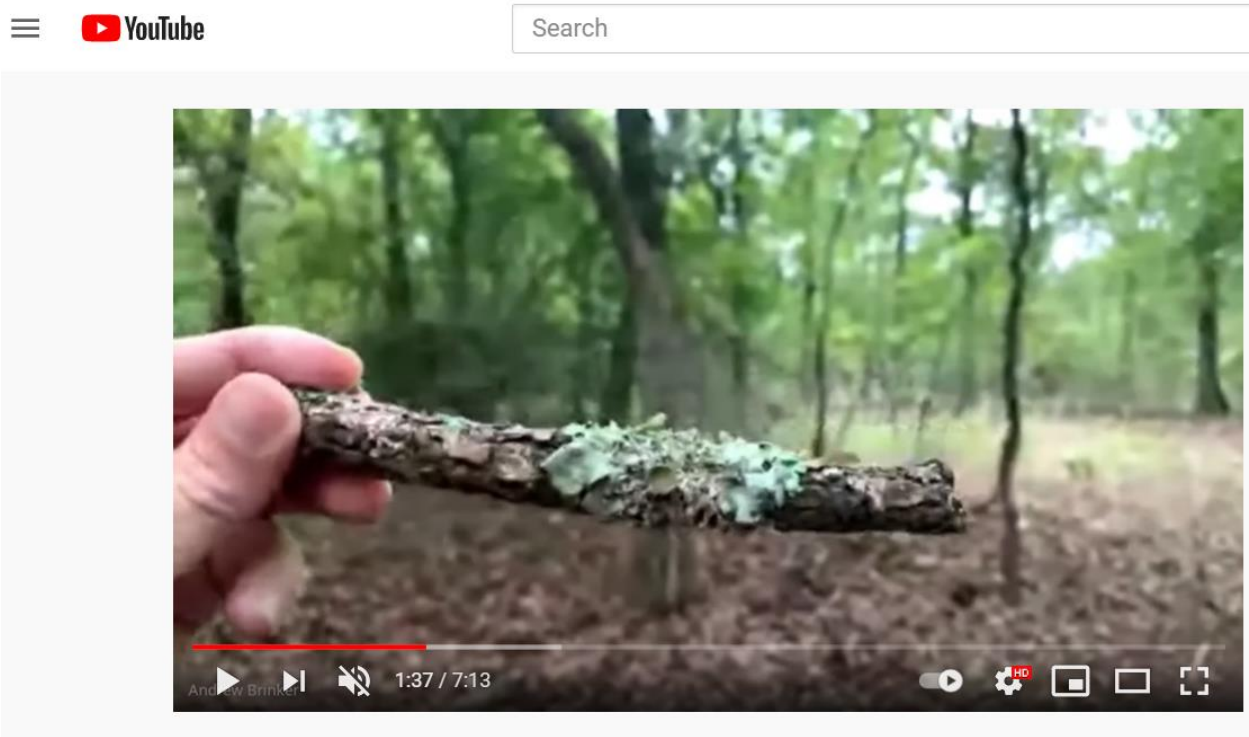
Appendix I

Pictures of Student Work from Paul's Plate Tectonic Project

Appendix J

A Still Shot from Charles's YouTube Video Virtual Field

Charles is showing his students different kinds of lichen that grow on dead wood.



Appendix K

Eva's Yellowstone Wolf Project

Yellowstone Wolves: What is the role of predators in an ecosystem?

Problem we need to answer: How has the ecosystem of the Yellowstone National Park been impacted with the reintroduction of the wolves?

Directions: Read to complete YOUR TASK. Click on the Blue Text for a link to complete the task. This is a complete lesson unit, you will be able to start and stop as needed. This complete unit is due on _____. When you are finished and added the information on this document, please make sure you submit and turn in your assignment in Google Classroom.

PREPARING	YOUR TASK (90 minutes)

To Do:

#1 Have you ever been to Yellowstone National Park? Would you want to visit? What is the impact when a predator is removed? **DISCOVER** : To begin with, explore Yellowstone National Park. Then Look at the images on each **YELLOWSTONE NATIONAL PARK GOOGLE SLIDE**

1. Put your name on a sticky note at the top left.
2. Drag the sticky note some place in the slide.
3. Then write down one observation.

The next part of the Google slides is an Agree/Disagree series of questions.

1. Drag a post-it to either Agree/ Disagree box.
2. Put your name on the post-it.

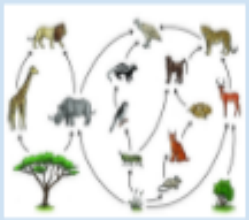
_____ Put an X when completed!

To Do:

#2 **YELLOWSTONE HISTORY GOOGLE FORM** Learn about the causes in the change of wolf population and the effects of reintroduction. Think of the perspective if you were a rancher, a Park Ranger, a local business owner, or a park visitor. Learn about the history of the wolves in Yellowstone National Park. You will be watching a video about Yellowstone National Park. Then you will read about the history of wolves in the park and the effects on the Yellowstone National Park Ecosystem.

_____ Put an X when completed!

Interacting/Application	YOUR TASK (90 minutes)



#1 Apply your knowledge by Creating a Food Web of the Yellowstone National Park. **YELLOWSTONE FOOD WEB CARD SORT**

#1 Apply your understanding of food webs and the relationships within, by creating a food web from the organism living in Yellowstone National Park.: Insert a copy of your food web in the box.Remember to hit ctrl and windows switcher keys.

Insert your picture of the Food Web Here.

_____ Put an X when completed!

#2 Analyze: Look back at your food web and answer the questions based on the food web.

Identify 4 producer- consumer relationships food web.

A.

B.

C.

D.

Identify 4 predator-prey relationships from the food web.

a.

b.

C.

d.

Create a food chain from the food web. Sequence the organism names in order from the producer.

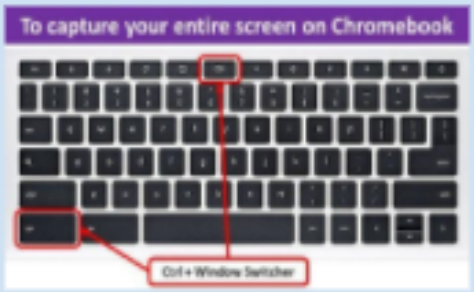
_____ Put an X when completed!

#3 Sequence Sort: Sequence the Events of the Yellowstone National Park with the Reintroduction of the Wolves

SEQUENCE EVENTS CARD SORT

Insert a copy of your food web in the box. Remember to ctrl and windows switcher keys.

Insert your picture of the Food Web Here.



_____ Put an X when completed!

#4 DATA ANALYSIS GOOGLE FORM

As a scientist, you need to be able to read, analyze and make conclusions about data. You will be looking at real data about the populations within the Yellowstone National Park. Your job is to analyze the data and then write a paragraph.

Analysis the graphs to compare how the changes impacted other organisms

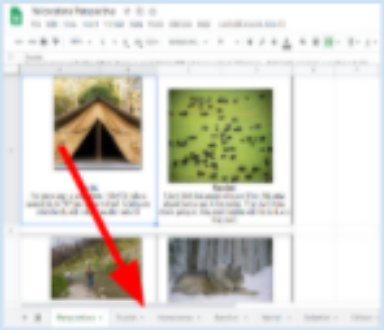
You are going to analyze data about the organisms of the yellowstone park ecosystem. At the end, you will need to write a paragraph as a conclusion of your data analysis. If you do not score 24 points, then you will need to resubmit your answers.

_____ Put an X when completed!

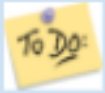
Extend	YOUR TASK (90 Minutes)

#1 GOOGLE SHEET COMPARE MATRIX

In order to be a participant in our democracy, you need to listen to other people's perspective. There are 5 possible scenarios, you will choose 1 group of citizens to represent and post your response based on your perspective. The citizen group's perspective is posted on the first sheet.
You will choose 1 perspective and fill in on their Google sheet.



- Tourist
- Rancher
- Hunter
- Scientist #1
- Homeowner
- Citizen of Town
- Local Restaurant Owner
- Nez Perce tribe Member
- Scientist #2



Choose one group of perspectives that you would like to represent. For each scenario, describe how your group of citizens would respond to the Impact on Environment, Town, or Community,Reasons for, and Reasons against.

- Scenario 1: Reintroduction of experimental populations of wolves. The designation "experimental wolves" gives the people who manage wolf populations more freedom in decision making and gives the wolves less protection.
- Scenario 2: Natural recovery (no action taken). Encourage wolf populations to naturally expand into Idaho and Yellowstone.
- Scenario 3: No wolves. Change laws in order to prevent wolf recovery.
- Scenario 4: Local wolf management committee. Turn wolf recovery management over to individual states and limit federal government involvement.
- Scenario 5: Reintroduction of non-experimental wolves. By designating the wolves as "non-experimental" they are given much more protection.

_____ Put an X when completed!

Extend	Your Task (90 minutes)

#2 Choose a scenario that you would support. Write a letter to a public official explaining your choice and the reasons why. Write a letter to a senator, mayor, local government, or any other governmental official. You choose 1 scenario that you would support. Explain why you choose that scenario and what you would the government official to accomplish (vote yes/no on a bill, create a law/amendment, or support funding. The letter needs to be 250 words.

Dear

Thank you

_____ Put an X when completed!

#3 What is happening 25 years later? Choose 1 of the below resources to create a Google Slide about the 25th Anniversary of the Reintroduction of the Wolves. Using the resources listed, Research the impact of the wolf reintroduction 25 years later. Create a **25 YEARS GOOGLE SLIDE** that summarizes your views.

RESOURCE #1

RESOURCE #2

RESOURCE #3

Your Google Slide needs to include:

- Your Name
- 2-3 Images
- 3-5 sentences summarizing the impact of the reintroduction of the wolves 25 years later.

_____ Put an X when completed!

Reflect	Your Task (15 minutes)

Reflect on what you have learned. What do you understand and what are you still confused by?

To Do: What has been the impact of the reintroduction of the wolves in Yellowstone National Park (3-5 sentences) ?

To Do: What I am still confused about the Yellowstone National Park Reintroduction of wolves is

_____ Put an X when completed!

How well did your group work together on the project?

What could you do better for the next project?

		1 NOT YET	2 GETTING THERE	3 GOT IT!
Ecosystem Stability	☐ **I can describe how environmental change can impact ecosystem stability.** 8.12(E)	Correctly identify 1-2 examples as positive or negative impact and explain how stability is related to examples.	Correctly identify 3-4 examples as positive or negative impact and explain how stability is related to examples.	Correctly identify 5-8 examples as positive or negative impact and explain how stability is related to examples.
Ecological Succession	☐ **I can describe how events and processes that occur during ecological succession can change populations and species diversity.** 8.11(B)	1 NOT YET	2 GETTING THERE	3 GOT IT!
		Correctly identify some types of succession per event, describe some changes to population/species and impact on diversity.	Correctly identify most types of succession per event, describe most changes to population/species and impact on diversity.	Correctly identify all types of succession per event, describe all changes to population/species and impact on diversity.

		1 NOT YET	2 GETTING THERE	3 GOT IT!
Interdependence	☐ **I can interpret relationships among organisms.** 8.12(A) ☐ **predation** ☐ **parasitism** ☐ **commensalism** ☐ **mutualism** ☐ **competition**	Correctly identify some of the relationships of predation, parasitism, commensalism, mutualism and competition.	Correctly identify most of the relationships of predation, parasitism, commensalism, mutualism and competition.	Correctly identify all of the relationships of predation, parasitism, commensalism, mutualism and competition.
Matter and Energy Flow in Ecosystems	☐ **I can analyze the flow of matter and energy through trophic levels using various models.** 8.12(C) ☐ **food chains** ☐ **food webs** ☐ **ecological pyramids**	1 NOT YET	2 GETTING THERE	3 GOT IT!
		Correctly creates some models of food chains, food webs and ecological pyramids including amount of energy availability.	Correctly creates most models of food chains, food webs and ecological pyramids including amount of energy availability.	Correctly creates all models of food chains, food webs and ecological pyramids including amount of energy availability.

		1 NOT YET	2 GETTING THERE	3 GOT IT!
Adaptations	☐ I can compare variations and adaptations of organisms in different ecosystems. 8.12(B)	Correctly compares some types of variations and adaptations for each ecosystem.	Correctly compares most types of variations and adaptations for each ecosystem.	Correctly compares all types of variations and adaptations for each ecosystem.

Appendix L

Colette's Fingerprint ID Lab

Class Latent Fingerprint ID Lab

In this lab you will be identifying and analyzing latent fingerprints of "suspects" from your class. You will need all of your knowledge of ridge detail, keen observation skills and a little luck to positively identify your unknown fingerprints. Keep in mind that latent prints left at crime scenes are usually only partial prints. No excuses about print quality! Fingerprints contain between 150-200 points of unique minutiae each. To make a positive fingerprint ID, courts require a minimum of seven points of matching minutiae detail. Since you're a rookie, I will only require that you name five points of minutiae to consider it a positive match. Good luck!!

Materials:

Individual lab sheet (1 per person)

Group set of 10-cards.

Group ziploc bag of rolled and plain latent fingerprints

hand lens

glue stick

Colored pen or pencil

lab notebook

Procedure:

1. Randomly choose 5 rolled individual fingerprints and 1 four-finger plain impression from the group bag.
2. Glue them into the spaces provided on your lab sheet.
3. Examine your prints with the hand lens. Look for ridge pattern and any large identifying details like scars or creases.

4. Using your fingerprint analysis notes in your lab notebook, identify ridge pattern and points of minutia on your latent prints. Label all minutia on your latent prints using your colored pen or pencil. No black ink! (10 points off)
5. Compare your prints to the 10-cards in your group set. Write the name of your suspect along with which finger and hand you believe left the latent print under each rolled fingerprint and 4-finger plain impression.
6. Answer the lab analysis questions.

Name:

Per:

Class Latent Fingerprint ID Lab

Rolled Individual Fingerprints:

1.

Ridge pattern_____

Suspect #_____

Suspect name_____

Source finger and hand of suspect _____

2.

Ridge pattern_____

Suspect #_____

Suspect name_____

Source finger and hand of suspect _____

3.

Ridge pattern_____

Suspect #_____

Suspect name_____

Source finger and hand of suspect _____

4.

Ridge pattern_____

Suspect #_____

Suspect name_____

Source finger and hand of suspect _____

VITA

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Education

Texas Christian University
Ph.D. in Science Education — 2021
Dissertation: "A passion for teaching science: a case study of five science teachers"

Hunter College
M.A. in Physics, Teacher Education Program — 2001

Texas A&M University
B.S. in Psychology — 1996

Teaching Experience

Fort Worth Country Day School (High School)

- Teacher – "Honors Physics" — 2003-
  Developed syllabus and administered all grades.
- Teacher – "AP Physics: Mechanics" — 2003-
  Developed syllabus to match AP syllabus set forth by College Board and administered all grades.
- Teacher – "AP Physics C: Electricity & Magnetism"
  Developed syllabus to match AP syllabus set forth by College Board and administered all grades.
- Teacher – "Psychology" — 2008-2017
  Developed syllabus and overall course structure, and administered all grades.

Related Experience

Breakthrough Collaborative, Fort Worth, TX

- Mentor Teacher — 2010 – 2011; 2014-
  Assisted Breakthrough Teaching Fellows in developing lessons, instructing students, and assessing students.

Fort Worth Country Day Summer Camps, Fort Worth, TX

- Science Camp Teacher — 2004–2010
  Developed curricula for and ran summer science and engineering camps.

Duke TIP Academic Adventures

- Teacher — 2012-2016
  Developed curricula and taught classes in physics, rockets, engineering, and forensics.

Fort Worth Country Day School

- Track & Field and Cross-Country Assistant Coach — 2004-2015
  Planned and supervised training of distance track & field runners. Helped supervise training of cross-country runners.

Fort Worth Country Day School

- Challenge Course Facilitator — 2004-present
  Certified facilitator for low and high elements. Rescue certified. Course safety advisor from 2010 to 2012.

PUBLICATIONS AND PAPERS

"Non-Mathematical Explanation of Precession"
The Physics Teacher — 2010

"Physics Challenge for Teachers and Students, April 2010 Solution"
The Physics Teacher — 2011

MEMBERSHIPS

American Association of Physics Teachers