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ANXIETY AND EMPOWERMENT:
AN ETHNOGRAPHY OF SCIENCE IN THE MIDDLE

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF ANTHROPOLOGY

BY

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I dedicate this dissertation to the excellent, outstanding, and positively inspiring teachers of Oklahoma. The state is lucky to have you and I hope that the work we have done together will contribute to the security and support you so deserve.

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ABSTRACT

Stacked within the Frontier Strip, 70,000 square miles of land constitutes the 46th state of the Union, Oklahoma. The state is known for its agriculture, energy, and aerospace industries, as well as rich cultural history and diverse ecology, geology, and geography. Unfortunately, the state is also known for a perceived lack of commitment to education, as well as to scientific literacy and advancement. Oklahoma consistently ranks among the bottom for American states' categories in education. We are 48th in per-pupil spending in public schools; and 70% of Oklahoma schools are Title I, receiving federal financial assistance through the Elementary and Secondary Education Act for children from low-income families.

This dissertation is about public school teachers and their challenges in teaching science in the Bible Belt. It encompasses multimodal research activities on science education in Oklahoma, including ethnographic field research, surveys, interviews, and scholarly review. The majority of data were collected over the course of 24 months in 2015 and 2016 with Oklahoma teachers and students. Data were collected primarily through teacher workshop and K-12 STEAM (science, technology, engineering, art, mathematics) programs designed by the author and funded through various public and private grants. The goal of this dissertation is to present a model for teaching called the Science Empowerment model, as well as to illustrate why the model is an ideal approach to science education.

INTRODUCTION

The fingers of Lake Texoma creep out in all directions on the border between Texas and Oklahoma. It is the only lake in America that has its very own government - Lake Texoma Indian Territory - and it was man-made during WWII. There are even rumors that Nazi prisoners did much of the digging. All around its edges, Texoma's creeping fingers grasp Cretaceous fossils, shuffling and stirring them with each new rain. Sometimes we get really lucky, and Texoma releases her grip on the life-shaped limestone at just the right time for us to find.

The art of fossil hunting consists primarily of pattern, shape, and texture recognition. The first time you go, all of the rocks in front of you look like something special, but also nothing special. You reach down and pick up dozens of pieces of stone, one after another, finding nothing that represents past life on earth. Your brain is straining to make predictions about what you're seeing, making categories and testing them out. First you think you'll know a fossil by its color - you have seen a dark chocolate trilobite in a museum, and a light grey mammoth skeleton. Surely other fossils of the same type will have those colors, too. But soon enough you realize this is futile, because every piece of limestone looks the same - the color differences are so small, you don't even notice them at first.

Then you start to see shapes - some rocks are round, some are jagged, some are very smooth. You begin to take a bit more time before dropping a rock back on the *ground after picking it up - maybe if you stare at it long enough, you will see a hint of past life. Textures begin to appear as well. Where before there was only limestone, now you can discern ripples, bumps, and slight variations in the surface of the rocks. And then - just like that - a fossil.*

One hundred million years ago, Oklahoma was covered by a shallow ocean. Imagine the Sooner State underwater, before its beautiful red Permian dirt was ever exposed to the sunlight. Swimming by are ammonoids of all sizes - some tiny, just born; others huge, the size of the truck tires that race by on I-35 today. Ammonoids had a curious practice of staying within close range of their birthplace in the water column all their lives. Imagine only going within a few miles of your origin for two or three dozen year. Everything you know, everything you have eaten, every mate you have chosen, would have had to encounter you right on your own turf.

Ammonoids are shelled creatures, cousins of today's nautiloids. Their shells grow in a mathematically perfect, equiangular swirl where each arc of the shell grows at the same ratio for each quarter turn it makes. Naturalists have called it the "magnificent spiral" for four hundred years. Chunks of ancient ammonoids are often among the first fossils Oklahoma teachers ever find. They are the first concrete piece of the past that those teachers hold in their own hands and examine with wonder, looking up and around them at the radically different world they live in today.

Over the course of eighteen months of expeditions with teachers, I have accumulated many ammonoid chunks while helping hundreds of teachers bring fossils from road cuts and riverbeds to their classrooms all over the state. This dissertation is a product of those expeditions, as well as field trips, science camps, and professional development workshops done throughout every region of Oklahoma, 2014-2017. It is rather untraditional for a cultural anthropology dissertation, written in a blend of styles for the purpose of being academically cogent as well as legible and useful for an intended audience of public school teachers. It is part novel, part scholarly review, part manual, and part ethnodrama. Field data are woven throughout in the form of narrative, conversation, and thick description, with a purposefully reflexive style. The collective whole is meant to bring a view of the teacher's life to academia, and to bring a view of the anthropologist's tools to educators.

DISSERTATION OUTLINE

This dissertation is arranged into thematic sections containing several components: data collected through surveys taken by Oklahoma teachers; ethnographic descriptions, vignettes, and conversations from the field; excerpts from semi-structured interviews with individuals intimately involved in science education in Oklahoma; and a review and discussion of pertinent literature and theoretical perspectives.

Chapter II, *Identity*, encompasses a review of survey data following the themes of self-perceptions, authenticity, and subjectivity. In particular, I will explore aspects of human existence that intersect to build what I refer to as "science identity". Aspects include religion, race, class, and gender. While these are some of the most crucial topics anthropologists have traditionally kept at the forefront of our studies, it is important to acknowledge the fact that some contemporary ethnographies may not include the stark wording: "religion", "race", "class", and "gender", as if these were mutually exclusive entities. Here they will be worded starkly for the purpose of linguistic clarity for the non-anthropologist reader, but keep in mind that these aspects of identity are in no sense exclusive, bounded, or discrete. They are actually intermeshed and intertwined to the point of no return, and any extraction I am doing for the purpose of communication is totally arbitrary.

In Chapter III, *Anxiety*, I will explore the topics of scientific authority and literacy. As an epistemology, or a way of viewing and knowing the world around us, science has traditionally been in a privileged position. Notions of cultural citizenship rely on knowledge of, adherence to, and reinforcement of science as modernity. I will discuss what I have identified as the "3 C's of science literacy": crisis, competition, and citizenship. I attempt to illustrate why striving for science literacy alone is not enough to create powerful, positive science identities.

Chapter IV, *Suminagashi*, reviews the concepts of personalization and choice in education. Science Empowerment relies in many cases on hands-on learning approaches, which are also discussed in this chapter.

Chapter V, *Empowerment*, is meant to be the equal and opposite reaction to issues presented in Chapter III, *Anxiety*. I describe ways in which cultural intelligence can be integrated into various educational contexts, and why it must be in order to achieve authentic, meaningful science learning.

In the Conclusions, I treat the issues brought up in previous chapters and offer specific advice to various stakeholders. I discuss nuances of doing, teaching, and learning science in various contexts.

OVERVIEW

The state of Oklahoma is a unique and complex site of educational issues, especially in science. At the time of this writing in 2016-2017, teachers are making the transition from Common Core standards to Oklahoma Academic Standards in their classrooms (Oklahoma House Bill 3399, 2014). Academic standards, mandated and enforced both at the state and federal level, are tied to standardized testing, school ranking, and funding. In Oklahoma, there has been a battle in the past ten years between the philosophy of libertarianism that calls for local control over school requirements and resources, and the more liberal concept of full participation in federal oversight and financial support (Carmichael et. al, 2010).

Academic standards and the development and implementation thereof are a cornerstone of the way public schools are run in the United States; though, depending whom you ask, that cornerstone either needs to be reinforced and protected, or brought down and rebuilt. Compulsory federal and state standards in Oklahoma are like the crumbly, ancient ammonoid beds of Lake Texoma. No matter what changes around them, they carry a sense of permanence that can only be broken with the most diligent strikes from a rock hammer; and the sense that no matter how much has weathered away and seems imperfect, those who persist in the work will be able to unearth and preserve what has been there all along.

What stuck out immediately after Oklahoma's politically-driven repeal of Common Core began in 2014, contemporaneously with several other states, was the debate over what would replace them. I focus here on science, of course, but trust that this wasn't the only contested subject. As Next Generation Science Standards (NGSS), a federally supported but state-specific set of curricular parameters, have made their way into schools all over the country in the past few years, several states rejected them outright or in part including Texas, Wyoming, Idaho, and Oklahoma.

The Next Generation Science Standards call for students to master a demonstrable understanding of evolution via natural selection and its evidence, among other topics that tend to stir up social controversy in the Bible belt. The standards also require students to "communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence" (National Academies, 2013). This is quite the scandal in many schools around the US, if you can imagine. The reason people wanted to get rid of Common Core in the first place is that they perceive it to be a show of federal overreach. NGSS was treated, right out of the gate, as just another government burden. Oklahoma created the OAS, Oklahoma Academic Standards.

Though I will discuss this in some depth in later sections, suffice it for now to say that science teachers in Oklahoma need a platform and voice in describing how their daily lives are affected by academic standards, as well as such external factors as curricular changes, policy changes, and school politics. Perhaps teachers going into science education are expecting to present objective facts to absorbent student minds without obstacle, but are in for quite a shock when students will openly deny, argue with, and dismiss scientifically factual information. To get right to the core of this issue, I have spent several years listening as teachers have expressed their discomfort and lack of confidence with teaching socially-tenuous content, namely biological evolution.

TEN LITTLE QUESTIONS: THE PILOT SURVEY THAT STARTED IT ALL

In 2015 as policymakers, teachers, and other stakeholders worked to develop and codify the Oklahoma Academic Standards, I decided to do something that cultural anthropologists do not often engage in: quantitative data collection. I decided to survey Oklahoma science teachers about the new standards, and I was most interested in seeing how teachers conceptualized the stresses and demands of new standards with the presumed challenge of teaching evolution in a “Bible-believing” state (Brunn 2015).[i]

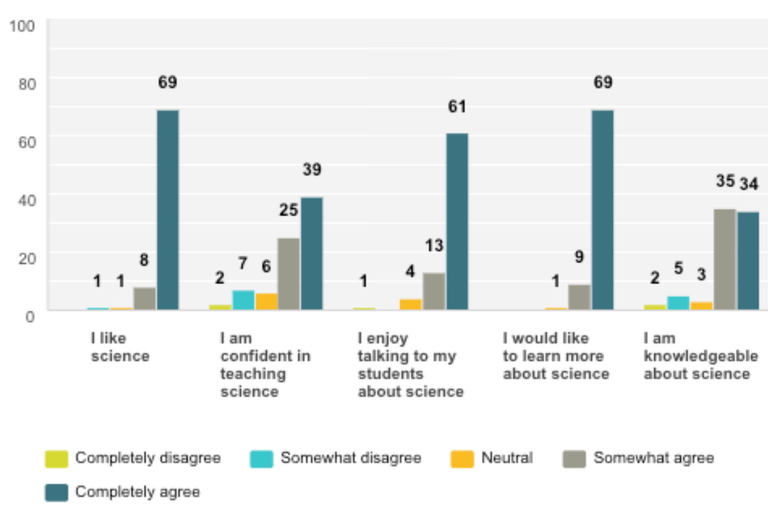
Science teachers are in the difficult position of dealing with student belief systems that may vary considerably from normative scientific epistemology (Yates and Marek 2013, 2014, 2015; Rutledge and Mitchell 2002). Discernible student-science tension seems to happen more often with the introduction of certain topics, and herein biological evolution comes into focus. I began doing ethnographic fieldwork in Oklahoma science museums (IRB #4766) in 2014, which also revealed distinct patterns of science educator challenges and coping methods, and began to illuminate the complex web that constitutes science education in Oklahoma. Museum educators reported having had regular conversations with public school teachers about their perceived inability to bring science into their classrooms in an effective or accurate way. These fears push teachers to bring their students into local museums for science classes in the first place.

A survey consisting of ten questions was designed to collect basic demographic data and to get a sense of how participants define themselves in terms of science teaching. All answers were presented in range or list format, and each question had a space for participants to write alternative answers. I distributed the survey on social media sites populated by Oklahoma science teachers, as well as in person at a pilot version of the teacher professional development workshops I began developing at that time (late 2014 – early 2015).

Individuals participated in this project in various formats. About half of survey-takers participated online via a public Survey Monkey™ link distributed on social media pages (n=43); the remaining half of survey-takers were nearly evenly divided between individuals who took the survey in person at the Women in Science Conference in Tulsa in 2015, and those who took it in person at the end of the Oklahoma Educators Evolve pilot workshop series in October 2015 (n=36). All participants were self-identified educators and signed consent forms prior to submitting surveys and interviews (IRB #5912).

Table 1: Pilot Survey Results

What is your age?	27.85% 36-45 21.52% 26-35 21.52% 46-55 16.46% 55-65 10.13% 18-25 1.27% 76 and over 1.27% I prefer not to answer 0% 66-75
What is your gender?	82.28% Female 10.13% I prefer not to answer 7.59% Male 0% Other
What is your formal education level?	50.63% Bachelor 36.71% Master 7.59% Doctorate 3.80% High school 1.27% Associate 0% Other 0% I prefer not to answer
What subjects do you teach/have you taught? (check all that apply – does not add up to 100%)	75.95% Science 35.44% Math 35.44% Other - Media/technology education - Robotics - Special Education - Engineering - Health - STEM - Computer Science 30.38% English/Reading 27.85% Social studies 13.92% Arts 6.33% Physical Education
How many years of teaching experience do you have?	25.32% 1-5 13.92% 6-10 13.92% 21-25

	12.66% 11-15 12.66% 16-20 11.39% 31 or more 7.59% Less than 1 2.53% 26-30
What grade levels do you teach/have you taught? (check all that apply – does not add up to 100%)	45.57% High school 41.77% 8th 37.97% 7th 32.91% 6th 26.58% 5th 16.46% 4th 13.92% 2nd 12.66% 3rd 10.13% 1st 10.13% College or University 7.59% Other - ESL 6.33% Kindergarten
How would you describe your level of experience with teaching science?	36.71% 11+ years 27.85% 1-5 years 13.92% 6-10 years 12.66% Little experience 8.86% No experience
Do you have any experience teaching with objects? (hands-on learning)	93.67% Yes 3.80% No 2.53% I'm not sure
Rate the following: • I like science • I am confident in teaching science • I enjoy talking to my students about science • I would like to learn more about science • I am knowledgeable about science 	

The pilot survey showed that most Oklahoma teachers are female, an average of 40 years of age, experienced in teaching multiple grades and subjects, and educated. The majority of Oklahoma teachers surveyed in this sample are proponents of hands-on teaching, and are veteran teachers with more than a decade of experience, including experience specifically in teaching science.

Survey results were statistically tested using a Mann-Whitney U test for equality of medians. This test was chosen because it is highly conservative works for non-parametric data sets (Hammer and Harper, 2008). The Mann-Whitney test uses ordinal values; thus the answers were transcribed so that they were in a consecutive increasing sequence. These values were then added to PAST software (Hammer et al. 2001) where they were executed using different, but approximately equal-sized, test groups at a P=0.05 significance level.

In plain English, this means that I coded peoples' survey responses in order to fit them into mathematical formulas for analysis. Based on the limited sample size, I wanted to see whether the survey answers were statistically significant, but the amount and type of data collected meant that the resulting distribution would not look like a normal bell curve. This means that I had to use what is referred to as a non-parametric Mann-Whitney U test, which is like a traditional t-test, but doesn't require that normally-distributed bell curve shape of data. The reason my data did not fit into a traditional parametric test is because "emotion" data do not fit well into usual mathematical measurements. This may be obvious, but it is important to note because it is one of the reasons cultural anthropologists avoid statistical treatments of the people they study and data they collect (Madrigal, 2012). Anthropological data are not necessarily statistically accurate in the sense of being fully and systematically replicable, but the data are extremely precise.

The statistical test comparing online (n=43) vs. in-person (n=36) survey takers showed no significant difference between the data sets for any of the five survey questions regarding science anxiety. In other words, there were not noticeable or statistically important differences between the people I surveyed in-person and the people who filled out an online survey. Therefore, I combined the data for the analyses I did next. The first comparison I made was between older and younger teachers, using above and below 45 years as a cut-off. Teachers younger than 45 years of age (n=47) were not significantly different in their enthusiasm for science, their confidence in teaching science, talking to their students about science, eagerness to learn more about science, or their knowledge of science than older teachers (n=32). This was surprising, because I somewhat expected older teachers to be more confident and knowledgeable in teaching science than young, new teachers. Similarly, formal education seemed to have little bearing on variation in the teachers' feelings towards science, as the null could not be rejected for any of the questions when comparing teachers with advanced degrees (n=35) and those with a Bachelor's or less (n=44). Neither were there any significant differences between how high school teachers answered the survey and how primary and secondary school teachers answered it.

The best indicator of "science anxiety" level, which is a main conceptual focus of this dissertation, was *experience teaching*. Less experienced teachers were significantly less confident in teaching science and felt that they were less knowledgeable as compared to more experienced teachers. Interestingly, male teachers appear to be more confident in their abilities. Though inconclusive in this first exploratory study because my sample size is not large enough to show a significant difference between men and women in this area, such results would be consistent with existing literature (Yates and Marek, 2014). This is an area of interest I will return to in later sections.

Since demographic data largely do not appear to differentiate anxious teachers from confident ones, I opted to compare the individuals based on their answers to each question. Unsurprisingly, teachers who completely agreed that they are confident in teaching science enjoy talking to their students about science significantly more than teachers who were less confident in their teaching. Both confidence groups felt similarly about wanting to learn more about science. Intriguingly, it was the confident teachers that felt more strongly towards wanting to learn more than the anxious teachers. Also interesting was that the most confident group felt that they are significantly more knowledgeable as compared to how the anxious teachers felt about themselves.

Table 2: Pilot Survey Question 10 (Agreement-Disagreement) Responses

	Completely disagree (1)	Somewhat disagree (2)	Neutral (3)	Somewhat agree (4)	Completely agree (5)	TOTAL
I like science	0.00% 0	1.27% 1	1.27% 1	10.13% 8	87.44% 69	79
I am confident in teaching science	2.53% 2	8.86% 7	7.59% 6	31.65% 25	49.37% 39	79
I enjoy talking to my students about science	1.27% 1	0.00% 0	5.06% 4	16.46% 13	77.22% 61	79
I would like to learn more about science	0.00% 0	0.00% 0	1.27% 1	11.39% 9	87.34% 69	79
I am knowledgeable about science	2.53% 2	6.33% 5	3.80% 3	44.30% 35	43.04% 34	79

A curious aspect of the survey results is the fact that teachers report enjoying talking to their students about science more than they report feeling confident in their ability to teach science. These separate questions may actually encompass the same activity, depending on how one perceives their role as a teacher. For example, some teachers may view themselves as lecturers or deliverers of scientific information, while others may conceptualize their role as that of a performer who is creating a compelling story about science with which students can personally engage (Pineau, 1994). While these two instances are certainly only part of a much larger spectrum, perhaps the data collected here illuminates participants' perceptions of science teaching as an exercise in speaking, versus science teaching as an active conversation or dialogue (Kubli, 2005).

Doing the pilot survey, as well as early exploratory ethnographic fieldwork in local museums, were foundational exercises in fieldwork that would shape all my research to come. It brought me to my essential research question: *What is it like to be a science teacher in Oklahoma, and how can the strengths of cultural anthropology be used to support science education?*

DEVELOPING THE SCIENCE EMPOWERMENT MODEL

After the initial pilot survey, which was supported in part with funding from the Paleontological Society, the budding Oklahoma Educators Evolve team applied for a larger grant to fund a full year of teacher professional development programming. We were awarded an NSF-OK EPSCoR New Project Grant in early 2016 (#105395500), providing funding for one year of programming. The Oklahoma Educators Evolve program has been the main source of data for this dissertation, and beyond collecting fossils we have also put on more "structured" professional development workshops at the Oklahoma City Community College and other sites. Teachers participating in Oklahoma Educators Evolve were given opportunities to fill out surveys, engage in informal and semi-structured interviews and focus groups, and be interviewed more formally in a one-on-one setting after the workshop. Approximately 350 teachers participated in Oklahoma Educators Evolve between April 2016 and April 2017, and about 50 of those opted to take a survey; others offered focus group or interview time and thoughts. The remaining 90-some survey-takers are a sample of National Science Teacher Association members who participated online. Data for this survey are presented in Chapter II.

What I learned speaking to hundreds of Oklahoma teachers about science education cannot be done justice in one dissertation, but herein I attempt to make a case for using the strengths of my field, cultural anthropology, to support and empower science teachers and learners. This dissertation presents a model for using anthropology to approach science education and teaching. The concept of using anthropological approaches to positively affect science education are not new, and many scholars have tread this ground before: “Certainly psychological and sociological approaches are useful in science education, but a more encompassing perspective from cultural anthropology can provide fresh insights into familiar problems associated with students learning science” (Cobern and Aikenhead, 1998). Indeed, plenty of literature exists that discusses science students and science learning from an anthropological viewpoint (Hawkins and Pea, 1987; Costa, 1995; Ogawa, 1995).

What I offer in this dissertation is an approach to science education that I call the Science Empowerment model, which is based on factors designed to ameliorate anxiety and build a positive *science identity*. This term refers to the intersection of many layers of a person’s being that influence how and what they think, and in what sense they incorporate scientific epistemology into their everyday lives. Science identity is not the same as “enculturation” (Hawkins and Pea, 1987) or “autonomous acculturation” (Cobern and Aikenhead, 1998) – considered the positive version of students’ newly acquired scientific understandings harmonizing with their existing worldview; or “assimilation”, the negative consequence of science learning wherein a student’s existing worldview is marginalized to make room for science (Jegede, 1995;

MacIvor, 1995; Baker and Koolmatrie, 1994; Battiste, 1986; Maddock, 1981); or, alternatively, "Fatima's Rules" (Larson, 1995). I agree with Cobern and Aikenhead (1998) and Solomon (1987) in thinking that learners do not *need* to convert their existing worldviews in order to be absorbed in the subculture of science, although this is a popular notion and has cropped up many dozens of times in my fieldwork.

SCIENCE IDENTITY AND THE SCIENCE EMPOWERMENT MODEL

I present in this dissertation an argument for why individuals who engage in the process of science education must be trained in anthropology, especially in order to succeed in creating a culture of Science Empowerment for their students. The primary reason is simple: this field has mastered the art of 'methodological agnosticism' (Traweek, 1992), which is a great tool for teachers to have when they are working with resistant learners on topics like evolution. Anthropologists have spent the past century progressively building an effective approach to learning new ways of thinking that is all about being able to simultaneously hold more than one belief system or view. In other words, epistemologically diverse people can find science meaningful and participate in it effectively, and more importantly be *included* in it effectively, without 'losing' themselves or their culture in the process.

Science identity is about how a person's self-conception intersects with three coexisting, orbiting factors that I will present in this dissertation: literacy, access, and cultural intelligence. The Science Empowerment model relies on a balance of these factors and their basis on a foundation of positive science identity.

An appropriate place to begin talking about science identity and empowerment is to define *science*. Science is a method; it is a way of understanding the world around us; it is systematic inquiry, a recipe for asking questions and going about answering them; it is also a body of knowledge, built over millennia of human exploration and curiosity. The National Air and Space Administration (NASA) defines science as "curiosity in thoughtful action about the world and how it behaves" (www.nasa.gov). Science has been defined many ways, each time a bit differently depending on the interested parties. From an anthropologist's viewpoint, and the way I choose to define the concept in this dissertation, science is how we come to know and find meaning in the world around us through formalized, systematic curiosity.

Factor 1: Science Literacy

Science literacy is a popular, politically charged issue. Political scientist Jon D. Miller has demonstrated that "only 28% of American adults have the sufficient understanding of basic scientific ideas to be able to read the *Science* section in the Tuesday *New York Times*" (Meinwald and Hildebrand, 2010:241). For most researchers of science education and literacy, this number is nothing short of alarming. The reigning discourse among scientists and researchers leads us to think that there is a major problem looming on the horizon for America's future if we do not bring the number of scientifically literate citizens up much higher, as quickly as possible. This view treats the importance of literacy as situated in its outcomes, which I will discuss in some depth in a later chapter. I am more interested in the *process* of literacy, in terms of how learners build a base of scientific knowledge, as well as how they go about honing scientific skills like skepticism and research.

Factor 2: Access

Access is an issue not separate from literacy, but rather overlapping and sometimes encircling it. Access, in my treatment of the topic, takes into account physical, geographical, technological, financial, and also symbolic barriers (race and gender). Education in a general sense is regarded as positive, empowering, and valuable; researcher John Immerwahr has stated: "higher education is generally perceived as extremely important [87% of Americans feel this way]…[and] the process of earning a degree is inherently valuable and is not merely a symbolic, largely meaningless exercise" (Immerwahr 2000; Kezar, Chambers, Burkhardt, 2015). Science education is an important source of social capital in contemporary America, and the ways in which we disseminate this knowledge are built upon a deeply flawed tradition of social gatekeeping.

Education is a locus of American classist assumptions, though we generally do not treat it as such because it is often seen as the primary vehicle to upward mobility. When we talk of education, the issue of *access* is both rampant and essential, but is conventionally framed such that: 1) education is the means for gaining access to other forms of social capital, and 2) having an education can be all that is needed for social mobility. America has a long history of having outsiders believe that *if you just work hard enough and get an education, you can do anything*. The discourse on STEM learning seems to ignore the tautological argument that "education begets access." I propose we begin crafting the conversation in such a way that allows interlocutors to consider access and education as both obstacle *and* bridge.

Factor 3: Cultural Intelligence

Modern public education tries to cultivate literacy while providing access, but often fails to take into account the third piece of the puzzle – cultural intelligence. Cultural intelligence means that educators and the systems in which they work must reach students where they are mentally and socially, considering carefully how the students' contexts have produced and molded those individuals, and building appropriate skills and rapport in order to reach students. Other scholars have noted this phenomenon previously, of course, though they may label it differently (Lisa Delpit [1988, 2006, 2012], Sonia Nieto [2002, 2009], and Chris Emdin [2016]).

Traditionally academic areas like anthropology can inform, support, and help teachers, and my goal has always been to build and reinforce a culture of strong respect and backing for teachers. There is one exception to this rule to be found in this dissertation, however, and that is cultural intelligence. Cultural intelligence must be a demand put on educators, rather than on students. Too often, the understanding and bridging of cultural difference in the classroom is thought to be within a student's control, but this is where teachers must step up. An enormous component of achieving culturally intelligent science education depends on administrative and policy-related support for teachers. This could be as simple as encouraging, providing, and requiring anthropologically-centered professional development for teachers; it could be as complex as requiring all preservice teachers to complete at least one course in anthropology. In any case, the whole system must be on board.

CHAPTER I: INTO THE FRYING PAN

FRAMEWORK

OH, THE HUMANITIES!

Anthropological fieldwork mirrors fossil hunting in ways I never thought it could. Bringing that first fresh notebook along for observing people is invigorating and terrifying; your pen flies across the page, struggling to capture each thing as it happens around you. To the newcomer, every utterance and gesture could be the key to understanding the cultural landscape of those around you, just as each piece of limestone could be a scientifically groundbreaking fossil. Your brain strains to find patterns and follow the shapes of human behavior; your eyes and ears become saturated with signals. Eventually, texture appears: some of those around you are exhibiting emotion in physical ways; others are speaking in particular tones; a few stand out as punctuations. And then - just like that - someone says or does something that piques your interest. You aren't sure how you noticed it, but after you conceptually isolate that first behavior as important, your attention begins to filter and sort other actions almost automatically. Once you find one, it becomes infinitely easier to find another.

When you imagine an anthropologist, you may think of a sweating, sunburnt European man locked in a skirmish with exotic plants as he attempts to reach an uncontacted group of people in the jungle. *He suddenly sees a break in the thick foliage, revealing a mostly-naked group of people with beautiful brown skin, hanging* *out near curious structures and doing elegantly simple things like making objects out of animal parts or carrying babies around on their hips. The people peer back at the anthropologist, looking fearful. The next moments are crucial, as men with painted symbols on their bodies approach him, crouching and baring handmade weapons.*

For decades, this is largely what anthropology was, at least for European cultural anthropologists who traveled to newly colonized areas of the southern hemisphere; as well as those who didn't actually go anywhere, but still wrote about such places ("armchair anthropologists", for example E.B. Tylor and James Frazer). Much of the world was a living laboratory for the affluent white male, and making contact with savage and primitive peoples was an adventurous and noble thing to do. The scholarly descendants of those first explorers would spend over 100 years fighting social sciences tradition, each generation with its own new set of conflicts, until the modern anthropologist would emerge. The new wave of anthropologists still travels across the globe often to do fieldwork; they still take many hundreds of pages of notes on topics like ritual, kinship, language, food, and dress; they still examine questions that are relevant to their times and academic contexts. Modern anthropologists are still largely Caucasian, middle- to upper-class, highly educated individuals with a core sense of wonder at those who are different from them.

The cultural anthropologist of today is different from those of the past for many reasons. My thoughts here are in no sense an exhaustive list, but rather are a few points that have been especially important for my own work. First, the world is connected in ways that the first anthropologists never could have imagined; the Internet alone has created new subfields of anthropological inquiry that will take decades to parse out. Second, anthropology straddles the awkward corners of the humanities, social science, and hard science in ways that its first practitioners were not responsible for recognizing and respecting; now the discipline strives to be reflexive and self-aware. Third, what counts as cultural phenomena worthy of study has morphed drastically since the early days.

When I introduce myself to undergraduates in the classes where I serve as a teaching assistant or instructor, I hesitate to tell them what I work on and how I do it because this is usually on the same day they are supposed to be learning for the first time that anthropology has nothing to do with dinosaurs. In an attempt to keep archaeology separate from much deeper time, studied by paleontology, we typically drive the point home that students will *not* learn about dinosaurs in anthropology class. My research interests muddle these waters. I am trained as a cultural anthropologist who examines science learning in informal contexts – and in these contexts, the more natural history, the better. Public science education is open to so many avenues and angles that there is probably no objective reason why an educator might choose one science over another for accomplishing their goals, but I will attempt to illustrate how I ended up choosing paleontology as the subject matter for bringing science to the public, considering I am part of a field that constitutes a rich mosaic of science itself, and why paleontology is a good choice for science outreach in

Oklahoma. I will begin with a personal account and then delve into relevant literature and research.

FROM ANTHROPOLOGY TO ANTHROPOLOGY AND EVERYTHING IN BETWEEN

As a freshly declared anthropology undergraduate more than a decade ago, I was steadfastly interested in humanity as a source of inquiry. I was fascinated by language, geography, food, gender, art, and material culture, among other categories. I attended a four-field anthropology program and would be exposed to cultural, physical, archaeological, and linguistic anthropology in relatively equal doses over the next six years. I quickly sided with physical or biological anthropology as my favorite of the four. Unfortunately, college was my first exposure to the life sciences, and I was woefully unprepared to study biology in any sense. My primary school experience had been completely devoid of evolutionary theory, and indeed, I had several teachers who, when pressed for information about the natural world and humanity's place in it, would tell me that men had one less rib than do women, and that what I knew about dinosaurs was wrong – they didn't live long ago, and T-rex was actually a vegetarian – "*how else could he have lived harmoniously with the other animals on the Ark?*" they asked – and I didn't know enough to disagree.

In college I would not excel in biological anthropology classes by any stretch of the imagination, but not for lack of enthusiasm and interest. I voraciously read the entirety of work written by Jane Goodall, Birute Galdikas, Dian Fossey, Frans de Waal, and Robert Sapolsky. I was even lucky enough to meet Jane Goodall, and eventually traveled to Indonesia to volunteer for an orangutan field research organization. I also became brave enough to enroll in my first earth science class (Paleontology 508 – Introduction to the History of Life); though I very nearly failed it, geosciences became my minor shortly thereafter. I knew I tremendously enjoyed the material, but had a seemingly insurmountable mental block to doing well in the courses. Fortunately, as a senior I was able to take many fossil-collecting trips around the United States with friends, and that is when I really started to have a command over the subject matter I was learning. I was also about three years into doing a series of museum internships at that time, and I had fallen completely in love with natural history museums in general. I wondered whether there are other people out there who love science with a passion, but don't do it as a profession because they "aren't good at it". I watched and listened to people exploring fossil exhibits in the museums where I worked, commenting that they had wanted to study dinosaurs as a child, but they had forgotten about science after performing badly in it in high school and college, or even in middle or elementary school.

Of course I failed to gain entry into any graduate programs for physical anthropology. Happily, I ended up doing my master's in Museum Studies. It was in this program that I began to carve out a niche as the only person in my cohort to be a complete science nerd, striving to work in a natural history museum, rather than in a modern art gallery or a colonial historic house. I focused most of my energy on exhibitions – learning to develop, design, and even build and install them - pale scars from a soldering iron still peek out from underneath my wristwatch. Exhibitions were, in my view, the medium through which museums could teach the public about science in ways that other things cannot; it was in exhibitions that people could see real things up close, read a carefully crafted informational script written by experts, and imagine how something would have looked or behaved in its original context by virtue of seeing a drawing or diorama. Exhibitions could serve as science lessons for those afraid or unable to learn in a school setting, and they could offer something that plays well to the visual and auditory strengths of many people who visit museums.

In the final year of my Master's work, I had two experiences that convinced me that my foundation in anthropology was relevant to natural history exhibit work. First, I spent a summer interviewing and observing visitors at the Royal Tyrrell Museum of Palaeontology in Drumheller, Canada, nestled in the gorgeous badlands of Alberta. Second, I worked for seven months in the education and museum studies research office of the Smithsonian. In both of these instances, I kept coming across people who came to the museum out of interest and enthusiasm for learning about science – but who would walk away from science exhibitions of all shapes and sizes still misunderstanding basic principles and ideas. Some would even walk away noting that they now believed more strongly in their creationist convictions after seeing the fossil evidence. It finally dawned on me that perhaps understanding cultural context and personal experience was the key to knowing how to make a great science exhibit. Obviously many others had thought of this before, so I quickly consumed the works of John Falk and Lynne Dierking (1992, 2001, 2009), Kathleen McLean (1993, 1999, 2007) and Nina Simon (2010), and others (Hein 1998; Hooper-Greenhill 1999, 2007; Weil 2012). Once caught up, I dove back into anthropology.

CULTURAL ANTHROPOLOGY, SCIENCE, AND THE MARKS ON MICHAEL PHELPS

> *This week has kicked off the 2016 summer Olympics in Rio de Janeiro, Brazil. As I try to take a short break from research to sit in front of my meager window A/C unit and rest my mind, I notice distinct circular bruises on Michael Phelps' shoulders as he prepares to swim for another medal. At first I think the screen is playing tricks on me, and right as I turn to my husband to ask whether he knows what the bruises are, I catch the sportscaster rambling, "those marks on Michael Phelps' shoulders are from an ancient Chinese healing technique called 'cupping'. Lots of athletes are trying it out this year…"*

Phelps believes that cupping, done by placing small glass cups on the skin and then inducing a vacuum within them until capillaries break, encourages blood flow and helps muscles heal. What the cups are actually doing is creating a bruise on the muscle, which is a blood clot (the opposite of flowing blood). Typically, when white people say "healing", my pseudoscience and privilege detectors go off. Especially when coupled with "ancient" and "Chinese". I frowned and shook my head at the television. After several nights of watching the Games, I would count a dozen other athletes with cupping marks on their bodies, and I would become nearly annoyed enough about it to post something on social media. But then I stopped and thought, *Why does it bother* *me so much that a man I've never met has chosen to give himself perfectly round hickies? And what does it have to do with my research?* Situations like these are a primary reason I have written this dissertation.

I must stop myself from falling into a cynical pattern of thinking, and instead try and view this, like everything else, through my anthropologist goggles. Taking to the Internet for more information on cupping made this endeavor both easier and infinitely more difficult, but I tried to step outside myself and away from the narrative in my head that people are gullible, superstitious, and scientifically illiterate. I scrolled through my Facebook feed, noticing a handful of articles about cupping right away. For example, journalist James Hamblin of the *Atlantic* wrote, "Something about the oldness, and the non-Western-ness gives [cupping] some enduring anti-establishment cred…" I saw this, and I had already read enough to sleep better knowing that others are as troubled by seeing intentional bruises on the white skin of an internationally known millionaire.

The adoption of "ancient healing" practices by white, middle-class Americans is offensive to me on two levels: first, as an anthropologist who is concerned about cultural appropriation and global exploitation; and second, as a science advocate who is absorbed in fighting charlatanism and promoting awareness of and appreciation for empirical evidence. So when people ask, "who is it hurting?" – I have mixed feelings, though strong ones, about the answer. A certain amount of privilege is necessary to achieve scientific illiteracy in the form of science denial, and examining and unpacking privilege is one of anthropology's strengths.

Cultural anthropology's relationship to science is a double-edged sword, and I propose to fight the worst parts of the field with the best parts. As I will review, there exist important and legitimate critiques of science and the epistemological perspective that science is the closest thing we have to the truth. Anthropologists have been right at the forefront of the "battle" between science and the humanities, even if one of our own, Bruno Latour, and others thought we couldn't possibly study science effectively (Latour, 1990; Woolgar, 1989). What I think is important about anthropology's perspective on science is the practice of approaching is as if it is one of multiple frameworks into which an average person may be enculturated. But anthropologists did not always feel this way - in fact, our field was responsible for the first classification systems applied to non-Western peoples that included words like "savage" and "barbarism", all because Europeans conceptualized science as being the key to civilization. At first, European anthropology was about seeing how civilized and rational and evolved uncontacted tribes were, and then being ready to patronize those groups about proper social civility when, surprise, they weren't.

Bronisław Malinowski began to change the view of such "pre-science" or "illogical" peoples when he published *Coral Gardens and Their Magic* in the early 20th century. This book was the last installment of a trilogy on the Trobriand Islanders - a *Return of the Jedi*, if you will. The ways in which these "uncivilized" people used logic in situations where they had control, such as tilling and planting gardens, was contrasted with how they would turn to superstition and magic when in situations with less control, such as faring the open ocean to fish. Malinowski pointed out to civilized, scientific Europe that their own behavior in situations of control versus lack of control were nearly identical, if only one replaced “magic” with prayer and religious faith. Malinowski was also one of the first anthropologists to meticulously collect and document his subjects’ technologies through the study of material culture. Rather than bringing science *to* people, my goals can be traced back to the tradition of recognizing and drawing it out of places where it already exists.

Cultural anthropology has a long history of misunderstanding science and people’s relationship to it, and this dissertation is, in part, an attempt to examine and remedy that, because cultural anthropology holds the key to improving science education and teaching.

BACKGROUND

OKLAHOMA: A FOSSIL IN ITS MATRIX

Oklahoma may not be the first state that comes to mind when Americans try to conjure images of cutting-edge education, and admittedly, it is for good reason. According to the National Center for Education Statistics, Oklahoma children score lower in reading, mathematics, and writing than most other states, and according to the Oklahoma Department of Libraries, one in five Oklahoma children do not have equivalent literacy skills to their counterparts in other areas of the country.[ii]

We rank even worse in science. Still, Oklahoma is home to nearly 1 in 5 of America's aerospace sector jobs because of facilities like Tinker Air Force Base, and has been a leader in America's energy industry.[iii] For such economic reasons, concern about Oklahoma education, especially in STEM (science, technology, engineering, and mathematics), has arisen among politicians, citizens, and other stakeholders over how the state will continue to fill and expand those industries with skilled engineers and scientists. In 2015, new Next Generation Science Standards (NGSS), locally adapted as OAS or Oklahoma Academic Standards, began to replace the Common Core Science Standards (CCSS) that had been in place in Oklahoma for less than ten years. Personally, I think the new standards show promise in terms of helping construct a stronger pipeline for Oklahoma children to be able to pursue science as a career. But more importantly for my research, I think the standards will give Oklahoma kids a leg up in terms of pure enjoyment and passion for science. A primary reason for this: their very own teachers wrote the standards.

In Oklahoma, the relationship between schools and museums is complex and interdependent. Government policy and a lack of public support for schools have led to fascinating twists and turns in state educational standards development and implementation, wherein the responsibility of schools to teach people science has created a great dependency on local informal education outlets like museums because teachers are either unprepared or uncomfortable doing so. Where paleontology and natural history museums come into play here for me are through their indispensable feature: collections. Being able to show the public original fossils, scientific fossil casts, and other specimens is tremendously valuable in teaching socially contentious topics like evolution and climate change. As a place with fantastic geologic history learning opportunities, an amazing natural history museum and scientists, and a great need for understanding science, Oklahoma is an ideal place for using paleontology to teach science.

PALEONTOLOGY AS A TEACHER OUTREACH TOOL FOR OKLAHOMA EDUCATORS EVOLVE

I wish to clarify what attracted me to natural history as a medium for science outreach, considering I already belong to a field that is rich in content for science outreach. Are there actually particular subjects in science that make for better or worse public education? This is an area of inquiry with little to no published literature to my knowledge, and I believe it largely comes down to personal preference for most of us who work in science education. Tremendous science communication endeavors have been undertaken through the medium of astronomy (Neil Degrasse Tyson, Bill Nye, and Carl Sagan are household names); physics and geology also have great, though perhaps less celebrity, advocates (Robert Hazen and James Trefil). I will try to clarify three things that make it a good medium in general, and why I choose it over the anthropology-based areas of science in which I am formally educated.

I chose to use paleontology as a framework for presenting socially controversial and difficult scientific topics to teachers. Unlike the other natural sciences, paleontology is rarely taught effectively in schools, though it is actually an incredibly effective tool for public science education. Paleontology is treated as a juvenile novelty; kids enjoy learning about dinosaurs and woolly mammoths, but rarely does the conversation extend beyond common examples of extinct animals. As a source of primary scientific data, paleontology is sorely underutilized in most classrooms. The fossil record provides most of the direct observations of past life to which scientists have access, allowing us to reconstruct the evolutionary and climatic history of this planet going back billions of years. Paleontology lessons have a scope beyond what can be observed in a human's life, offering insights into a world unadulterated by human influence. Paleontology is a hybrid science, commonly mixing elements from the traditional natural history disciplines of biology and geology with the more analytical fields of math, physics, chemistry, and engineering. With proper training, educators from all disciplines could use fossils to engage and teach students about wide-ranging concepts, from the biomechanics and evolution of flight in early birds, to using CT technology to find out exactly how much dinosaurs relied on smell, to extrapolating total length estimates from teeth of the giant shark Megalodon, to name a few examples.

The science of paleontology is rather small and young compared to physics or mathematics, and its history is full of problematic situations and characters (Jaffe 2001). There are several reasons it is valuable for public outreach. First, it is a complex, interdisciplinary undertaking that demands incredible creativity and imagination from its professionals. Knowledge of anatomy, physiology, osteology, botany, zoology, biology, sedimentology, taphonomy, and dozens of other areas can be called into play in paleontology on a daily basis.

An understanding of both the living and the nonliving (organic and inorganic) is essential, but also a deep appreciation for physics, earth processes, and chemistry. Art and engineering also make frequent appearances in the science, and even nuanced study of ethology and psychology contributes to what paleontology knows. People who are interested in a huge range of areas are able to find something interesting in paleontology. Personal interest is a major factor in science learning (Falk, 2001; DeBoer, 1999; Lancy et al., 2010), and paleontology has the spectral power to attract varied learners.

Second, paleontology is a science that is full of human interpretation, and I mean this in the most complimentary of ways because a paleontologist cannot simply watch and record what their subjects do. They must imagine, reconstruct, apply, and deduce things in ways that many sciences do not have to, and some are even arrogant enough to think that this makes it a "softer" science. A personal inability to perform complex statistics or apply mathematical formulas does not prevent success in paleontology, though of course having these skills doesn't hurt. A paleontologist's interpretations and deductions are based on a huge, dynamic encyclopedia of natural and physical knowledge, making their lines of reasoning broad and robust in ways that peers in other disciplines can understand and verify. The fact that it is approachable from so many angles and learning style preferences is an incredible advantage if one considers how many people struggle with science anxiety because they believe they are not good with numbers and analysis (Mallow 1978, 1981, 2006; Mallow & Greenburg 1983; Steele et al, 2002; Ede 2012).

Third, and this is a point with which other anthropologists might not agree (Lett, 1997), paleontology is something that manages to transcend the usual lines we draw between humans and nature. It allows humanity to glimpse into the whole world's heritage, of which we are but a tiny part. "Heritage" is a word used traditionally in the humanities, but increasingly in the sciences (Henriques and Reis, 2015), and I am cautiously optimistic about using it in this context, though absolutely not in the sense of erasing or overpowering ideas of *cultural* heritage. Of great importance to the Oklahoma Educators Evolve program has been the existing legislation that serves to support these ideas, because the distinction between 'heritage' and 'nature' in legalese means that teachers can collect certain fossils from public land to create a classroom collection. The same cannot be said for archaeological artifacts, which are protected by the Antiquities Act of 1906. Oklahoma teachers are given the barest of budgets with which to purchase materials for their classrooms, and having the ability to collect fossils legally helps combat this problem tremendously.

Paleontology is both personal and social. It creates an understanding of the world as a whole – a big, broad picture – and of our planet as an energetic and ever-changing place with a deep history; but also, our world as a place where we each personally live and experience things. I think many sciences can do this, but paleontology brings them together in ways that appeal to many learners.

For these reasons, paleontology is a great medium for public science education. But why would an anthropologist choose it over, say, archaeology – part of another far-reaching, umbrella discipline? I do not choose archaeology as my primary medium for public science education even though it is more "scientific" than other areas of anthropology, in that it values empirical evidence, and even though it is broadly appealing. Mostly I don't do so because I recognize that humanity generally does not see itself, nor has it seen itself in most of our past, in terms of modern scientific understandings (Gurian, 2006); there is something deeply emotional about categorizing humans this way. For this reason, it is inappropriate to operate as if everyone does see themselves and their ancestors as scientists do.

Museums, for example, have a history of doing this in ways that have contributed to institutional and public racism for centuries, mostly through archaeological collection practices (Conn, 2008; Karp 2006, 2012; Marstine, 2008; Karp et al, 2013). While I do take the stance that humanity is just one species among millions of others in the evolutionary tree of life, I think that teaching science primarily through archaeology has the potential to be socially problematic and unsavory in ways that paleontology is not, especially in Oklahoma, considering the state's history of indigenous suffering (McBeth, 1983; McReynolds, 1960; Miner, 1976). People seem to have a hard enough time understanding and accepting scientific ideas that have been established as factual for centuries, and I have simply made the decision to try and separate that struggle from the struggle of getting people to conceptualize past and present peoples as being equal to them.

Many scholars have tackled the issue of evolution denial and misunderstanding (Cobern and Aikenhead, 1999; Aikenhead and Jegede, 1999; Mullins, 1995; George, 2001; Bybee, 2001; Rosenau, 2012) and even in Oklahoma in particular (Yates and Marek, 2013; 2014). Evolution is one topic where paleontology is especially useful for teaching the public because fossil evidence is concrete, tangible, and convincing. I am also working on public education in climate change to some extent, and paleontology is an excellent medium for this because it offers so many lines of evidence by which to understand climate throughout Earth's history. All of this being said, paleontology is also my chosen science for public outreach because people – especially children – love dinosaurs, and I will not argue with that.

A VERY BRIEF TOUR OF EDUCATIONAL THEORY

The story of how people began to think about "education" as a nebulous cultural activity is an old and ongoing one. My humble treatment of the issue begins over one hundred years ago in Italy, where Maria Montessori opened her first school for children. She believed that education comes from experience, and that successful learning environments must be learner (child) centered. Though one can now tour any furniture store and find child-sized chairs, tables, and desks, it was not so in Montessori's time. She created spaces for her students that were both accessible and comfortable to them, with working tools small enough for the children to build real projects. Her ideas were so simple and sensible, and yet have been foundational to how children all over the world spend their days today. Kolb's 1984 work *Experiential education: Experience as the source of learning and development* provides a helpful overview of how we use Montessori's ideas today.

Shortly after Montessori began her career, the United States would meet its own foundational education thinker, John Dewey. His seminal work *Democracy and Education* was foundational in showing that when a society thinks about how to educate upcoming generations, a most profound problem we must face is how to find "a proper balance between the informal and the formal, the incidental and the intentional, modes of education." (1916:9). Many practices in today's formal classrooms reflect a lack of understanding of the strength I see in hands-on learning methods. Dewey's work on "modes of education" has been foundational in encouraging me to think about what kinds of classroom practices are most effective in teaching science.

Contemporaneous to Dewey was Jean Piaget, a Swiss educational theorist and psychologist whose ideas about learning were both groundbreaking and essential to the world of education. In the early 20th century, the concept of "intelligence" was largely thought to be measurable, especially within the parameters of tests. In 1919, Piaget worked at the Alfred Binet Laboratory School in Paris, where he was tasked with creating and standardizing a French version of an English test of intelligence. In doing so, he noticed distinct patterns in the incorrect answers that children gave on the tests, and so began a lifetime of examining, explaining, and celebrating mistakes as great indicators of how children learn (Mooney, 2000:77). Over a long and illustrious career, Piaget formulated a model of childhood development wherein individuals acquire advancing levels of reasoning as they grow and are exposed to new experiences.

In the 1920s and 1930s, Russian theorist Lev Vygotsky was developing some controversial theories about children's learning. He was against using standardized tests to analyze the intelligence of children, and thought instead that intelligence is constructed as children experience new things and develop from one stage of learning to the next. He is known for his idea of the "Zone of Proximal Development", which is the conceptual "distance between the most difficult task a child can do alone and the most difficult task a child can do with help" (Mooney, 2000:101). Vygotsky thought that interaction between children and peers or adults is what advances their learning; this is a slightly different view from that of Piaget, who thought of learning as a more internal process. The tension between personal versus collaborative learning would take a lasting competitive, individualistic turn in the United States after World War II.

The 1950s were tumultuous years for education in the United States, as the Cold War firmly replaced World War II at the forefront of policy makers' minds. Standardized testing was about to become institutionalized to new levels, and science would become manifested in the education system as the National Science Foundation and the National Air and Space Administration sprang up as well-funded, widely-supported organizations. The focus of education during this period was much more about competition and national issues than of general research or interest in science, which essentially began with the launch of Sputnik I by the Soviet Union in 1957. Researcher Carol Anelli has written, "The goal [of pouring billions of dollars into science education after Sputnik] was to produce a bumper crop of young adults in STEM careers" (2011:236). The concept of teaching science for the purpose of global competition has not fizzled out in the past sixty years.

The 1960s came with a fresh focus in education on what we are teaching, how we do it, and why; these issues directly paralleled the concerns of civil rights reformers. Curriculum theory, which had been around in one form or another since the turn of the 20th century, became a topic of popular discussion in the 1960s (Johnson, 1967; Beauchamp, 1968; Schwab, 1969) as theorists put a stronger focus on how education is a transmission of values. Curriculum creation is a nebulous enterprise, and it is useful to think about how our values are shaping modern science curriculum. The discourse of curriculum is a conversation about the roles in society that we educate students into, as well as the values we think we should instill in students. An important issue for thought here is how science curriculum may play a role in civil issues. It had been taken for granted that STEM careers have been generally assigned to white men, and the 1960s sparked a transition of thought about this tradition.

More “radical” philosophy would follow. In 1971, Ivan Illich published his famous book *Deschooling Society*. In this work, Illich founded his concern for students in the American school system: “The pupil is ‘schooled’ to confuse teaching with learning, grade advancement with education, a diploma with competence, and fluency with the ability to say something new.” (1971:1). This assertion reminds me of John Dewey’s ideas about modes of education - formal and informal - and I think that modern formal classrooms still reflect what Illich was talking about. Hands-on methods, which may be more prominent in informal settings than formal ones, have the potential to address the concerns Illich had with how people are “schooled.”

Schooling, and more broadly, the focus of educational discourse in America, consistently zoom in on individual learning and out to society’s larger issues, and back again. An example of an issue related to individuals, but traditionally tested on a wide scale, is intelligence. Well after Piaget began noticing problems with intelligence tests, Howard Gardner was one of the best-known education researchers to publish fresh thoughts about what “intelligence” means. In 1983, he published his *Frames of Mind:*

The Theory of Multiple Intelligences, which churned up a tidal wave of new and reframed ideas in education. Gardner's work showed that individuals have certain skills and proclivities, or "intelligences", but that with the right environment, resources, and effort, any person can develop their other skills or intelligences more fully.

Staying within the vein of thinking about individual development, theorists in the 1990s began more seriously talking about how people acquire knowledge and skills. Robert Sternberg's *Thinking Styles* (1997) deconstructs, explains, and even celebrates how people learn. Sternberg described learners as preferring one style of thinking to others in most situations, categorizing them based on their inclination to take direction, proclivity for organization, and willingness to work with people, among others. Sternberg thought that individuals' preferred styles of learning showed that people certainly self-govern, especially in their own learning. This is important because it means that learning is an active, rather than passive, task – as many theorists had asserted before.

The 21st century has seen a return to issues of equality and access that were first seriously treated by educational scholars in the 1960s. Sonia Nieto (2009) and others have met the new century head on with difficult questions about the American education system and critical analysis of pedagogical practices. We have moved into an age of new questions for which educational theorists may draw strongly from disciplines such as anthropology and philosophical epistemology.

CHAPTER II: DOING ANTHROPOLOGY WHERE THE WIND SWEEPS DOWN THE PLAINS

I am covered in sweat and still panting from the walk. Three miles away in 85-degree heat and 96% humidity sits my car, at Frederick Douglass High School. Ducking inside the ornate stone building in front of me is a relief. The capitol is beautifully air-conditioned and all its marble surfaces are cool to the touch. Everywhere swarm folks in red – old, young, white, brown, frowning, smiling – nervously, excitedly preparing to meet their representatives. Men and a few women in tailored suits make their way through the crowd, some pausing to read signs that children are holding, but most simply walking by, focused on their destination. Outside the Senate chamber, other marchers fan themselves with handmade posters. I am grateful to catch a breeze from one that reads, "If we don't support them now, they will end up in the prison system or worse." I am tired and hungry and wondering how to get back to my car at Douglass – walk, probably. I think about the cold linoleum halls of that school, where my students raced Lego cars and learned about Newton's Laws of Motion in summers before.

Nearby a tall individual is getting in a heated conversation with three marchers in red. He is a transgender man. I am surprised to hear the three marchers in red – public school teachers – arguing with him. One is even laughing at him. This month Oklahoma lawmakers have been working on their very own "bathroom bill", joining a dozen or so other states claiming that *keeping transgender individuals out of the restroom that matches their gender identity is a measure "to protect the kids". Just like today's protest of public education budget cuts. Just like? I can't believe the words the marchers in red are saying to the transgender man.*

The marchers in red are carrying apples, clutched between their phones and posters. The apples each have a sticker with a legislator's name on it. If they give them a symbol of education, perhaps they will think more favorably about funding our schools. I wonder how many of the apples will end up in the trash.

I am considering talking to some Senators. Do anthropologists do that? Which hat am I wearing today – which identity? Did I really just come here to write a few pages that might go in my dissertation?

On the walk over from Douglass, I paid close attention to my surroundings in a way that I find difficult to do while driving my car. I have been to Douglass too many times to count, as well as the blocks around it, but never on foot. What I noticed for the first mile or two between the school and the capitol was a distinct smell. Hot asphalt mixed with urine and spilled beer. The acrid scent permeated the sauna-like air. The sidewalk – when there was one at all – was covered in brush and debris. A hill stood abruptly to my right as we marched, and crude stairs had been fashioned out of bricks into the side of the *hill. On one flight, I saw that two trees had grown right out of the ground between cobbles. Life finds a way, I thought.*

Suddenly as I walked, the air seemed clearer, the sidewalks became consistent and crisply maintained, and homes had beautiful iron gates around their perimeters. The Lincoln Historic District is characterized by large, ornate homes of brick and stone. As my group of marchers fringed the capitol complex, perfect green lawns blanketed the space around oil derricks. The strain between green beauty and black iron, wildly mismatched neighborhoods cobbled together in an awkward jigsaw, and a hundred people who work indoors putting themselves into the full onslaught of the southern sun all seemed, simultaneously, both familiar and strange.

METHODOLOGY

This dissertation features a mixed-methods approach – one that sometimes demanded I run statistical analyses in the computer lab all day; one that sometimes demanded I run alongside children to catch insects in a field; and one that sometimes demanded I run teacher outreach sessions in modest public park facilities, furiously scribbling field notes all the while.

Adapting anthropological methods to educational settings is a challenge for many reasons, but doing so is worth the effort, if only for the contextual depth and descriptive richness that an interdisciplinary approach can provide: “The anthropology of education sits at the crossroads of anthropology as a discipline, schooling as a professional field, and education as a perennial human endeavor” (Levinson & Pollock 2011). The primary way anthropologists can achieve detailed portrayals of the texture of educational settings is through participant-observation, a method used by many fields that can allow for both qualitative and quantitative analyses (LeCompte and Millroy, 1992; LeCompte and Schensul, 1999, 2010). Participant-observation is one component of the greater toolkit of ethnography, which can be described as a systematic recording of some aspect or intersection of aspects of daily life. The methods of ethnography are well established (West, 1975; Erickson, 1984; Spindler, 1987; Anderson, 1989; Tobin and Davidson, 1990; LeCompte et al, 1993; Frank and Uy, 2004), but its legitimacy as a research tool rests on the reader’s perception of the power of first-person narrative as an instrument for data collection.

While quantitative methods obviously produce important, interesting, and applicable results from which I will draw in my own fieldwork (Lawson and Renner, 1974; Haladyna and Shaughnessy, 1982; Marek and Cavallo, 1997; Yates and Marek, 2013, 2014, 2015), they may not necessarily constitute the most informative path to an intricate understanding of how social identity plays a role in science learning and teaching. I have primarily used ethnographic methods in my research for two reasons. First, education, among other social sciences, is historically fraught with misleading, ill-conceived interpretations of human intelligence and learning that are based heavily on quantitative handling of data; relevant examples include The Bell Curve (Herrnstein and Murray, 1994) and the work of Arthur Jensen (1972, 1998). Ethnography reduces possible misinterpretations of my data. Second, there are many beautiful examples of ethnographic educational description in anthropology that have already established the strength of such approaches to evaluate and critique what have traditionally been quantitative interpretations of educational behavior (Ogbu, 1974, 1992, 2003; Foley, 1991; Levinson et al, 1996; Foley et al, 2000), and from these I draw both inspiration and direction; ethnography provides the level of resolution that is need to examine the social construction of science learner and teacher identities.

Qualitative methods offer researchers creative and exciting options for deciding what data to collect, as well as how to collect and analyze those data. And since “writing is not an innocent practice…we know the world only through our representations of it” (Denzin, 2001), the representations I offer in this dissertation must be myriad in order to attempt any semblance of truthful portrayals of science teachers and learners. In spending brief but intense and recurring periods of time with educators around the state of Oklahoma, the nature of our relationship has grown from workshop acquaintances to trusted confidants. This work frames that relationship and its consequences by introducing key concepts and “characters” through the medium of vignettes, drawn from actual conversations and situations that happened in the field.

The choice to use ethnographic methods is not always met with approval. I was fortunate to meet a few prominent science education researchers in person while doing this work. One of them reviewed a report for me once. On it he had scribbled all over in red ink, circling and crossing things out, slashing my words and putting question marks by things that made no sense to him. Typical graduate edits, of course. But something that stood out to me was the way he drew a thick circle around one particular photo I had included in the report. It was a picture taken at the Whitemound site in southern Oklahoma, my first time taking teachers there to fossil hunt. Throughout the report I had included many other photos from the field; this was, however, the only one he circled. Written next to the circle was: "*Is this really necessary?*" What set this picture apart from the others is simply that I am in it.

I had to jog quite a way from the "mound" of Whitemound in order to take a photo that would encompass the whole site and all the teachers who were there that day. I was at least 50 yards afield, taking several photos, when someone shouted that I should be in the picture too. I laughed and swung around, raising my cell phone high enough to take a selfie with everyone and the whole site in the background. If you have been fossil hunting on a giant ranch, you know that this is no easy feat.

The photo would end up memorialized as one of many things that invited criticism in my work. I think, at least in some part, it is because the tradition of professional research presupposes that the researcher be objective to the point that it is almost like they were never there at all. I grappled with this every day when I first started doing fieldwork, reluctant to embrace the fact that anthropology is not about objectivity, but rather about something like honesty. When I took this first field selfie at the suggestion of my "subjects", it started to become clear that being a participant-observer, and an effective ethnographer, means that anthropologists must recognize that we are in the picture, too. We are the filter of people's words, the sieve sorting out how to bring people's actions to life through writing, a mirror on humanity. An ethnography is a selfie.

Educational ethnography has typically been carried out in classrooms and schools around the world. This option was certainly open to me as I thought about how to do my research, and in the first months I thought Oklahoma public school classrooms would make an ideal field site. My fieldwork is odd because I made an effort to create many of the contexts in which I did it. I wrote grants and created my own programs over a three year period, thinking all the time about how I could get closer to teachers in an unstudied habitat. Before I created contexts, though, I started where any good ethnologist might start: my local museum.

In the spring of 2014 I set up a small table in the Great Hall of the Sam Noble Museum and eagerly tried to get the attention of the museum visitors strolling by. When they were nice enough to stop and talk to me, I implored them to take a short survey. I wanted to know, in general, what people like about going to natural history and science museums, and what they know in general about the things on display. In a deeper sense, I wanted to know how visitors go about absorbing information in museums and fitting into what they already know. But doing quick surveys didn't really tell me anything about that - actually, all it did was lead to more questions.

After I published that first survey (Doucette-Frederickson, 2015), I began to work very closely with science museum professionals. It had occurred to me that if I wanted to know how people use and learn from science museums, that I could either sit in the Great Hall for months, day after day, gathering tidbits of visitor culture based on highly interpretive observations; or, perhaps, I could go elsewhere in the museum to find answers to my questions. The first challenge - which would essentially look like an ethnography with museum-as-village - has barely been undertaken by anthropologists yet. The second challenge - going elsewhere in the museum to find answers - began to make the most sense for what I was trying to understand about my subjects. I went to the museum's Department of Education and got permission to set up camp in their classrooms. Eventually I got permission to do this in two local museums (one dedicated to natural history, the other to modern osteology), and began primarily doing participant observation in their classrooms and conducting interviews with educators before and after classes.

Around this same time, I started teaching at science camps in museums and other similar settings. This was serendipitous because I needed the extra work to support my academic endeavors, but the more time I spent teaching engineering and science concepts to different age groups all over the Oklahoma City area, the more I realized that the situation was almost like getting paid to do research. It was through this work that I laid the foundation for creating a vast and diverse network of STEM educators and learners throughout the state who would eventually become my subjects, collaborators, and colleagues.

I realized two things quickly: 1) I would not get IRB permission to study people while at work; and 2) the access I had to observing, participating, and interviewing was severely limited by the places I could find the people I wanted to study. For example, in trying to gain access to Oklahoma teachers through the museums, I battled my fair share of roadblocks - primarily because I had no jurisdiction over the spaces, in the sense that I was perceived to have more researcher autonomy than institutional authority. I could only hope that museum staff would allow me to visit the site and see the things I needed to see. Truthfully, the museum staff were only peripherally interested in the kinds of things I might find out from anthropological research in their space. They were there to do a particular job, and in many museums, that job does not include researching the visitors. This seems to be especially true of university museums like mine, which are organized around the goal of producing scientific scholarship related to the collections upstairs. The people who visit the first floor swirl around like smoke, always present and somehow integral to the museum's existence, but still not an important part of the gaze of the institutional Eye.

More than anything, I wanted to understand how local teachers use the museum as a resource for science and ethnology. The issue of lack of access to educators began to frustrate me quickly, as I would get a rare invitation to participant-observe in the museum classroom and during that time educators would tell me about things happening in and around their community that were of huge interest to me, most of which I could have attended in person if informed. Eventually I realized that if I wanted to observe certain events and behaviors, that I might have to pave my own road forward. So I began writing grants, meeting teachers in other contexts, working with local educational organizations, and developing curriculum. I suspect now that I did this, at least in part, to set some of my research up as a "laboratory". I would have more control over the setting. And for me, it became clear early on that studying was not going to be enough - I am an applied anthropologist, apparently. Though I did not do this intentionally, I believe it worked out for the best because it created unique spaces for me to study what I view as a moving target: the formation and preservation of science identity.

OKLAHOMA EDUCATORS EVOLVE

A brief description of each Oklahoma Educators Evolve workshop is necessary for the reader to understand the context in which I have collected most of my data. Two workshops were held in April 2016; the first was a field trip. Educators gathered at the Sam Noble Museum parking lot and traveled to Kingston, Oklahoma in a caravan of rented University of Oklahoma vehicles. We had a brief orientation session at the OU BioStation in Kingston before moving on to a local site. The site is in a riverbed (a publicly accessible waterway), which we accessed by parking near a bridge and climbing down to the bed. The site bears Cretaceous ammonoid fossils, among other specimens. We collected at the river for several hours before packing up and driving to the next site in Sulphur, Oklahoma. This site, White Mound, is well known in the state and lies on private land. The landowner allows group access with a gate and per-

person permit fee. At White Mound we collected Devonian trilobites, brachiopods, gastropods, corals, and other small specimens.

The second OKEE workshop in April 2016 was held one week after the first, at the Oklahoma City Community College Family and Continuing Education Center. It was primarily attended by those participants who had been in the field the week before, as it was geared toward showing teachers how to prepare and use the specimens they had found. Graduate students from six departments at the University of Oklahoma led sessions throughout a full day. The sessions were: *Life* (biology), *Earth* (geology), *What is Science?* (Nature of Science), and *Human Evolution*. Teachers rotated in small groups through each session, with group discussion time at lunch and after the last session.

In September 2016, teachers met early in the morning on a Saturday in the town of Bartlesville, Oklahoma. We traveled via caravan to a public collecting site north of Bartlesville, where the Oklahoma border meets Kansas. We spent half of the day along a stretch of road cuts collecting Pennsylvanian (300 million years old) bivalves, brachiopods, bryozoans, corals, and more. The second half of the day was spent back in Bartlesville at a rented hotel conference room. We spent time sorting and identifying the freshly-collected fossils before doing two large-group sessions, *Paleontology* and *What is Science?*.

On a Monday morning in October 2016, I ran a short OKEE session in Keyes, Oklahoma in the panhandle region of the state. The session was focused on showing teachers at a rural school how they can utilize local paleontology to teach concepts across all grade levels and subjects. Two extra days were spent in the panhandle exploring Black Mesa to plan for a future OKEE field trip with teachers.

Also in October 2016, a group of teachers met early on a Friday morning at the Great Salt Plains state park in Jet, Oklahoma. It was teachers' fall break, and the same workshop would be held both Friday and Saturday for different teachers. We spent part of the morning looking at Oklahoma fossils and discussing local geology. Then we spent 4-5 hours at the salt flats, which is a large open area in the park where Permian salts have evaporated out en masse. The area is popular for digging large gypsum crystals. After the collection period we gathered at the park community center to clean and inspect our finds, as well as partake in two short sessions: *Geology* and *Evolution*.

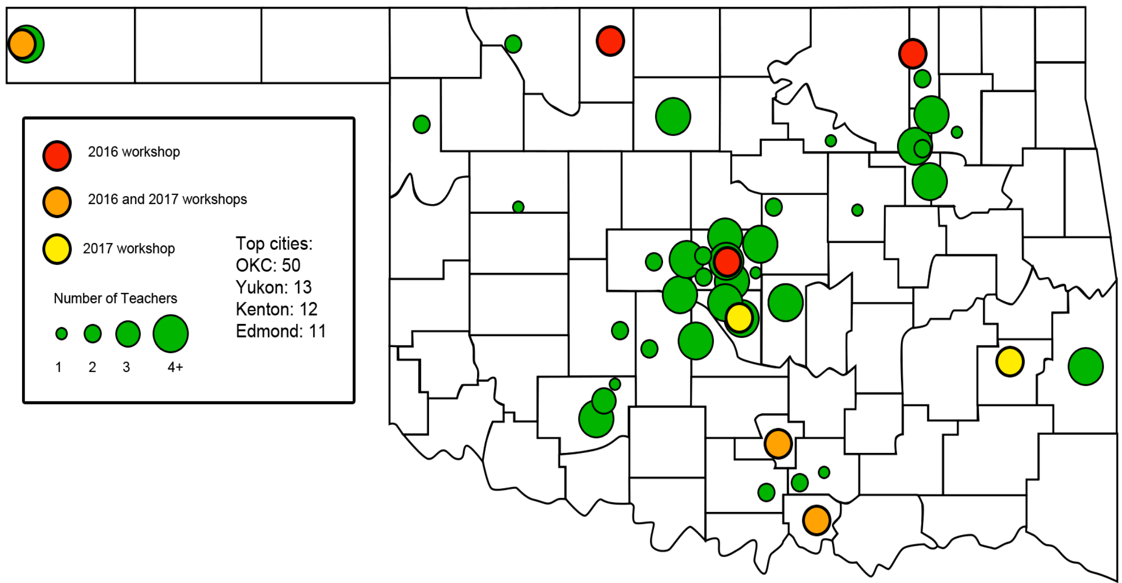
The end of 2016 was spent planning the next six months of programming. A Saturday in January 2017 was spent at the University of Oklahoma forum building, where a group of teachers met for breakfast and OKEE orientation. Teachers grouped together to work on a day-long project creating a "Shark Tank"-style pitch for a grant-funded project they wanted to apply for. We spent three hours at the Sam Noble Museum across the street gathering information and ideas as we took private tours of exhibits and collections. After lunch, the groups worked with OU graduate students to create their proposals. At the end of the day groups presented their pitches and received feedback from all participants, including staff and teachers. The best presentation was awarded with fossil casts and materials from the Prehistoric Planet™ store, in order for the winning teacher to start her new program, *"Junior*

Paleontologists". OKEE staff would also sponsor a multi-teacher grant proposal submitted in March 2017.

Teachers gathered at Robber's Cave State Park in Wilburton, Oklahoma on a warm February morning at a large rented space in the park lodge. After OKEE orientation and breakfast, teachers split into groups and followed graduate student guides on the trails of the park, exploring ecology and local geology. After lunch, the groups participated in a murder mystery, *MegaMurder: Pleistocene Megafauna Extinction*. Staff had evidence stations set up where teachers would examine photographs, materials, and fossils, as well as do short activities in order to build hypotheses for how the Pleistocene megafauna went extinct. Stations included: cave art, flintknapping, atlatl toss, stable isotopes, paleoentomology, and fire ecology.

Registration for OKEE workshops numbered approximately 450 slots. The attendance rate held consistently at or below 50%, however, and many teachers attended more than one workshop. In total, I estimate that we reached 200 Oklahoma teachers directly, and thereby perhaps 5,000 students.

Figure 1: OKEE Participant Locations



SURVEY OF SCIENCE TEACHER PERSPECTIVES

The primary dataset explored here was obtained in 2016 and 2017 via both in-person and online survey collection. The sample (n=152) is comprised of two subgroups: first, a set of Oklahoma teachers who chose to attend a professional development workshop as part of the outreach program Oklahoma Educators Evolve between April 2016 and February 2017, who took a survey in-person at the end of a workshop (n=60). Second, a national teacher sample - members of the National Science Teacher Association (NSTA) - who opted to take the same survey online via their listserv in October 2016 (n=92). These groups are comparable and appropriately representative for this study for the following reasons: 1) all of the teachers in this study have experience with primary and secondary public school science, even if their full-time job is to teach other subjects like mathematics and language arts; 2) the survey participants from both subgroups are the cream of the crop in terms of involved, engaged, and passionate teachers who go out of their way to, as one teacher put it, “choose excellence”; 3) all participants identified as having personal and/or professional interest in recently adopted academic standards (Next Generation Science Standards for the NSTA group, and Oklahoma Academic Standards for the Oklahoma group). Teachers were asked to share their level of agreement with listed statements (possible answers: Strongly Disagree, Disagree, Neutral/Not sure, Agree Strongly Agree).

Table 3: Educator Survey Questions (n=152)

A. Science and technology endeavors should be publicly funded.
B. I would prefer to do experiments rather than read about them.
C. I would like to be given a science book or piece of scientific equipment as a gift.
D. Americans do more important science than professionals from other countries.
E. I consider myself to be scientifically literate.
F. Scientists usually make bad teachers.
G. You can only call yourself a ‘scientist’ if you do professional scientific research as a job.
H. Scientists do a good job of exploring diverse perspectives.
I. Scientists need to take responsibility for teaching science to the public.
J. Money strongly influences what scientists do.
K. Scientists cannot be religious.
L. If science reveals something socially controversial, we should avoid it.
M. Thinking like a scientist is innate - a person is either born with it or not.

N. Science is objective, so it does not matter who is doing it - the answers would be the same.
O. Some cultures are better at science than others.
P. Men and women are equally good at science.
Q. A teacher inspired me to like science.
R. I chose to teach science because I think it is the most important school subject.
S. I think many of my students could excel in science careers.
T. I consider myself to be a scientist.
U. When I form an opinion, scientific evidence is the most important factor.
V. I understand the scientific peer review process.
W. Scientific knowledge is the closest thing we have to the truth.
X. I encourage all my students to pursue science careers equally.

The data were conducive to a Pearson correlation test in SPSS because I was able to code the participant responses numerically (Madrigal, 2012). The data from Q1 were exported from Survey Monkey™ and organized in Excel before being imported into SPSS. In Table 1 below, very statistically significant ($p<.001$) correlations are highlighted in red. Correlations of moderate, and a few of marginal, but interesting, significance ($p<0.05$) are highlighted in yellow. The column heads are the same statements as the corresponding rows, but have been coded A-X for simplicity's sake. Data were also statistically tested using a one-way ANOVA, controlling for source. In plain English, I wanted to test whether teachers' survey answers correlated. In other words, *if they think A, are they also more likely to think B?*

According to the data[1], there are several conclusions to be drawn about teachers. I will describe the statistically significant correlations before discussing.

If a teacher believes that science should be publicly funded, then they are less likely to believe that science should avoid socially controversial topics, and they are more likely to agree that they would like to receive a science book or equipment as a gift, that they are scientifically literate, that thinking scientifically is innate, that men and women are equally good at science, that all of their students could excel at science, that they are a scientist, that science is an important factor for decision making, and that scientific knowledge Is essentially truth.

Teachers who report that they would prefer to do experiments than read a book are more likely to report that they would enjoy getting a book or equipment as a gift, that Americans do better science than other countries, that their students could excel at science, and that they encourage all of their students equally to pursue science careers. Teachers who enjoy getting science gifts are less likely to believe that you can only call yourself a scientist if you get paid to do it, and they are more likely to see themselves as scientifically literate. Those same teachers also report that scientists need to take responsibility for teaching the public, that money strongly influences scientists' work, and that men and women are equally good at science.

Teachers who believe that America does more important science than other countries are less likely to believe that they are scientifically literate, and that money

[1] APPENDIX A

influences science strongly. Conversely, they are more likely to believe that science should avoid controversial topics.

Teachers who consider themselves scientifically literate are less likely to believe that science should avoid socially controversial topics, that scientific thinking is an innate trait, and that some cultures are better at science than others. They are more likely to believe that scientists need to teach science to the public, that money strongly influences science, that science is objective, that men and women are equally good at science, that many of their students would be good at science careers, that scientific evidence is an important factor for making decisions, that science is the closest thing we have to the truth, and that they encourage all of their students equally in pursuing science careers. Considering oneself to be scientifically literate also correlates with considering oneself to be a scientist, and understanding the process of peer review.

Teachers who believe that scientists make bad teachers are less likely to believe that scientists do a good job of exploring diverse perspectives, and are more likely to believe that scientists cannot be religious.

Teachers who report that a person can only be called a scientist if they do professional scientific research are less likely to believe that scientists need to talk more with the public, and that money strongly influences scientists.

If teachers believe that scientists do a good job of exploring diverse perspectives, then they are more likely to report that a teacher inspired them to do science and that they encourage all of their students equally to pursue science careers.

Teachers who think scientists need to do a better job of educating the public are less likely to believe that science should avoid controversial topics. Conversely, they are more likely to believe that money strongly influences scientists, that men and women can do science equally well, that science is the most important school subject, that they are a scientist, that science is important for decision-making, that they understand peer review, that science is the closest thing we have to the truth, and that they encourage all their students equally.

If teachers believe that money strongly influences science, then they are more likely to believe that science is the most important school subject, that they are scientists, that they understand peer review, that scientific knowledge is the closest thing we have to the truth, and that they encourage all of their students to pursue science careers equally.

Teachers who believe that scientists cannot be religious are more likely to think that science should avoid controversial issues, and that some cultures are better than others at science.

Teachers who report that science should avoid controversial topics are less likely to believe that men and women are equally good at science, that many of their students could make great scientists, that they themselves are scientists, that scientific evidence is the most important factor for forming opinions, that they understand the peer review process, and that scientific knowledge is the closest thing we have to the truth.

Teachers who feel science should avoid controversial topics are more likely to believe that thinking like a scientist is an innate trait, and that some cultures are better at science than others.

If teachers think that science in an innate trait, then they are less likely to believe that men and women can do science equally, that science is the most important factor for making any decision, and that they understand the peer review process.

Teachers who think that science is objective are more likely to believe that they themselves are scientists, that science is the most important factor for decision-making, that they understand the peer review process, that science is the closest thing to the truth, and that they encourage all of their students to pursue science careers.

Teachers who believe that some cultures are better at science than others are less likely to believe that men and women are equally good at science, and that many of their students could excel at science.

Teachers who believe that men and women are equally good at science are more likely to believe that science is the most important subject in school, that many of my students could excel at science careers, that science is the most important factor for decision-making, that they understand peer-review, that scientific knowledge is the closest thing to the truth, and that they encourage all of their students to do science; they are also more likely to consider themselves to be a scientist.

Teachers who report that a teacher inspired them to like science are more likely to believe that science is the most important subject in school, that many of their students could excel at science careers, that science is the most important factor for decision-making, that scientific knowledge is the closest thing to the truth, and that they encourage all of their students to do science; those teachers are also more likely to consider themselves to be scientists, and to understand the peer review process.

If teachers think that science is the most important school subject, then they are more likely to believe that many of their students could excel at science careers, that science is the most important factor for decision-making, that scientific knowledge is the closest thing to the truth, and that they encourage all of their students to think about science careers. Those teachers are also more likely to consider themselves to be scientists, and to understand the peer review process.

Teachers who feel that many of their students could excel at science are more likely to believe that science is the most important factor for decision-making, that scientific knowledge is the closest thing to the truth, and that they encourage all of their students to do science. Those teachers are also more likely to believe that they understand the peer review process, and identify themselves as scientists.

If teachers identify themselves as scientists, then they are more likely to believe that science is the most important factor for decision-making, and that scientific knowledge is the closest thing to the truth. They also report equally encouraging all of their students to do science, and that they understand peer review.

Teachers who believe that scientific evidence is the most important factor for decision-making are more likely to report that they understand peer-review, that scientific knowledge is the closest thing to the truth, and that they encourage all of their students to pursue science.

Teachers who report that they understand peer-review *are **more** likely to believe that* scientific knowledge is the closest thing to the truth, and that they encourage all of their students to do science.

If teachers believe that scientific knowledge is the closest thing to the truth, then they are more likely to believe that they encourage all of their students to do science.

Discussion

Some themes and patterns are visible in the data and become clearer with description. First, perhaps being a scientist is a profession that is fundamentally different from education. Teachers whom we may describe as scientifically enthusiastic, such as those who enjoy receiving scientific books or equipment, do not believe the label “scientist” is reserved for those who do science professionally and believe they are more scientifically literate than those who do not enjoy such gifts. Identifying as a scientist correlates with more positive opinions of science and science education.

Teachers who are less likely to avoid controversial topics also believe America is not better at science, science is not innate, and that all cultures are capable of doing science. Teachers who believe they are more scientifically literate are less likely to believe science is innate or that some cultures are better at science than others.

Teachers who believe in the public funding of science also do not believe controversial scientific topics should be avoided, and think that that science is the closest thing we have to the truth. Teachers who believe they are scientifically literate also believe money is a driving force in science.

EMOTION DATA

Beyond the agreement questions, I also wanted to know how certain situations might inspire emotions like anxiety or frustration in teachers. I presented teachers with scenarios, which are drawn from previous, intriguing conversations with educators in various contexts. The survey also presented teachers with four "emotion" options: 1) Positive, excited, happy; 2) Frustrated, uncomfortable, overwhelmed, annoyed; 3) Anxious; and 4) Neutral or calm. Teachers were able to choose as many of those feelings as necessary, and also indicated whether the scenario had happened to them (numbers do not add up to 100%).

Table 4: Emotion Data (n=152)

	Excited, Happy, Positive	Frustrated, uncomfortable, overwhelmed, annoyed	Neutral or calm	Anxious	This has happened to me
A student asks you a science question to which you do not know the answer.	62.76% 91	8.97% 13	39.31% 57	8.97% 13	72.41% 105
A student asks you how to pursue a career in science.	90.97% 131	1.39% 2	18.06% 26	2.78% 4	52.78% 76
You are speaking with parents who disapprove of the science curriculum.	4.20% 6	35.66% 51	55.24% 79	26.57% 38	35.66% 51
During a unit on geology, a student insists that crystals, rocks, and fossils can hold certain powers or energy.	6.21% 9	18.62% 27	77.24% 112	4.14% 6	19.31% 28
A new science article comes out that does not agree with what you have previously taught your students about a subject.	38.19% 55	9.03% 13	54.17% 78	11.81% 17	38.89% 56
A student asks what you think about anthropogenic climate change.	48.28% 70	12.41% 18	48.97% 71	7.59% 11	42.07% 61
You are teaching a newly developed science unit.	65.52% 95	17.93% 26	19.31% 28	33.79% 49	55.86% 81
A student questions your religious beliefs.	13.19% 19	12.50% 18	79.17% 114	5.56% 8	54.86% 79
A student says scientists are atheists.	5.56% 8	24.31% 35	73.61% 106	4.17% 6	37.50% 54
A colleague asks your opinion on a recent science story in the news.	66.43% 95	2.80% 4	39.16% 56	2.80% 4	48.95% 70
You have taken your class on a trip to the museum and a student asks a science-related question to which you to not know the answer.	57.04% 81	5.63% 8	47.89% 68	4.23% 6	34.51% 49
An administrator or colleague discourages you from saying the word “evolution”.	7.04% 10	61.97% 88	32.39% 46	14.08% 20	13.38% 19
You disagree with something in your students’ science textbook.	13.99% 20	29.37% 42	55.94% 80	8.39% 12	35.66% 51

A student asks you a History of Science-related question.	65.96% 93	2.13% 3	37.59% 53	4.26% 6	41.13% 58
Another science teacher at your school tells you they don't believe in evolution.	9.22% 13	48.23% 68	48.94% 69	13.48% 19	21.99% 31
A student tells you they don't believe in evolution.	12.06% 17	19.15% 27	75.89% 107	6.38% 9	48.23% 68
You are asked to briefly explain the Nature of Science to your students.	63.64% 91	9.79% 14	34.97% 50	7.69% 11	40.56% 58

DESCRIPTION OF FINDINGS

Teachers are made most anxious when confronted by disapproving parents, and teaching a newly developed science unit. They also report some anxiety in situations involving administrators and colleagues saying that they do not believe in evolution or that they should not use the word "evolution", though this does not happen nearly as often as I had expected.

Teachers primarily feel excited and positive when they are asked a question (by a student) to which they do not know the answer.

Teachers remain calm when faced with parents who disapprove of the science curriculum, when a student makes pseudoscientific claims, when they are asked for an opinion about relevant issues in science, when they disagree with something in the textbook, when a student says they do not believe in evolution, and when a student says scientists are atheists.

Teachers become more uncomfortable or frustrated with adults and colleagues who say they don't believe in evolution, than they do with students who say the same.

Teachers are happy and comfortable when talking about the History or Nature of Science; students challenge them with questions to which they do not know the answers; students ask how to pursue careers in science; colleagues as their opinion on science-related news; students ask their opinion on anthropogenic climate change; and when teaching a newly developed science unit. The last one is interesting because teachers also report being anxious when teaching new units.

Only 13.38% of teacher reported that a colleague or administrator discouraged them from saying the word "evolution".

OKLAHOMA VERSUS THE UNITED STATES

There are interesting differences between Oklahoma teachers and teachers from the greater United States. In the National sample (n=92), teachers were more likely to agree with the following statements than Oklahoma teachers (n=60):

- Science and technology endeavors should be publicly funded;
- I consider myself to be a scientist;
- Scientists need to take responsibility for teaching science to the public;
- Money strongly influences what scientists do;
- I chose to teach science because it is the most important school topic;
- I think many of my students could excel at science careers;

- I consider myself to be scientifically literate;
- Men and women are equally good at science;
- When I form an opinion, scientific evidence is the most important factor;
- I understand the scientific peer review process; and
- Scientific knowledge is the closest thing we have to the truth.

In comparing the National sample to Oklahoma teachers for the survey questions aimed at reporting emotion, Oklahoma teachers are generally *less* comfortable with getting questions from both students and peers about science to which they do not know the answer; they are also less comfortable with questions about anthropogenic climate change, as well as finding textbook contents with which they do not agree, and being asked to discuss the Nature or History of Science.

Teachers from the National sample reported a higher occurrence of students asking how to pursue careers in science; speaking with parents who disapprove of the science curriculum; being questioned about their religion; disagreeing with a science textbook; being asked to talk about History and Nature of science issues; and having a colleague ask their opinion about science in the news. Oklahoma teachers experience both teachers and students telling them they don't believe in evolution than do teachers from the National sample.

Comparing National Science Teacher Association (NSTA) members' survey results with Oklahoma teachers' results proved interesting. I am most concerned with helping Oklahoma teachers to become more scientifically literate, to learn about the

Nature of Science and peer review, and to think more broadly about how public funding affects their livelihood as science teachers. The surveys reveal areas where Oklahoma teachers need to work on their level of confidence.

CHAPTER III: SCIENCE IDENTITY

PRIDE AND PRESSURE: CONCEPTUALIZING IDENTITY

In this dissertation I have chosen to use the word "identity" to describe a person's cultural and personal perception of individuality. Anthropology has a rambunctious history of arguing over individual human distinctiveness and how it ought to be framed, and for good reason. "Identity" is sometimes understood to mean parameters assigned to a person by external forces and cultural constructions, and this has been recognized as problematic in anthropology for some time. For example, the blanket identity terms "Native American" or "American Indian" have been thrust upon incredibly diverse indigenous groups in North America for hundreds of years, when they are a colonizer's categories.

In anthropology, we have begun using terms like *subjectivity* and *ontology* to mean 'identity' from the point of view of the individual in question (Biehl, Byron, and Kleinman, 2007; Heywood 2012; Holbraad, Pedersen, and de Castro, 2014). Subjectivities exist in the mind and through the view of the individual, and the term is frequently used by linguistic anthropologists in some form or another. Ontologies are a loftier thing, concepts of the nature of being, and how or what things essentially *are*. The term "ontology" is used more frequently in the vocabulary of computer science or philosophy, and though this might seem a strange adoption for the anthropologist, the metamorphosis of a phrase from science to the humanities and into our discipline is actually quite common (think of words like theory, evolution, relativity, and entanglement). In any case, I am choosing to use the word "identity" in this work for the sake of common vernacular and clarity.

One could certainly make the argument that studying teachers falls under the scholarly realm of "occupational identity" (Beijaard, Meijer, and Verloop, 2004; Hargreaves, 1980; MacLure, 1993). However, being a teacher says quite a bit about identity beyond the parameters of the job, especially as the individuals in question invest more time, energy, and personal resources into the job over years of work. Being a *science* teacher, in particular, creates an interesting space for exploring intersectional identity.

Identity is both a pride and a pressure; it can be the cause for connection between individuals, and a source of stress. Identity can single you out and make you belong, all at the same time. It is both fixed and fluid; it is personal and impersonal.

As far as anthropology goes, identity is just as nebulous as anything else we can spy through our metaphorical microscope; as one scholar has written, "it appears that there are no dominant definitions, theories, or rules about identity in anthropology" (Reedy-Maschner, 2010:24). This work probably does not look like an ethnography of cultural identity as anthropologists have traditionally written. Teachers are not a discrete cultural community connected by shared race, ethnicity, sex, religion, gender, or geography; rather, they are an imagined community, as envisioned by Benedict Anderson (1983, 1991, 2006). Though Anderson used the concept to explore nationalism as a phenomenon, I employ the term here to reference the existence of teachers as a group of people with shared goals, practices, behaviors, and beliefs. Their status is both institutional and symbolic (Geertz, 1973).

I have parsed ethnographic data into several categories: racial identity, class, religious identity, and gender. These categories are arbitrary and have been purposely selected and labeled as continuous, but somewhat separate, concepts.

RACIAL IDENTITY AND REPRESENTATION: SCIENCE IN THE MARGINS

I drove past the sign for Okfuskee County just as the sun rose to the spot where it's too high to ignore, but too low to block with the car visor. Locals call this "Ohfuckme" county. Pulling up to the old high school, an actual rooster crow scratches my ears. There are long swaths of grass and plants patterned over it, but a faded Boley Bears sign still stands in front of the brick building. It hasn't held a class since 2008. I parked my truck on the grassy shoulder of the road and watched my rearview mirror, waiting for another anthropologist to drive up. With my calendar on my lap, my mind drifted between the plans for the day and this same day one year before. It was the second summer my partner and I would offer a STEAM (Science, Technology, Engineering, Arts, Mathematics) camp in this town.

I checked the time on my phone – 7:22 am – and looked at each of the faces on my wallpaper photo. It was taken at this same camp last year, during a *star party. The dozen or so kids in the picture, surrounding me and grinning, had just peered into a NASA-grade telescope for the first time, and were excitedly discussing what they saw: the Milky Way, a binary star system, and even Saturn's rings, all as clearly as if they were just a few feet away. The kids' expressions in the photo on my phone screen were ones of pure, unadulterated fun, and I couldn't wait to see them again.*

In cultural anthropology, using "race" as a category for cultural distinctions is problematic because it is a social construction, rather than a biological one. But race as a category holds deep meaning, and the meaning people assign to it is at the root of issues I saw in the field. These include inequity, segregation, discrimination, and issues of representation. The primary place that these issues became obvious in the field research were in Boley, Oklahoma at STEAM (science, technology, engineering, art, mathematics) camps held there during the summers of 2015 and 2016. Systemic and systematic racism in Oklahoma have managed to create racial histories and geographies that played a large role in much of my science learning fieldwork. I am including a section on race in this dissertation because it was such a prominent factor while planning and executing camps.

Our first STEAM camp was held the hottest week of 2015, at the beginning of August. Our university had awarded us a grant of $10,000 to bring the children of Boley an exceptional science camp experience. Boley is a small, historic all-black town near Oklahoma City that was founded by Creek Freedmen at the end of the 19th century. It was a thriving town from about the turn of the 20th century until the late 1920s. Boley now has a much smaller population than it did during its heyday, and many businesses that once flourished in the area have since moved to other areas. There are many fascinating aspects about Boley, but most importantly for this project, it is a town with no public education. Its school district was annexed in 2008, and the school-aged children of Boley now travel to Paden, Prague, and other surrounding towns for public school instruction. This desegregation of schools is a double-edged sword, in that the schools the children now attend receive more funding and often have smaller class sizes and more extracurricular options; however, children from an historic sundown town (Loewen, 2005) are now attending school with the children of white individuals who perhaps purposely chose a school away from Boley for their children in order to avoid inclusion of students of color in their children's lives.

Though there are some community spaces in Boley (namely a Senior Center and the Well Springs Community Service building), there are no libraries, schools, or other public educational outlets. The STEAM Camp project has been an effort to bring a free, engaging, and robust learning opportunity to the youth of Boley during the summer, when school is not in session and many children are left without educational options.

The Boley STEAM Camp project was an attempt to gain insight into how informal education opportunities can provide a stronger sense of science identity and confidence in participants, both students and teachers. Informal educators have invaluable insight to share regarding science education and STEAM learning.

In 2016, after the first Boley STEAM camp had been completed, Columbia University professor Christopher Emdin published an important book that would cause me to think more deeply about race and science education in the context of one of Oklahoma's historic all-black towns (*For White Folks Who Teach in the Hood…and the Rest of Y'all Too: Reality Pedagogy and Urban Education)*. In the social sciences and humanities, compulsory science education has been viewed as racist in the sense of marginalizing a student's existing way of thinking in order to make room for science (Hodson, 1993; Emdin, 2016). To pretend that this marginalization is a myth is to perpetuate white supremacist notions of what students ought to know, and how they ought to think. Emdin (2016) presents the concept of *neoindigeneity*, wherein youth of color are made to conform to the subculture of science as an act of their continued colonization. In his work, Emdin points out how traditional science education does not make room for "sharing the mic" and co-constructing discussions. The first step necessary for people to begin co-constructing and engaging in meaningful science learning is to determine that they are, in fact, a part of that world and subculture which they are trying to learn.

Issues of racial representation in both teaching and science have emerged as incredibly important aspects of the fieldwork I have engaged in, especially at STEAM camps. No matter what the intentions and preparation of the teacher, making sure that children and teens feel comfortable with science is affected by differences in teachers' and students' membership in groups of cultural dominance (Ehrenberg, 1995; Hirschfeld, 1995; Dee, 2005; Pacas, 2011). Ethnic Matching, as this concept is called (White, 2014), is a central issue of many educational initiatives and sites (see Noguera, 2009; Delpit, 2012; Ravitch, 2013), and certainly shaped the Boley STEAM Camp.

Ethnic Matching and Stereotype Threat

Perhaps a teacher has come into the teaching profession because it is a chance to save children whose only way forward is education; she stays a teacher because the children need her. A white teacher knows she must produce students who can perform, behave, and perhaps even succeed – regardless of color. She knows their world is different from hers, and yet in so many ways, it is also the same. Her disadvantages were walls to climb, and if she can teach her students of color that their disadvantages are too, then they will climb right past their excuses. Believing this is a sign of educator benevolence. But it is really a benevolent oppression.

Modern works on educational history and policy serve as excellent guides to how racism works in modern schools, especially under the guise of "cultural conflict". Lisa Delpit is has masterfully laid out the history of racist educational policy and modern installations of race ideology in schools (1995; 2012), focusing in recent years on the rise of the charter school and organizations such as Teach for America and

TeachNOLA who have usurped veteran teachers of color with inexperienced, mostly white teachers in classrooms that are predominantly inhabited by poor children of color (2012:112). Along this same vein, the work of former US Assistant Secretary of Education, Diane Ravitch, is insightful because Ravitch served the Bush administration and was an early champion of standardized testing. Now, however, she fights against corporately-influenced, racially-based educational policy that has led to the school privatization movement (2010; 2013). Other scholars (Nieto, 2002; Ayers, 2008; Walker-Tileston and Darling, 2008; Kozol, 2012) have voiced their concerns about the misunderstanding of "culture" among school professionals (teachers and administrators, among others), and called for a critical examination of teacher training and preparation for working with children who do not belong to their perceived racial (now called "cultural") group (Delpit, 2005). Anthropology and its history offers some insights of how to move forward.

A brief history of race, anthropology, and education

> *"This 'old white people' business does get a little tired…go back through history and figure out, where are these contributions that have been made by these other categories of people that you're talking about, where did any other subgroup of people contribute more to civilization?"*
>
> *– Representative Steve King (R-Iowa), on national television in 2016.*[iv]

Anthropology has a complex relationship and history with racial issues in education. In 1869, Sir Francis Galton asked his readers: “How much of a man's success is due to his opportunities, how much to his natural power of intellect?” (1869:37). Concepts of success, intelligence, and education are tied together in conventional American discourses, and there is a long-standing divide between those who believe that human “intelligence” is innate and heritable, and those who think that educational opportunities are what determine “intelligence”. The difference between these ideologies is crucial to understanding how education is perceived, discussed, and funded in American public life. Even within the past decade, some scholars have still been looking for a biological link between race and intelligence as a way to avoid discussing deeply embedded social inequalities in the education system.

In 1966, a team of Johns Hopkins researchers headed by sociologist James Coleman produced a government-commissioned document called the “*Equality of Educational Opportunity*.” This report asserted: “The evidence revealed that within broad geographic regions, for each racial and ethnic group, the physical and economic resources going into a school had very little relationship to the achievements coming out of it…”. Having been created to determine how the federal government should shape its public policy, the Coleman Report was then used as a source of evidence for later racist assertions in educational policy and practice.

In 1973, differential psychologist Arthur Jensen published a work of such assertion called *Educational Differences* that sought to define the relationship between race and intelligence. This book was a follow-up to his explosive 1969 article on raising IQ (Jensen 1969), which asserted that programs designed to correct for a history of racial inequalities and help bolster scholastic achievement among minorities are essentially pointless, as differences in intelligence are inherited, and inheritance is determined by race. His ideas were coined as *Jensenism*: "The theory that an individual's IQ is largely due to heredity, including racial heritage" (Brace, 2005:245). Perhaps this theory was part of a larger trend towards explaining the lack of achievement in lower classes of Americans, following such work as *The Culture of Poverty* (Lewis, 1966). It is important to note that Jensen and others, including psychologist J. Philippe Rushton, were able to conduct lifelong careers in racially driven research due to the generosity of the Pioneer Fund, an establishment founded by Nazi sympathizers whose aim "was to promote status of 'white persons who settled from the original thirteen colonies prior to the adoption of the Constitution…' and to support research on 'race betterment with special reference to the people of the United States'" (Brace, 2005:240).

In 1994, a book called *The Bell Curve* (Herrnstein and Murray) came out that would prove to simply be a recrudescence of Jensenism, scientific racism, and psychometrics. There was a hailstorm response to this work among researchers (Fraser, 1995; Devlin, 1997). Herrnstein and Murray depend greatly on the work of J. Philippe Rushton in their book, misusing life history theory and other outdated ideas from biology and psychology to explain perceived racial differences in intelligence tests and other behaviors such as criminality and sexuality. The book was well received among conservative crowds, despite the more than half-century of research before it that should have prevented its existence, starting with Otto Klineberg's 1935 *Race Differences*, through the work of Brace (1971) and Armelagos (1995), among many others.

The Bell Curve is a paradise of racist ideologies, wherein the differences of the present are not based on a historically particular account of systemic inequality and disenfranchisement, but rather on an in-the-moment snapshot of quantitative information. It reads much like the work of the old British school of anthropology, which did not use a culturally relative approach to understanding differences among people. We may consider *The Bell Curve* to be a thinly veiled quasquicentennial celebration of Francis Galton's *Hereditary Genius*. To summarize the basic assertions found in *The Bell Curve*, a passage from Fish's (2002) volume will suffice. The volume was written as "a response to these beliefs: 'Human intelligence is an important form of behavior that can be measured by IQ tests…there are racial differences in intelligence…Because racial differences in intelligence are genetically based, not much can be done to change them; and it is pointless, if not counterproductive, to waste money on social policies that attempt to do so.'"

Anthropologists would pay special attention to dismantling the claims and "evidence" of *The Bell Curve* over the decade or two after its publication. Much of this literature uses biologically based arguments to refute the book. For example, Brace (1999) systematically examines hallmarks of human intelligence: language, technology, and culture; and explains variations from region to region in the archaeological record, noting that culture is a useful adaptation to an ecological niche and therefore evolved everywhere (1999:258). In other words, there is no single group of humans that is innately more intelligent than any other.

Selections from Montagu's (1999) volume *Race and IQ* spend considerable time examining the genetic underpinnings of intelligence. For example, Jensen's assertion that 80% of intelligence is genetically determined, as well as its treatment by Bronfenbrenner (1972), are reexamined, concluding that "contrary to Jensen's contention, a high heritability coefficient for a particular ability or trait cannot be taken as evidence that the ability or trait in question cannot be substantially enhanced through environmental intervention" (Montagu, 1999:178). In the same volume, Montagu points out that the argument over how to interpret the findings of difference between races has never been about examining how we measure actual intelligence, but rather justifying socially constructed values of worth and merit that are based on racist ideologies (1999:194).

Educational racism has evolved from a public legal issue to a deadly virus that seems impossible for some people to see. For example, public schools are no longer segregated *per se*, but "white flight", funding disparities, and other issues are clear indicators that racism is alive and well in American schools (Irons, 2002).

Perhaps the most important concept to examine in the modern educational discourse is *culture*. Taking an observation from the work of Ladson-Billings (2006), it is necessary to point out how the word “culture” is retrofitted or appropriated in conversations about race and education in order to create a way for teachers, policy makers, politicians, and others to talk about race, inequality, and difference without actually labeling such difference as “race”. For example, a teacher may say that they have difficulty with students who have a different “culture” from their own, when they are actually referring to a student’s perceived racial category. Washburn cautioned against this sixty years ago: “Some writers have tried to settle racial problems by substituting another word…after all, words are only symbols…The danger is that changing words may appear to solve problems, when it only obscures the fact that we are doing the same things as before” (Washburn, 1944:73).

CLASS

Twenty miles past Boley, Clearview is one of Oklahoma’s historic all-black towns. Forty-nine people live there. The air was thick and full of mosquitos as I stepped out of my car in front of the largest building in town on an August evening, just a few days after the annual STEAM camp.

The air conditioning in the Clearview town hall was better than I expected, but I still tugged at my cardigan and tried to discreetly fan my neck and face. My STEAM camp partner and anthropologist colleague, Suzette, sat serenely next to me. The city council meeting hadn’t been going for ten minutes before the pleasantries had melted away, revealing anxiety among the council.

"We hear good things about the STEAM camp y'all did," a woman, clearly in charge of the council, smiled hesitantly at me. "Yes. We just finished our second STEAM summer camp over in Boley…"

"Now why Boley?" someone interrupted.

Clearview was different from the other towns and their councils and women in charge that Suzette and I had visited to talk about STEAM camps. The typical response to our spiel about the tiny black town with no public educational outlets usually ranges from mild interest and positive reception, all the way to tear-filled Anglo eyes. Very few people of influence in Oklahoma seem to know anything about Boley, save perhaps its famous rodeo, and they usually react to hearing about it as if they had just peered into a 17th-century cabinet of curiosities. "*In Okahoma?! I had no idea!*" they exclaim. But Clearview is much smaller even than Boley, and more than half its population lives below the poverty line. But a hundred years ago, Clearview had a school, hotel, print shop, post office, and of course a small selection of churches. It was a little boomtown along the Fort Smith and Western Railroad; and its story changes, like Boley, during the Depression. Prosperity there came to a halt, residents left, and with them went capital and opportunities. To Clearview, perhaps Boley could be viewed like a more fortunate counterpart - though to be honest, I did not get the chance to ask anyone in the town whether this hunch holds any truth. I felt only that I could see it written on their faces.

“Boley was chosen for several reasons,” Suzette said carefully, glancing at me ever so slightly. “I did much of my graduate work there and know a lot of people in the community. Janessa, too - she and I are from the same department. Our department has ties to the town.”

“I see, I see.” People began looking away, dissatisfied with this explanation. “But -” I blurted, “they wanted us to come, too.” I looked at my hands for a second, then smiled awkwardly at the council. Gracefully as ever, Suzette measuredly picked up the pieces of my eagerness to please and to be accepted. “That’s correct. The mayor and I - Doctor Shelton, the current mayor - the mayor and I had several conversations about the possibility of something like a camp, and then there came an opportunity to get a grant. At that point it made sense. Now -” Suzette straightened up and an inquisitive look fell across her face - “would you all be interested in something like that? A camp?”

“What do y’all do?” someone else asked patiently. Suzette turned to me. “I will let Janessa take this one - she is in charge of the camps and curriculum.” My awkward, nervous smile returned as I dove into my tried-and-true description of What We Do At Camp. The room became, I thought, more relaxed as Suzette showed the council and townspeople photos of our Boley camps and I described what we had done. But very quickly the conversation took a step toward the obvious - public schools.

A councilwoman told us that the state had cut 10% of funding to their district in the past year. The council murmured a list of all the things that money used to pay for. “The teacher shortage is *real*,” she looked me straight in the eyes. An older man joined in, telling us that the local schools need teachers so badly, that they are asking most any adult in the area to volunteer as a substitute. “*Do you know anyone?*” Moments like these test my resolve to insist on STEAM camps. And were I less stubborn, I might actually fall for that feeling that conservative bystanders instill in me: *why should we have science camps if we don’t even have regular science classes?* I sat in contemplation for a few moments while Suzette wrapped up our presentation and Q&A with the council. Then it was someone else’s turn to talk.

A tall man with tanned and wrinkled skin to match his leather jacket stood up and smiled at everyone. Perhaps I imagined it, but I felt the room shrink back at his presence. A badge gleamed at his chest; his belt was heavy with a thick black holster and handgun, hand-held radio, and cell phone. He peered out at us from under a black leather cowboy hat.

“Good ev’nin’, y’all,” his voice was viscous like syrup. “I’m here onaccounta the sheriff’s office. You know ‘lections are comin’ up soon. We want ta bring somethin’ new to the area that will bring some jobs, bring some opportunities ‘bout.” He approached a poster board propped up on a table near me, turning it around to reveal illustrated architectural plans. I noticed he was wearing a blue wristband with the words *Police Lives Matter*.

"We are askin', to please vote *yes* to a sales tax hike that's gonna build us a new Okfuskee County Jail." He went on to explain how the existing jail has 35 beds, but nearly 100 inmates at any given time. "There is so much crime in the county - we can't keep up."

The man offered some answers to the council's questions, noting that sales tax in the area would go from about 9% to 10%. He noted that the county had to spend tens of thousands of dollars in 2015 alone on courthouse repairs related to things that happened at the jail. He told the room, quite soberly, how much the county needed the jobs that would assuredly be created by building the new jail. After a few more moments on his soapbox, the man thanked the council for their time and left. Soon after the meeting was adjourned.

Just a few weeks later, I saw an article online titled "*Voters say YES to new jail*", linked to the Okemah News Leader website.

CLASS AND SCIENCE ENGAGEMENT

Imagine for a moment you are a 12-year-old Oklahoma boy, with sun-bleached blonde hair matted to your forehead and large freckles sprinkled over your nose. Your hands are rough and strong, but are not as thick and calloused as your feet, which even bare are as tough and protective as a pair of shoes - though you only go barefoot when your cowboy boots are heavy with mud and manure from the pasture. It is summertime, but you are up at dawn. You heard the screen door close, though your mom and step-dad tried to leave quietly to get to work while it was still dark outside. Today you will wear your better jeans (the ones with less rips), and a faded t-shirt (the one with less paint stains). You wake your little brother and make sure he is dressed and ready to go. You each take a long swig of fresh milk out of the bottle in the fridge before stepping out into the crisp morning air, a two-mile walk ahead of you. Today you are going to camp.

By the time you reach Pecan Street, where a small row of buildings comprises your town, you are starting to feel the day's heat settling in. Pecan Street is paved, too, so you can smell the asphalt and rubber heating up that you couldn't smell within a mile of your house. Approaching the tiny community building where you spend all your afternoons helping the Mayor and making sure your brother finishes his homework, you spot a few vehicles that do not belong to anyone you know in town. *People from the University*. You hope they are from OSU and not OU - OSU is where your uncle went to college, and you've always liked the orange more than the crimson and cream.

"Mornin'!" you greet a pale, pudgy woman who looks about 25 or 30, building a precarious pile of things from her car to take into the community center. You and your brother run over to help, and she is happy to meet you, already sweating and tired. The things you carry into the community center look interesting: containers full of art supplies, stacks of colored paper, a big bag of round plastic petri dishes. "Careful with this one," the lady instructs you, handing over a big box containing clunky old microscopes. After that, you carry in a stack of LEGO brick kits, a big jug of vinegar, and three tubs of what looks like junk. Now you are really intrigued. More kids from town start to show up and help unload the unknown vehicles of half a dozen strange adults.

The adults have brought food, too - stuff they don't sell at Mr. Bud's store across the street. You crunch your teeth into a shiny red apple and turn your attention to the first lady you talked to, who has now gathered the strangers into a group at the front of the stuffy room you are sitting in.

"Good morning!" she declares, "Welcome to STEAM camp. We will spend the next week exploring Science, Technology, Engineering, Art, and Math. How many of y'all like science?" Like most of the other kids, you don't raise your hand; by the end of the week, though, you would.

Imagine catching a glimpse of some of the STEAM lady's many packets of papers scattered around the community center's break room, where you have earned the title of Kid Who Knows How To Make Coffee And Is Happy To Do So. One of the papers, covered in the lady's scribbles and some printed paragraphs, reads:

> *Pew Research (2005) shows that evolution is accepted by about half the population of the United States, despite acceptance by the scientific community. This correlates with a low education level (Lac & Himelfarb, 2010) and fundamentalist religious beliefs (Miller & Okamoto, 2006).* - Fairchild, 2012

Billy, the young man from this imagination exercise, is a real middle schooler living two hours east of Oklahoma City. He rides the school bus for 50 minutes each morning and each afternoon from August through May. This is one reason he knows how to make coffee. He has to drink it every day in order to stay awake and alert at school, as well as finish his homework late into the night.

Imagine being Billy and coming across the STEAM lady's papers that say you, a young but devout Christian kid, must disbelieve evolution because of your "low education level" and "fundamentalist religious beliefs". Like him, you would likely feel betrayed and insulted, and either disengage with the strangers, or resist them. We owe Billy more than this.

Rural children do not enjoy the same access and approaches to science education as suburban and well-off urban children do; they are often written off altogether as the next possible great minds of science (Oliver, 2007; Avery, 2013). Furthermore, youth of color and poor youth are offered less personalized and hands-on experiences because of teacher presumptions about poverty, violence, and disengagement (Emdin 2016:39). Being rural and poor can be a detrimental enough combination for a child hoping to go into a STEM career; add the large helping of racism that Oklahoma's black farm-town youth experience, and you have a recipe for an irreparably negative science identity.

RELIGIOUS IDENTITY

My first panhandle thunderstorm approached slowly all afternoon, and then began its crescendo over the Black Mesa B&B quite suddenly. Safe inside my cabin, I *watched sheets of rain crash past the screen door. Maybe it will wash the bugs off the car, I wondered, tucking away the mild anxiety that the university might charge me extra if I returned a rental vehicle to them with slaughtered insects all over the hood, the unfortunate casualties of fieldwork.*

The smell of the rain washing the ancient hills of another layer of sediment soothed my headache. I had risen early that morning to pack the car and spend a few precious moments on the Internet while I still had spotty motel Wi-Fi. Examining my map of Cimarron County as I tied on my hiking shoes, I went through a mental checklist of what to do all day. I would head west on road 325 out of town until I found the turnoff for Black Mesa State Park, some 25 miles away. After that – *just follow the signs*, I supposed.

I stopped at a truck stop for snacks, coffee, and – at the very last second – an OU hat to keep the sun out of my eyes. I was pleasantly surprised to see it on a shelf, since OU was over 300 miles away.

Road 325 is a wide-open road that would inspire most people to drive as fast as they could, but I still traveled 50 miles an hour, listening to a country song fumbling through thick static on the radio. A giant grin spread across my face as I turned slowly off the main road when I saw the first sign for the park. In the road just ahead of me, something dark was on the pavement. *A tarantula!* I couldn't believe it – it was just sauntering across the road. A few moments later, I passed another; then three or four more as I drove up to the Black Mesa State Park entrance. I vowed to stop and get a photo of one on my way back to 325.

Lugging a gallon of water with me, I hiked up one of the park trails and followed its rocky lead over several hills. I stopped to take photos a few times, panting as an elderly couple passed me on the trail. Ok, so I'm not cut out for fieldwork as most scientists know it, but I love to pretend. I kept bumbling along until I came upon a small gathering of petrified tree trunks. I approached them happily – fossil plants are my favorites – and I noticed a placard. It read: "*What happened to this forest? Millions of years ago a natural event occurred which caused this area to be quickly covered with mud. The trees were buried in sediment which contained minerals. Because they were submerged, these trees were not able to decay. Instead the woody structure of these trees was slowly replaced with minerals from the sediment. Once the area was dry again, the fossilized trees hardened into rock, leaving us with a timeless sample of this ancient forest."* The word *millions* had been scratched out, presumably with a creationist's car keys.

After walking the park trails for another hour, I went back to the car and drove to 325. No tarantulas this time, unfortunately. I followed 325 farther west until I saw a sign for Black Mesa Nature Preserve and the Summit. I knew the Summit was the highest elevation point of Oklahoma and that there were trails there. My water jug and I made it to the first mile marker before we decided not to trek the next 7 round-trip miles alone.

I was in the panhandle for a few reasons. First, I was going to give an Oklahoma Educators Evolve presentation to an entire school staff of eleven people in a town near Kenton. I had called principals around the state looking some who wanted to bring OKEE to their schools, and one in the panhandle decided to invite us. She wanted just a quick, 2-hour workshop on a Monday morning, so I decided to take the weekend to scout out spots for a longer OKEE fieldtrip to the area for the upcoming spring. Second, I needed to have a quiet place to write. And third, honestly, I wanted to see how a tiny rural school had been dealing with the new science standards (especially teaching evolution).

In the crisp darkness of the next morning, I fumbled to the outhouse near my cabin and dressed in the dark before approaching the main 'lodge'. Inside, a woman with a sickly sweet voice had caught sight of me through the screen door and welcomed me through, trilling, "well good morning! Breakfast is ready!" as I gingerly made my way to the hand-hewn wooden table. I opted to pour myself a large coffee before dressing up a plate of beautiful golden waffles with homemade jams and syrups. My mouth was already full of bacon and eggs when my hostess stopped fussing in the kitchen and sat next to me at the table.

"Now, you're from OU?" She drawled, smiling and stirring her coffee.

"Yes...here doing fieldwork for my dissertation."

"Oh my! Well." She sat back in her chair, fidgeting with her apron strings. "And where is your husband?"

I paused for a moment before answering, pretending I was still chewing. "He's at home, working on his own dissertation," I smiled meekly, "He's a paleontologist."

"Oh! Well I know plenty of *them*," she gestured out the front window, where the sun was just beginning to spill red over the mesa. "Out here all the time. Looking for Lord knows what!" she giggled, but then quickly resumed an austere mood as she looked at my t-shirt, which showed a silhouette of our state and read *Oklahoma Educators Evolve* (with an ammonoid as the "O") and asked, "What kind of fieldwork are you doing up here?"

"I'm here to work with teachers. Trying to understand what the challenges of their jobs are…" - I took a sip of thickly pulped orange juice - "...and especially how they deal with teaching evolution." *There, I said it.*

"Oh, *really*?" one of her eyebrows disappeared up under her wispy red bangs and her mouth became as stiff as a finch beak.

"Yes...there are new science standards - state-level ones - and teachers need some help getting ready for those, for teaching evolution. I'm here to help." I said carefully.

My hostess took a long breath and glanced out the window for a moment before answering, "Well, I *suppose*...who am I to say what the Lord meant by seven days?" She smiled so sweetly I thought her teeth might fall out. I forced the edges of my mouth upward and nodded before quickly slurping down the rest of my coffee and clearing my dishes from the table.

On the way to my destination I passed a wealthy philanthropist's land, which I recognized from photos hanging in the collections at Sam Noble Museum. I slowed as I drove past the large wooden building where his Native Explorers program participants stay each summer as they spend three weeks learning about paleontology in the Mesa. After a short joyride at 40 miles an hour, I came to a complete stop by a weathered sign that read *Kenton Easter Pageant* because two cows had wandered into the road. I glanced at the clock and panicked for second before remembering that this is the only place in Oklahoma on Mountain Time - I was still early for my workshop. Soon enough the bovine traffic cleared and I drove into town. I realized I did not have an actual address for the school (nor the GPS to find it), but a few turns and a little looking got me to the right building within minutes.

Three small tables constituted my stage for the morning. I carefully unpacked, unwrapped, and arranged each fossil on the tables. I would be using the school resource professional's room for a two-hour Oklahoma Educators Evolve session. She was busy making a pot of coffee while I filled up her small room with fossils, collecting guides, writing utensils, OKEE swag, and specimens. A teacher walked in and stretched her hand out toward me. "Good morning! We are excited you're here!" I smiled and shook her hand, introducing myself. She was already looking past me, eagerly eyeing the fossils on the tables. “This one…” she lightly touched a black *Herrerasaurus* skull cast, “...was it cooked?”

“Sorry?” I was puzzled.

“Like, is it this dark color because cavemen cooked it? Charred like barbeque?” she looked at me excitedly, and earnestly, waiting for confirmation.

“Oh! Actually...this is from an animal that lived a long time before that. It was called *Herrerasaurus*,” I explained, doing my sincere best not to sound patronizing. The teacher scrambled to write down the name, and immediately told her next coworker who came into the room. Their genuine excitement was infectious.

When the rest of the staff had arrived and taken a seat, I introduced myself and began a powerpoint presentation about the geology of Black Mesa and the Oklahoma panhandle. Interwoven with stratigraphic maps and photos of outcrops was the narrative of why Oklahoma Educators Evolve exists, and why I came to the panhandle. Our discussion about Oklahoma geology lasted well over an hour, until finally someone was comfortable enough to ask me a personal question. “So, y’all teach evolution, mainly?” a young agricultural sciences teacher asked.

“Yes, we do specialize in evolution. We are focused on helping teachers get ready for the new science standards, and help them build confidence in teaching subjects that aren’t always comfortable to teach.” Several teachers nodded.

“So…have you all met much resistance when teaching evolution? How is it going here?” I probed. The teachers looked at the table, each other, their hands – anywhere but at me. Finally, the agricultural sciences teacher spoke.

“Well…we don’t, really,” she sat up straighter, now looking me right in the eye, “Up here we all kind of see this evolution business the same way.” She was saying, without actually saying it, that no one at the school was teaching evolution (including the science teachers). I was surprised but probably should not have been – this is the stereotype (or perhaps suspicion) I have heard plenty of scientist colleagues perpetuate.

There are scientists who would argue that science and religion (or other symbolic aspects of identity) are not compatible, in the sense that you cannot authentically belong to one without being kept exclusive from the other. Scientists Richard Dawkins, Lorna Salzman, Steven Weinberg, and Sam Harris are a few of those who feel this way. A Pew Research survey has shown, as well, that scientists who believe in some form of deity or higher power number just half of those Americans who do (51% versus 95%, respectively). Furthermore, 41% of scientists polled for the 2009 survey said they do not believe in god or a higher power, versus the 4% of Americans who share this view. One particular field experience illustrates the point that religion and science are often perceived as mutually exclusive; one middle school science teacher from a small city west of Oklahoma City shared with me at a workshop: “I truly believe God sent y’all to me, brought us together. I have waited all my career to hear a scientist say that I can be a Christian and love science, too.”

Conversely, plenty of scientists seem to be living exceptions of the idea that religion and science do not mix. For example, Robert Asher’s book *Evolution and Belief: Confessions of a Religious Paleontologist* and Francis Collins’ book *The Language of Science and Faith: Straight Answers to Genuine Questions* are among the numerous guides that exist for scientists grappling with their religious identity. Teachers understand this. Surveyed with the statement: “Scientists cannot be religious”, over 90% of them disagreed. They do not see a conflict with being a scientist and being religious; however, discussions in the field illuminated the fact that students do not see things this way over and over.

A primary component of Oklahoma Educators Evolve workshops is a session focused on the Nature of Science. During this session, What is Science?, at the very first workshop, several teachers began discussing their experiences with student perceptions of the nature of science, as well as their own. It became immediately clear that their experiences bridged a wide spectrum of personal perspectives. For example, one middle school teacher shared that what kept her on track each day at work was a constant reminder that her primary job is to help students learn the joy of science. Another, more experienced teacher, chuckled at this and said that she coped with challenges in her classroom by reminding her students that science conveys a particular perspective about the universe, and that they don’t have to necessarily agree with it in order to pass her class. A third teacher chimed in that she usually ended up explaining to her students that she is a Christian, and that science is something that strengthens her personal faith, so if they are Christians then science does not need to offend their religious sensibilities.

As soon as the group began talking about personal religious beliefs and faith, the conversation toned morphed into an almost apologetic chorus. A rather quiet teacher, Maria, spoke up to tell the group about her recent move to Oklahoma and the anxiety she had developed within just a few months of teaching science in the state. Maria admitted a deep fear of the teacher whose classroom mirrored hers in their hall, saying that he was an evangelical pastor, and that he had, on more than one occasion, called her out into the hall to remind her that "teaching evolution is illegal."

Jeannie, a high school teacher with over fifteen years' experience teaching science in Oklahoma, was one of the first to respond to this erroneous claim, reassuring Maria that she not only can teach evolution, but also that she *must*. Jeannie went on to share that each year, her new batch of students would have individuals who accused her of being "unchristian" or even "atheist" when she introduced the concept of biological evolution in class. She said that it really bothered her, and though it happens every year, the discomfort and anxiety she gets from hearing these deeply personal accusations never go away. Jeannie explained that she is a Christian, and considers herself to be a good person, but that she falls into a trap of questioning herself and her faith when students call her an atheist. The other teachers in the small group concurred, and some shared that this had also happened to them at least once in their classrooms.

The idea that a person who is both a science teacher or advocate and a Christian must not be a true or authentic version of either is essential here because it seems to be a primary source of anxiety for science teachers in Oklahoma. It must follow that students feel a similar sense of fear and self- doubt when their values are called into question because of an expression of interest in science. The anxiety comes not from a fear of science, but from a social stigma surrounding science as an epistemology.

Oklahoma is home to one of the highest rates of Biblical literalists and creationists in the United States (Pew Research Forum, 2015). Oklahoma teachers are worried about how students perceive them and their identities as it relates to the larger cultural context. Furthermore, the students in these examples make it clear that assumptions about identity come into play when certain topics are discussed. As if a student who identifies as Christian might suddenly distrust a teacher whom they thought was also Christian, but has now presented this "other side" of themselves by teaching evolution. When a student distrusts a teacher based on these cultural factors and a perceived clashing of ideologies, how does learning happen? How can learning happen if a student feels betrayed, and a teacher feels defensive? And how do educators work to syncretize religious identities and the demands of teaching science?

I want to briefly address this in terms of common intelligence and ability instruments, because they are so prominent in educational studies and the assumptions we make about learning. Jeffry Mallow, one of the relatively few researchers of science anxiety, has published discussions of Piaget-based reasoning tests (Marek and Cavallo, 1997; Bybee and Sund, 1982; Lawson and Wollman, 2003) and their efficacy in evaluating an individual's ability to use formal reasoning; he has noted that the tests "have not controlled for the variable of anxiety" (Mallow and Greenburg, 1983:98). This is an interesting critique, as the distinctive concept of the learning cycle (Marek et al, 1990; Maier and Marek, 2006; Marek 2008, 2009) can be interpreted as making plenty of room for student anxieties (with the concept of disequilibration). On the other hand, the theories and tests of foundational researchers like Piaget have been critiqued as being too "psychologized", rather than dutifully taking cultural factors into account (Spindler, 1987), and some have argued for a more socially-conscious way of thinking about how we teach and learn science (O'Loughlin, 1992; Wegerif, 2011; Weinstein, 1998). In other words, when researchers conceptualize how students (and educators) learn and use new concepts, their social anxieties must be taken into account; perhaps when students do not exhibit formal reasoning abilities in science but do so in other activities, anxiety is the changing variable.

In terms of offering useful professional development and suggestions to educators, the answer to these questions lies in the Science Empowerment approach; more specifically, in the *cultural intelligence* component of the model. Research has shown over and over that simply presenting information (*access*) and informing students that it is factual and well-supported (*literacy*) does not provide sufficient ingredients for the amelioration of resistance and science anxiety (Rozenblit and Keil, 2002; Hall, Ariss, and Todorov, 2007; Nyhan and Reifler, 2010; Mercier and Sperber, 2015; Sloman and Fernbach, 2017). The two factors alone, access and literacy, cannot successfully create the positive science identity needed for students to "equilibrate" (Marek and Cavallo, 1997) and engage with science in a meaningful way. In order to add the cultural intelligence component, two steps must be taken: 1) understand and conceptually identify with student beliefs and anxieties; and 2) use the Nature of Science as a bridge between student and teacher. In my experience, scientists can become frustrated and resistant with the first step, but Oklahoma teachers have it down to an art. A well-trained scientist is typically great at the second step; Oklahoma teachers, based on what I have learned in the field, need scaffolding and support that they are not currently receiving in order to comfortably execute step two.

Education researchers have known for decades that step two, using the Nature of Science, is vital to teaching science effectively. This is especially true for teaching evolution (Sandoval and Morrison, 2003; Cavallo and McCall, 2008; Eick, 2000; Fairchild, 2012). Oklahoma Educators Evolve staff decided to use existing resources for our first Nature of Science (NOS) workshop session, *What is Science?.* We opted to try a popular NOS activity called the Checks Lab. Developed in the early 1990s for ENSI (Evolution & the Nature of Science Institutes), the Checks Lab synopsis reads:

"Each team has an envelope containing a series of personal bank checks. A few are removed at a time, and the team attempts each time to construct a plausible scenario that involves those checks. With each subsequent removal of checks, appropriate revision of the scenario is done. Final scenarios are compared by the class. Class discussion is designed to show ***how the available evidence, along with human values, experiences and biases, influence observation*** *and* ***interpretation****, even in science.* ***Scientific argumentation*** *(requiring evidence for all claims) is encouraged, in compliance with the new NGSS and Common Core Standards."*[2]

Crowded around their tables, teachers participated in the Checks Lab; or rather, a newer version of it called the Emails Lab.[3] A series of 16 emails, cut out and separated from context, is given to a pair or team of participants. They are directed to randomly select four emails and set the rest aside. Then they must examine the four emails and try to determine what they story is; they try to parse out how the emails are connected to one another in a greater narrative. After discussing their ideas, they are directed to select four more emails for examination. Their task then includes deciding where these new pieces of information fit into their existing narrative. The activity continues thus until each group thinks they can reconstruct the whole story with 16 emails. The emails are modified from the original activity, done with a series of bank checks.

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[2] http://www.indiana.edu/~ensiweb/lessons/chec.lab.html
[3] http://www.nsta.org/highschool/connections.aspx

As the teachers worked on sorting out the emails and discussing their ideas about what the narrative could be, I would periodically stop them and ask them to share their ideas aloud. Teacher groups consistently engaged in explaining their reasons for organizing the stories as they chose to; and just as consistently, there is always a group of "sillies" who take the activity in add directions. When it is the sillies' turn to speak, one can hardly make out the narrative being told between their chattering and laughter. The stories leap from one ridiculous situation to the next without explanation, and it seems that their goal is to be as silly as possible. Group A has said something like, "These two people are married and their son is sick. They bought him a toy to cheer him up when they visited him in the hospital. The emails show that somebody is sick, and that the husband spent money at a toy store, so this seems like a reasonable explanation." Meanwhile, Group B will gasp, "This lady saw a hot guy at the store. One of them posted a Craigslist Missed Connection, but on their first date, they crashed the car into a toy store!" before collapsing into belly-jiggling laughter.

Without saying it, we all seem to collectively know that this story is ridiculous. Pause for a moment to gage your own reaction to the stories. If you are wondering what makes one group's narrative ridiculous and another's plausible, when we know we will never learn the whole and true story being told by the emails, then your train of thought has stopped at the right station. This is, of course, the whole point of the activity - to realize that evidence supporting our claims is what makes science a powerful form of knowledge.

Once while doing this activity with a group of teachers, the "silly" group presented a rather asinine narrative and the rest of the group just groaned audibly. One of them then exclaimed, "What?! We're kindergarten teachers! Our kids have imaginations. We have to, too."

I would sit and think about this particular moment for probably far too long - especially because it kept happening. To me, it reflects the stereotype that science isn't fun, and worse yet, has nothing to do with imagination, which I find incredibly offensive. Why is it that teachers of very young children seem to believe that those kids cannot think about evidence and what it means? Why is evidence-based reasoning considered equivalent to the death of imagination? Sure, Piaget might not agree with what I'm saying. He might insist that a preoperational-stage child cannot think in the abstract, nor perceive and understand much beyond their own ego. But perhaps he would reach the same conclusion I have: children who are just beginning school reside in the space between everything having to be concrete and right in front of them, and everything being a possible game of pretend and plausibility. This space is the fertile crescent of science.

DARWIN'S IRRELEVANT DEATHBED

A teacher approached Oklahoma Educators Evolve staff Alex, Dennis, and I at a workshop in spring 2016. I recognized her as a pre-Kindergarten teacher, Abby, who had attended another OKEE workshop the previous fall. I smiled and asked how her day was going. “Well...I actually had a question,” Abby straightened up a bit and turned to Alex, “What you said about Darwin and natural selection...I heard - from a reputable source - that he took it all back on his deathbed.” She raised one eyebrow slightly and pursed her lips, waiting for a response.

“That is interesting. Where did you read that?” I asked, sincerely.

“I...I don’t remember off the top of my head, but it was reputable,” she said haltingly, not looking away from Alex.

“As far as I know - and I have been reading about Darwin for a long time - I don’t think I have ever heard that,” Alex said carefully, “but more importantly - even if he did - it wouldn’t change what we know about evolution today.” Abby looked distressed but kept her composure. “Oh? Why not? What if he lied?”

“Because the observations he made were real - and many people have verified them. Scientists do get things wrong...I get things wrong all the time. What matters is what we can observe and verify and test outside of the things we think. We keep each other in check, in case we are wrong.”

“Well. I still think he took it all back.”

“Either way, he was right the first time,” Alex said, careful not to sound dismissive, but with an unintentional air of finality. Abby did not look totally satisfied, but was still finished with the conversation.

I could not help but think about the dynamics between female teachers and male scientists, and how they contribute to tension between the groups. I have experienced male teachers making similar assertions as Abby, but to me rather than a male staff member; the result was typically different, in my own experience. Male teachers tended to behave more combatively, in the sense of continuing their assertions stubbornly even in the face of more information and evidence. But those same teachers would engage in seemingly much more productive conversations with Dennis, Alex, and other male OKEE staff at our workshops.

GENDER: AN ANTHROPOLOGY OF EXHAUSTION

Prying open her eyes, Donna exhales and blinks a few times before reaching for her cell phone. It's 3:00am and the alarm is ringing. She swipes it off and pauses for a moment before getting out of bed. She can hear the coffeemaker crackling on in the kitchen, set ahead the night before in anticipation of the incredibly early morning. She stretches and trips over a pile of lightly battered notebooks on her way to turning on the bathroom light. She hopes a quick shower will wake her up enough to make the upcoming drive.

Twenty minutes later, with wet hair and fresh coffee burning her tongue, Donna starts her car and backs slowly out of the driveway. Her GPS is set for Bartlesville, Oklahoma. With a four-hour drive ahead of her, she relaxes into the seat and scans the radio for upbeat music.

It is Saturday morning, and Donna has already worked 60 hours this week. She makes a mental list of things to do when she gets home from Bartlesville in 16 or so hours. Laundry, walk the dog, make dinner; she remembers that she still has to grade the whole pile of notebooks she'd tripped over earlier. She refocuses on the road ahead, taking a deep drink of coffee. Usually she doesn't get to drink her morning coffee until lunchtime, when her students finally clear the room and she has a 20-minute break to sip the lukewarm liquid while planning next week's lesson and eating a few bites of two-day-old leftovers for lunch.

By 7:30am, the sun has made an appearance over Bartlesville as Donna pulls into the parking lot of the hotel. She spots other people who must be there for the same reason as she – it is obvious from their comfortable clothes, hiking boots, and faces featuring a mix of apprehension and curiosity about what the day will hold.

The border between Oklahoma and Kansas is about 30 miles north of the hotel, and we set out in a line of cars to find a particular road cut near Peru, Kansas. Peru's population is just over 100, and a simple blink will cause a driver on highway 166 to miss it. After some searching and turning around our caravan a few times, we parked along a dirt road leading to a cemetery. We donned safety vests and worked our way through the long wet grass to the base of an outcrop.

I turned and glanced back across the road, squinting through the morning fog along the shoulder. The paint was chipping off cemetery signs and grave markers alike, which were just visible over a hill. For some reason I felt solemn looking at the markers, even though I was about to dig up hundreds of remains – and quite eagerly, at that. Next to me, Donna is already squatting, her eyes firmly on the ground, her right hand brushing through piles of sediment as her left arm acts as a column to hold her steady. After several minutes, she stands up and stretches her back. "Not much over here. Let's keep walking," she reports. This is Donna's fifth field trip with us, and at this point she is an expert. Other teachers, looking up at her from their places on the muddy hill, silently begin to follow Donna further along the road cut.

I cross the road to take a photo of Donna and the other teachers, and finally start to recognize the subtle differences in piles of muddy sediment and rocks that sit along the outcrop as I trip and stumble over them. I had been here once before, in late autumn, when the grasses and other vegetation were nearly dead and out of the way of eager fossil hunters. Climbing up a few feet, I see some very dark shale pieces that have washed out of the road cut in particular places. Peering close, I instantly recognize a smattering of crinoid stalk pieces, looking like a handful of tiny spilled buttons.

"Over here!" I call to the teachers. As they cross the road one by one, I show them the minuscule fossilized zoo in my palm and point out which sections of sediment will yield more for them. Soon enough we are all settled comfortably into soft seats of dirt, concentrating quietly on the ground in front of us. As I find brachiopods, gastropods, and other ancient little animals, I hand them to the teachers around me and explain what they are. Soon they do not need me, now able to recognize fossil shapes and textures with little trouble.

Donna catches up with me after about an hour, laughing as she approaches. “That is a sad little spot. Come over here, the picking’s easy!” she gestures about 25 yards away to another blackish, shaley hill that looks more accessible and apparently more productive than the one I had been prospecting. I follow Donna to her spot, several other teachers in tow. We kneel and sit on the ground and begin harvesting the hill. Almost every teacher, aside of course from Donna, has told me that this is their first time fossil hunting. *“But my school is only an hour from here, by Tulsa.” “How do I get permission to bring my students here?” “My kids would love this. They are going to freak out!”*

The sun was high in the sky and burning our necks before Donna and I, and a couple other determined teachers, noticed the bright cluster of safety vests back by the cars. “They’re done already?! I’m just getting started!” laughed high school biology teacher, Jackie. “I know. I just found a really good spot and I could sit here all day,” responded high school physics teacher Isaiah. Donna shook her head and scoffed, though good-naturedly, “I might just stay here while y’all go to the workshop!” she smiled.

We started trudging back to the cars, which were now pulling out onto the road one by one and heading east. Josh, one of my graduate student staff, slowed his car and rolled the window down to tell me that they were all going to another road cut along 166. At this, Donna and the other teachers put a bit more pep into their steps, excited to see another site.

As we drove up to site two, I noticed an older teacher named Steve collecting fossils away from the other teachers. His kneepads showed plenty of wear as the dulled, worn plastic barely glinted in the sun. After parking, I jogged over and said hello to him, and asked him how he was doing. “Oh, good! Just not as young as I used to be,” he chuckled. He said this was his first time going fossil hunting, and that after teaching middle school science for 17 years, he was thinking about taking students out to a site closer to his school. “I just never really thought about taking them. But I guess it is pretty safe and they would love it,” he paused, bending to pick up a horned coral. “I’ll give you my card when we get back to the workshop. I run our school’s science club.” Another teacher came to find me just then, asking for help identifying a fossil.

Thirsty and sweating, we stomped our muddy boots on the road as we prepared to get back in our cars after another 25 minutes of hunting. I piled into another staffer’s car – an undergraduate who wants to be a science teacher – and teacher Jackie climbed in next to me. As we headed east towards state road 75 back to Bartlesville, Jackie recounted her excitement for the morning’s experiences. “I went to school for biology – horticulture specifically. Never really got to take geology…but if I go back for my Master's, I will!" she grinned. I considered for a moment how most of the teachers I interact with went, or are going, to school for Education; it had been a rarer teacher, in my experience, who earned a science degree and then became a teacher in Oklahoma. I felt myself slipping into deep thought about the political economy and gender politics of science and education, but tore away from my reflection as I asked Jackie how she had decided to become a teacher.

"Well, it was weird," she chuckled. "I didn't do the traditional thing. I loved science and wanted to do something with biology – plants especially, as it turned out – and…well I worked at the zoo for four years…then I started applying for teaching jobs. That was only after I failed my OSET a couple times!" Jackie laughed, referring to her state science teacher exams. "But I still need my cert – I work at a charter school…so it's a bit different…but I really like it. Actually I never thought I would be a teacher. Never really occurred to me. Just, like, one of my friends asked me one day why I wasn't a teacher. Huh…now I am." Jackie gave a little shrug and smile, relaxing and pulling out her cell phone to text.

We pulled up to the hotel and parked in its lot. As Jackie and I went through the lobby to our rented conference room after agreeing to leave our muddy boots in the car, I saw that most of the teachers were now in socks, as well as most of my staff. We shuffled past a group of hotel staff that was preparing the large ballroom for a wedding ceremony and reception. They looked at our dirty hems with mild curiosity, and perhaps annoyance, worrying that we would track mud into the path of the wedding party that afternoon.

Safely in our own large, comfortable conference room, teachers and staff began to relax as they found seats and started taking fossils out from their packs. I grabbed a boxed lunch for myself and settled in at a table with a group of teachers from far-eastern Oklahoma ("basically Missouri", they called it). I dove into sorting the fossils in front of me.

"I *cannot wait* to bring these to class," smiled Gina, a fourth-grade teacher, not looking up from the pile of brachiopods in front of her. "We are getting ready for math testing and these are going to be so helpful!"

"Oh yeah! I didn't even think of math…Ugh. I wish I had collected more. The math teacher at our school couldn't come today," shared Sarah, a middle school English teacher from a neighboring district. "She had a doctor's appointment she couldn't miss."

The other teachers nodded knowingly. "I had one the other day," said Gina, "and my doctor said the funniest thing. He was like, 'I always know when there's testing or standards changing at school because all my teacher-patients get elevated blood pressure!'" Gina grinned around at the laughing group.

Several articles have come out in the past year about teacher health and stress. This was not the first time a workshop participant would share a story about their own or their colleagues' health; it was a commonplace part of teacher discourse. In America, teachers put in an average of over 1000 instructional contact hours per year, which makes up only half of the job of being a teacher; the other half, of course, is planning, grading, developing, and everything else. Elsewhere in the world, teachers do not come anywhere near working this much – for example, in England teachers do 695 instructional hours per year; in Japan, they do 510; and in Finland, 553.[v] Teacher stress and burnout is an enormous issue, and no discussion of education can be complete without it. Teachers are as stressed and exhausted on the job as doctors, if not more so (Farber, 1991; Chen and Miller, 1997; Kyriacou, 2001; McManus, 2013; Caringi, Stanick, Trautman, Crosby, and Devlin, 2015; Prilleltensky, Neff, and Bessell, 2016).

When the subject does come up, teacher stress is treated as an issue that the teachers themselves are responsible for managing; the narrative revolves around how they must prevent their own burnout (Gold and Roth, 2013). Plenty of advice is given: meditate (Winzelberg and Luskin, 1999; Anderson, Levinson, and Barker, 1999); use mindfulness (Chiesa and Serretti, 2009; Roeser, Schoner-Reichl, and Jha, 2013); take a stress management course (Neves de Jesus and Conboy, 2001); use aromatherapy (Austin, Shah, and Muncer, 2005); engage in cognitive-behavioral modification programs (Nagel and Brown 2003; Richardson and Rothstein, 2008); or engage in "stress-inoculation training and exercise" (Long, 1988). The stress of being a science teacher in Oklahoma may be amplified by the gender of the teacher, as I will review in more depth in the following section.

SCIENCE AND GENDER: A BRIEF REVIEW

> *Clustered near one another and keeping low out of the wind, twenty women worked tirelessly on the task in front of them. All the while they chatted and laughed, but never took their eyes off the work. They do the work partly because they must, and partly because they want to. They do it at this particular time and place and in this particular way because this is where, when, and how it has always been done. Some of them are new to this, and watch older and more experienced women closely as they work.*

This scene is a common one in ethnographies. Somewhere "exotic", the women might be weaving strong palm mats for trade, gifts, or household use. On the particular cold, windy March morning of this example, Euro-American women were collecting fossils in southern Oklahoma. The fossils would not go to a museum, or be displayed on a mantle in someone's home. They were not even for the production of scientific knowledge. The fossils would be used to teach Oklahoma children about earth science, biology, and the Nature of Science. One might say that the fossils were for the "delivery" of knowledge, rather than the "production".

When I surveyed National Science Teachers Association members (n=92), only one disagreed that women and men are equally good at science. However, 15% reported that they do not encourage all their students to pursue science careers equally. This is in contrast to Oklahoma teachers (n=66), where eight teachers either disagreed or reported being "not sure" about whether men and women are equally good at science; furthermore, 30% reported that they do not encourage or are not sure about encouraging all their students to pursue science careers equally. More than 20% of teachers said they were not sure or did not think that many of their students could excel in science careers.

Gender disparity in science careers has been attributed to the phenomenon of *stereotype threat* (Spencer et al, 1999; Schmader, 2002; Steele et al, 2002). Stereotype threat refers to how individuals or groups of learners learn to perceive themselves as being less able to do certain tasks, in this case math and science, based on what stereotypes exist about their racial, gender, or other cultural identity. Literature on the effects of stereotype threat in math and science settings for girls and women is relatively robust, and has shown a strong relationship between female performance in these subjects and gender identification that leads to manifestations of stereotype threat (Spencer et al, 1999; Quinn et al, 2001; Schmader, 2002; Steele et al, 2002; O'Brien and Crandall, 2003; Johns et al, 2005; Kiefer and Sekaquaptewa, 2007; Schmader et al, 2008). Typically, female students have been expected or perceived to be less assertive, less likely to raise their hands, quieter, less likely to debate, and less likely to fully delve into hands-on science experiments than are their male counterparts (Kelly, 1985; Bar-Haim and Wilkes, 1989; Shepardson and Pizzini, 1992; Rahm and Charbonneau, 1997; Brownlow et al, 2000; Francis, 2000; Nosek et al, 2009).

In a job description, employers don't – *can't* – explicitly call for a certain sex or gender. So how do we end up with a career field being dominated by one gender versus another? This is true of the teaching profession, especially in schools organized for young students, grades Kindergarten-5th. Science education is a prime example of a gendered division of labor. Because teaching is an occupation populated by at least 80% women, according to the United States Department of Labor, the issues of teacher stress and health, coupled with the fact of gender disparity in STEM careers, comprises a gender-based problem. Aside from the problem of unequal labor demands and stress, women are being expected to prepare students for STEM careers that they themselves were deterred from, all at the cost of their own health.

The phenomena of stereotype threat and math anxiety as they relate to gender are incredibly intriguing for researchers (for example, Brownlow et al 2000 and Beilock et al 2010), and scholarly work done in these areas thus far reveals an asymmetrical pattern of men's and women's involvement in science. In my own research on the more general concept of science anxiety, it is clear that gender is a hugely important factor in the everyday dissemination of scientific knowledge. Teachers' (K-12) normatively assigned role is to prepare children for success in college. The overwhelming majority of teachers who have participated in my research are female, and this is true for the sciences and mathematics as much as it is for language arts, music, and other subjects that are traditionally ascribed "feminine" interest. The issue: the majority of scientists (doing science) are men, while the majority of educators (teaching science) are women. Scholars have begun to conceptualize this split as a product of economic sexism, in which a "service industry" job like teaching is seen as less valuable, less important, and ultimately less masculine than a “primary production” job like making scientific discoveries (Catsambis, 1995).

There is indisputable gender disparity in both STEM education and occupation, but the numbers are stranger than they appear. For example, the popular discourse would indicate that women are hopelessly behind in STEM education – only 31% of STEM degrees were awarded to women in 2009 – but women outnumber men in biological science degrees, which may speak to the differences between fields in the natural and physical sciences. Even more interesting is the fact that high school STEM course enrollment is almost equal (51% boys, 49% girls; National Center for Education Statistics, 2010). So the issue is not that girls are actually behind boys in education, it is that somewhere between secondary and postsecondary schooling, they are discontinuing participation in STEM fields. Between degree conferral and the launching of a career, even more women are discontinuing their path in STEM. This is interesting, because over 60% of college degree earners are female, which demonstrates that this is not simply a matter of women opting to forego college. It is worth noting a US Department of Education statistic that postsecondary female enrollment in STEM sits at around 24%, whereas the health sciences and education & training categories retain 70-81% of female students (NCES, 2010). According to the 2013 US Census, only 10% of male STEM graduates are absent from the STEM labor force, compared to 20% of their female counterparts. Training and experience in STEM have been shown to correlate with increased teacher confidence in Oklahoma (e.g. Yates & Marek 2014), so knowing these facts is paramount to understanding teacher science anxiety.

Anthropologists and sociologists have commented on issues in education such as the social purpose of college (Brodkin, 1998:31), parental pressure to "choose" STEM majors (Harris et al, 2004:186), and the great barrier of 'family versus career' that women must overcome in order to fully participate in STEM (Bystydzienski, 2006). This includes a woman's identity within her labor and education. In the next chapter I will review some of these facets in more depth.

CHAPTER IV: ANXIETY

COMPETITION AND SCIENCE LITERACY

Perhaps the most popular STEM-related phrase for politicians, scientists, and teachers in the public sphere is "science literacy". A lack of such literacy is perceived as a crisis. There is a clear undertone of classism echoing through the political and economic discourse on the "STEM crisis" in America. Political economy plays an important role in the contemporary science learning conversation. Interlocutors of science literacy discourse include educators and scientists, but there also exists considerable concern among economists and politicians about the future of scientific knowledge in America. Part of the sense of emergency over science literacy rests on the notion that the economy will suffer greatly if American citizens do not increase "scientific excellence and technological innovation" (Burke and Mattis, 2007:4).

Even human economy is affected, in that immigration of science and technology specialists to developing nations is slowing:

> *A decreasing number of students are acquiring STEM skills, and there is a suggestion that students in some developed countries are not performing as well as students in developing countries...some developed countries relied on immigrants with STEM skills to meet their needs. The immigration of STEM workers has slowed as their home countries become more advanced.* (Burke 2007:5).

Notice how this instills a sense of panic at the possibility of the United States moving “downward” on the global hierarchy. As Erika Lee (2004) has demonstrated, there are explicit gatekeeping practices in American citizenship policymaking and rhetoric, and it seems that the concept of the educated American being less scientifically literate than his or her foreign – therefore “lesser” – counterpart is nothing short of a political-economic nightmare (Gilpin, 2011).

The product of recent research has gone against the common grain of compulsory STEM prominence in American education, especially regarding career pursuance. The common narrative on STEM in America is generally one of an emergency in which there is a vast shortage of qualified applicants to innumerable open jobs in STEM fields. This rhetoric has barely been contested in public discourse, and even within science itself. However, statistics reported by the National Science Foundation in 2014 have shown otherwise: U.S. higher education is producing at least 100% more STEM graduates than the amount of jobs available to them upon graduation; and alleged shortages of professionals in fields such as engineering, information systems, and computer sciences are apparently nothing more than myth, as these graduates in fields actually have high unemployment rates, at 7-11%. STEM industries have also seen shifts in the labor market as technology and demand change. For example, occupations such as petroleum engineering have come back into fashion since the 1990s; but engineers who work in construction have faced a job shortage.

If the rate of unemployment for STEM-educated Americans is much higher than we are led to believe, and developing nations need less and less immigrant STEM workers to fill their own job markets, why do we continue to push the common rhetoric of emergency in STEM education rates, especially for women? As Kempner and Tierney (1994:3) echo, "we live in a world in which knowledge is used to maintain oppressive relations." If America is not the leader in STEM-based knowledge – technological advancement, revolutionary medicine, innovative new energies, and beyond – how may those relations be maintained?

More than twenty years after Congress passed the National Defense Education Act, ideas about the importance of science literacy had not changed much in the eyes of policymakers. The issue was still about protection from, and retaliation against, threats to national security. In 1983, the Reagan administration's National Commission on Excellence in Education published a report called *A Nation at Risk,* asserting that the US education system was "failing to meet the national need for a competitive workforce." It was meant to alert the American public of the threat of "peers in other industrialized nations…[who were] 'threatening our very future as a Nation and a people'" (Anelli, 2011:237).

This was part of a long vein of research on literacy and education framed as a "public deficit" beginning during the Cold War that continues its presence in modern discourses (Bauer, 2009). The answer to the crisis of this public deficit and "national need" has been the evolving legislation of standardized educational knowledge and testing. Sociologist and educational theorist Mark Garrison has explained that "failure is a designation of value…the discourse of failure serves to discredit [what schools have done]" (Garrison, 2009:3). Education is perceived as having a nation-building role, and Garrison has argued that "setting standards is a function of political authority, bound up with the political theory and social values of that authority" (Garrison, 2009:8). Science enjoyed a solid period of several decades of strong government funding during the Cold War. A mark of the end of this era, however, came in 1993 when Congress pulled funding for a Superconducting Super Collider after the collapse of the Soviet Union. As there was "no more crisis", there was also no need to fund such a project. Discoveries in high-energy physics have since come from CERN, the European Organization for Nuclear Research, rather than an American agency or group.

The media has also contributed to producing messages of crisis. For example, science journalist and political writer Chris Mooney has recently published *Unscientific America: How Scientific Illiteracy Threatens Our Future*, a book about the political and practical perils of a scientifically ignorant nation. He writes:

> *We live in a time of climatic change and energy crisis, of widespread ecological despoilment and controversial biomedical research. We have great cause to fear global pandemics, nuclear proliferation, and attacks by tech-savvy terrorists. We stand on the verge of pathbreaking new discoveries in genetics*

and neuroscience that could redefine who we are and even upend our society. (Mooney and Kirschenbaum, 2010:4)

The scientific community also perceives a crisis, manifested as a lack of knowledge in the American public, as well as a respect for and a trust in science. To that community, this means a decreased interest in science careers and great losses in science funding. In numerous interviews, astrophysicist Neil deGrasse Tyson has compared science literacy to vaccines, famously asserting that such literacy can protect a discerning person from exploitation by "the charlatans of the world". Carl Sagan lamented before his death in 1996,

> *"We've arranged a global civilization in which most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster…sooner or later this combustible mixture of ignorance and power is going to blow up in our faces."* (Sagan, 1995)

Science, at its core, is a way of evaluating competing claims, wherein the victor must demonstrate adherence to empirically supported facts. In this sense, science is about competition at its most fundamental level. Discourses on science literacy commonly frame issues in terms of competition. Chris Mooney is one of many writers that has published literature on political involvement in, and competition for the right to speak about, science (Mooney, 2006).

Neil deGrasse Tyson, among other scientists and personalities in the media, has asserted on numerous communication platforms that "Science literacy is an important part of what it is to be an informed citizen of society." Chris Mooney has also lamented the situation:

> *"The United States…is simultaneously the world's scientific leader – at least for the moment – and home to an overarching culture that often barely seems to know or care…Americans built the bomb, reached the moon, decoded the genome, and created the Internet. And yet today this country is also home to a populace that, to an alarming extent, ignores scientific advances or outright rejects scientific principles."* (Mooney 2010:3)

According to relatively recent data, 88% of the sources that Americans use for science and technology information come from television (40%), the Internet (28%), and newspapers (20%) (Indicators 2010). Nisbitt and Mooney (2007) point out that the public does not necessarily use such media reports as a scientist would, e.g., by asking whether one side of the issue has garnered strong support from the scientific community. Instead, they contend, the public uses news outlets whose viewpoints match their own, thereby reducing exposure to alternative views and the likelihood of becoming better informed.

Physicist James Trefil has written extensively on the importance of understanding the nature of science, as well as scientific literacy in a larger sense. "Scientific literacy is…knowledge about science that the average citizen needs in order to take part in the public debates that are so important in a democracy" (Trefil, 2007). Perhaps Trefil's most applicable statement to the realm of citizenship discourses has been the observation that "most people will never need to do science for a living. Everyone, however, will have to function as a citizen, and they will need to be scientifically literate to do so." (Trefil, 2008a:155; Anelli, 2011). Trefil is one of many researchers that has mentioned the importance of citizens being able to process the news they are exposed to every day; for example: "Scientific literacy is the matrix of knowledge needed to understand enough about the physical universe to deal with issues that come across our horizon, in the news or elsewhere" (Trefil, 2008a:28; Anelli 2011).

Geologist Robert Hazen has also picked up on this vein, noting in his coauthored volume with James Trefil: "Some time in the next few days you are going to pick up your newspaper and see a headline like 'Major Advance in Stem Cells Reported' or 'New Theory of Global Warming Proposed.' The stories…will deal with issues that directly affect your life – issues about which you, as a citizen, will have to form an opinion if you are to take part in our country's political discourse" (Hazen and Trefil, 2009). Clearly, there is a feeling among many individuals that citizens are: a) receiving and seeking news about science, and b) actively making decisions about science policy. A recurring theme in this research has been evaluating the truth in such statements, especially related to the access to science that is afforded Oklahoma teachers, who are mostly female.

Perhaps access to science education seems equal. For example, the Free Application for Federal Student Aid (FAFSA) is “gender blind”, among other things, and there are numerous grants and scholarships available for women and minorities seeking a university-level science education. However, one must consider issues of generational class differences when considering access to education; as anthropologist Karen Brodkin describes, a child born to the middle class must live up to that class, even though the cost of education is far greater than it was for their parents (Brodkin, 1998). For a woman reaching for a college education, financial mobility is not her only barrier to access, especially in STEM.

Even after a woman has achieved an education in science and goes on to found a career in a STEM discipline, the social odds are stacked against her. Bornmann et. al. (2007) note in their meta-analysis of gender differences in grant peer review that male applicants have greater chances of receiving grant funds in the sciences than their female counterparts (7%). Note as well that such studies as are represented in this meta-analysis are treating gender as a binary system of male and female only, and do not explicitly attempt to assess the situations of other genders. As science narratives revolve around objectivity (Appadurai, 2000) and the Scientific Method, how is it that STEM achievement fails to be a meritocracy, as we often argue that science itself is?

As anthropologist James Clifford has written, “Any claim to authenticity must always be tactical, politically and historically contingent” (Clifford, 1986:562). I think this is especially interesting to consider when it comes to science, which is internally regarded as being the best way to objectively evaluate claims. Science literacy discourse certainly reveals that this sentiment is not necessarily true for those "outside" of science, and yet literacy is asserted to be important all the same. We (society) have created and perpetuated rhetoric wherein it is a cultural emergency if we are not scientifically literate. The emergency is talked about as either science-based or economy-based (STEM emergency), and the common thread is competition.

It is necessary to think of STEM access and opportunity as being available to a certain class of citizen. The conventional narrative is that a comprehensive science education will lead the learner to a greater position in life, with more access to knowledge and outstanding literacy, through which the learner becomes an *educated citizen*. This narrative, however, does not account for the colossal struggle that any person outside of a specific class will have to endure in order to even gain access to such an education, much less beyond. In 2011, African Americans occupied only 11% of the STEM workforce, and Hispanics occupied 7% (US Census 2013).

Even if individuals have access to science education and careers, and become sufficiently scientifically literate, these two factors are still not enough to achieve Science Empowerment. The missing ingredient is cultural intelligence, on the part of educators and others in power. This requires a brief review of the power of science as an epistemology.

SCIENTIFIC EPISTEMOLOGY AND POWER THROUGH LANGUAGE

Scientific knowledge has been widely revered for its authority and utility since at least the Enlightenment in the Western world (Ede and Cormack, 2012), although science has always had its adversaries. Historically, objections to science were largely of a parochial or religious sort (Weinberg, 2003), but the discipline of anthropology may be what eventually changed this to a more humanistic sort. During the 18^{th} and 19^{th} centuries, science became more clearly delineated into the beginnings of a complex web of practices that included philosophical undertakings, technological endeavors, and experimental explorations into the natural world.

During the early ontogeny of anthropology, natural science branched partly into clusters of (European/Euro-American) thinkers who tried to examine humanity from a biological perspective. This path, while fantastically useful and interesting in modern practice, was first fraught with traditional notions of the Great Chain of Being and colonialist hierarchies; and so "science" became a primary tool of imperialist powers to justify expansion, study, and oppression of non-white peoples around the world, as well as to create institutionalized racist folk taxonomies (Fish, 2002). Before long, the libraries of elites would house the works of "scientists" like Sir Francis Galton, Comte de Buffon, and Samuel Morton (Brace, 2005). I choose to put the *scientist* label in quotations because it is incredibly problematic for these men and others like them. These individuals did work that was rigorous, substantially detailed and meticulously curated, based on what they perceived as hard evidence, and viciously peer-reviewed by other thinkers of the time; so in a sense, it was science. But this is a great example of how scientific knowledge is a cultural construct, because what is accepted and culturally reproduced as *science*, rather than some other form of knowledge, is inseparable from the social experience of that science. Today, we do not call their work science.

Labeling a phenomenon as a cultural construct must not be a means by which to diminish it (Ortner, 1972). Cultural constructs like religion, gender, race, and citizenship are incredibly meaningful and important, and therefore we are really losing something if we are completely ingrained with the idea that such constructs are somehow worth less to humanity than science's general quest for "objective reality". And perhaps of more utility to scientists: it *does* matter what people believe, if we want them to take science seriously (Gregory and Miller, 2000).

I want to address an issue that may be an elephant in the room for scientist-readers, and that is the problem of a seemingly growing movement toward mistrust in, and even outright rejection of, science in the past several years (Lewandowsky and Oberauer, 2016). This phenomenon is occurring all across the American political spectrum (Mooney, 2006; Berezow and Campbell, 2012), where liberals seem to be concerned about food, medicine, and health, and conservatives may be more concerned with environmental and educational regulations, among others. An issue I see at the root of the problem for both ideologies is the perception that science, government, and industry are synonymous and do not have citizens' best interests at heart. Scientists seem weird, foreign, or out of reach; they do not seem like real people.

In the Science Empowerment Model, the imbalance we may find here is that cultural intelligence is ignored, access is skewed, and literacy is all but missing completely. I think that scientists can and must take these issues into account. A typical response to such an assertion is: *"But, isn't being good at science enough? Why does outreach have to be my job, too?"* And of course, this concern is generally valid, especially among underpaid and overworked science graduate and undergraduate student populations. A primary goal of the Oklahoma Educators Evolve program through which I did much of my fieldwork is that every teacher in Oklahoma would know a scientist personally. Obviously our reach is not yet so vast, but what has been achieved so far in bringing teachers together with local scientists is enough to make me write program funding proposals until my fingers fall off.

In any case, I want to stress to scientists that it can be frustrating to read about the "privileged epistemology of science", especially since history and philosophy of science is barely touched as a topic in college science courses. My point here is that no matter how powerful science is and for all the reasons that it is, without working to help learners gain access, literacy, and be respected with effort on our part to work with cultural intelligence, then science will continue to be pushed away by the stubborn populace. With that being said, I will review how science exercises power through language, especially in museums and other institutional settings, and how scientists can take advantage of this information to improve their practice as Science Empowerment advocates.

Science has authority as a way of understanding the world; and definitions of the word "authority" often list the ability to execute will as a right. Science and natural history museums, as well as science classes in schools, envision and treat their own authority over their audiences. Language is the locus of authority, and it is also a key to empowering science learners. In museums, authority is said to fall to the "expert" – usually a curator - and visitors have traditionally been expected to yield to curatorial expertise. The same goes for science teachers. I contend that this may be "right" in an academic sense, but is perhaps a culturally unintelligent way to approach many Americans.

In the United States, democratic participation is not just a way of life, but a great shaper of our worldview and culture. The epistemic value many Americans place on their personal opinions is akin to the value scientists place on laws of nature, and I call this being "democratically-minded". It is important to distinguish that science is not a democracy as we typically think about democracies. Ingrained into many of our minds during elementary school, the perceived efficacy of the "Scientific Method" is based on the ideology that: 1) things, usually of a universal nature, can be known; 2) we must ask questions in order to find these things out; and 3) experimentation and reason can answer our questions and lead us to knowledge. Beyond votes, personal or private beliefs, an electorate, or even popular consensus, the scientist is an interlocutor that must attempt to follow the evidence wherever it leads; beyond that, I believe the scientist can benefit greatly from recognizing and incorporating enculturated ideas of democracy into the communication of their work. Social views and collective opinions have a strong hold on how people treat science topics, which one author has called “tides of consent” (Stimson, 2015). I will explore the dialectic between science and democracy in order to examine the problems faced by scientists in grappling with presenting what I term “non-democratic” science to a democratically-minded public.

The assertions I present here are founded on two normative factors: 1) scientists “sharing authority” is a powerful and effective method f for bringing knowledge and empowerment to audiences; and 2) science is not a democracy, in that the process for conducting scientific inquiry is based on empirical evidence, rather than opinions or votes (though of course, as I have explained, it is not quite so simple – this simplicity is for argument’s sake). I will elaborate on both of these points further in later sections, but must first elucidate the second point more fully. The processes by which scientists gain access to grants and other funding, and eventually go on to publish peer-reviewed hypotheses and data are certainly subject to debate, deliberation, argument, discrimination, and subjective notions. The Scientific Method was borne out of democratic ideology, but in itself cannot really follow the democratic process - unless we recognize and embrace the fact that science only happens through our own enterprise. Given, one of the most important tenets of modern science is the process of peer review, but even with this democratically-based practice, evidence is ideally what leads a scientist to one answer or another. So science, in its purest form, *can* offer a way for any curious person to make, organize, and hopefully verify observations.

The question for anthropologists, who I believe can best assist or become science communicators and educators in reaching their diverse audiences, is: how can scientists and science teachers share authority with learners when addressing topics that are not based on opinion? It is important to recognize how political ideology can affect the consumption of information - and in the current political climate, science especially. The ways in which we use language in science can affect how learners perceive and consume the information being presented.

Scientists and teachers have long fought the struggle of deciding how to exhibit and present ideas and objects to learners. Museologist Kathleen McLean brings a Bakhtinian sense of understanding to this problem: "the act of showing brings with it an inherent dialectic between the intentions of the presenter and the experiences of the spectator" (McLean, 1999:83). Scientists and teachers have many avenues for weaving their message, and we must realize that such messages are main way that learners can make meaning and have an entrance to connecting with material. A learner can and will make meaning from their learning experience, ideally, and the messages we convey must weave together many viewpoints, voices, and ideologies in order to accomplish this.

Where the science museum or classroom comes into play for these highly contentious ideas is in its positionality and agency as a locus of science learning. Shall a classroom be an extension of the “Ivory Tower”, or shall it be a creative, active, and loud bazaar? Museums have traditionally been referred to as “temples”, but there is a growing body of scholarship that instead treats the modern museum as a “forum”. Harrison’s *The Temple and the Forum* delves into this idea, albeit in the realms of art and literature, rather than science. Harrison (2007) notes: [the school] is meant to evoke “the concrete sense of ‘school’ as an actual edifice, a palpable institution – and so to call up…some sense of the institutional processes by which cultural knowledge is organized and transmitted.” Note that it is ‘organized and transmitted’, but not questioned, contested, or perhaps even digested.

Science classrooms can and should embrace methods of “democratizing” their content, and that this can be achieved through language. Linguist Alessandro Duranti (1997) has extensively discussed how language helps us to express knowledge; his ideas are applicable here because teachers must wonder how much embodied knowledge is required to understand a textbook or presentation. Language is directly tied to culture, which is a form of knowledge. Scientists and teachers must learn to engage with this concept and use language to democratize and decolonize their content in an inclusive and accessible way.

The classic “Sapir-Whorf Hypothesis” is also an important theoretical framework for my argument because language controls, and is controlled by, worldview. The applicable question for a science teacher is: how can we adhere to empirically demonstrable science while contending with learner worldview? Science museums can be excellent places to navigate this problem, if field trips are possible. The museum has advantages that other platforms of science communication do not; for example, a museum can create fun and engaging interactive modules that allow visitors to explore different questions and answers about topics of interest. Learning can be embraced as a free choice model. And when a trip to the local museum is not possible, exploring science on the Internet is also a free choice enterprise, though learning to sift through it is an important prerequisite. If science can be accessible, inclusive, and participatory for purveyors of a mosaic of worldviews, then the public reaction to science can only become more positive and empowering.

To the great advantage of science communicators are several linguistic theories. First, the works of Lakoff and Johnson (2008) and Hymes (2003) lay a solid foundation for understanding how language is both metaphoric, and possesses a strong poetic function. In other words, language has a performative dimension. The science teachers I have met in Oklahoma largely know that teaching is in some sense a performance, and also that performative arts can offer an excellent path to education for those often marginalized in science learning. Two specific linguistic ideas could be quite useful to science communicators. First, Sapir (1985) argued that all languages are continually creative, and I will take that notion a step further by contending that the language of science - which could be categorized as its own register - has fantastic opportunities to utilize creative approaches to communication. Second, Basso (1996) explored how language allows us to make imaginative historical constructions. This is not the common ideology in natural history museums, where the majority of the content is related to past life and processes on Earth, but it certainly could be with some finessing.

It is, perhaps, challenge enough for a museum to effectively present information about modern art, Civil War cannons, memorabilia from presidential races, or photographs of animals, among thousands of other topics. But what of the altogether *nonhuman* history of the Earth, which constitutes almost the entirety of Earth's past? How teachers tell stories about creatures and lands that existed long before humans, while also capturing the audience's interest and respecting their worldviews? This is especially difficult when we consider the fact that learners need to have experiences and examine objects or interpretations with which they can personally relate.

The work of these linguists, among others, is highly valuable for examining how museum language may be utilized to shape and improve visitor experiences. Above all others for the education professional, however, is Mikhail Bakhtin and his work relating to pedagogy. Science educators can find many useful theories in his work (Shields, 2007); specifically, his ideas about living in *biographical time* (2007:14), wherein a museum visitor or science student might opt to see their life through the lens of a "full knowledge of the context shaped by the intersection of time and space".

Bakhtin warned us to be mindful of a concept he called *chronotype,* wherein we "must recognize the complex interactions among past, present, and future" (2007:18). A mistake that natural history museums in particular seem to have made in the past, creating ongoing problems for today's professionals, is having conceptually separated the past from the present (and the future) in many public exhibitions. The natural history museum obsession with linear chronology and separation of geologically distinct time periods may well serve as an architect of learners' misunderstanding of the analog, rather than digital, flow of geologic time. Other essential Bakhtinian ideas, taken straight from physics, include those of centripetal and centrifugal forces of language, which are in constant juxtaposition with one another as we negotiate both our need for a coherent "center" and a loosened sense of reality as way to reflect and grow intellectually (2007:15).

Bahktin's *Discourse in the Novel* can ignite the science educator's approach by demonstrating how social stratification, and thus access and inclusion, is shaped by linguistic forms. Further, the teacher should avoid using an "exhaustive" linguistic approach to pedagogy because "language - like the living concrete environment in which the consciousness of the verbal artist lives - is never unitary" (2008:480). For science teachers, this means realizing that language is a constant *dialogue*, wherein a science learner must have some sense of being able to converse with the content in order to have the most effective experience.

Bakhtin held that “authoritative discourse permits no play with the context framing it, no play with creative stylizing variants on it. It enters our verbal consciousness as a compact and indivisible mass, one must either totally affirm it, or totally reject it” (Shields, 2007:19). It is more than just sensible for the science teacher, then, to act upon this notion and realize that individual and collective meaning-making in the science museum does not happen through authoritative knowledge impartation, but rather through other avenues. Shields encourages us to be mindful of when our methods of instruction “might reduce learning to memorizing of concepts rather than offering the opportunity for the creation of meaning” (Shields, 2007:19). If the traditional usage of authoritative language in the classroom can be morphed into a more naturally occurring, dialogic approach to conversing with learners, then we may begin to see an increase in learner understanding, enjoyment, and empowerment.

Oklahoma teachers already know this. In late 2016 I witnessed an elementary school teacher engage in a heated debate with a university professor. The professor insisted that rote memorization is sufficient learning, but the teacher knew better. She stood her ground against him in such a way that left me with no doubt that Oklahoma’s educators already know what I am saying – but I hope, at least, that some of what I have said about epistemological power and language is still helpful to them in classroom practice.

In a nation so entrenched in the ideology of democracy – of individual decisions, conscious choices, freedom, and liberty – American public discourse on most topics is reflective of such political worldviews. This is true of issues ranging from economy and religion to clothing, food, and music. Debate, innovation, friction, and intellectual disagreement have played a large role in moving the United States of America from a small colony to a leader of nations in just a couple centuries. Science is an issue because it poses challenges to the democratic model, and particularly because of our construction of how we may and may not think about science. In order to empower learners, scientists and teachers may take a page from anthropology's book and consider power dynamics and language when developing their work.

DO YOU SPEAK SCIENCE?

"Oh my gosh! Sorry!" cried Sally Ride, getting up to help Jane Goodall brush sharp little flakes out of her hair that had flown from Sally's hands. She had been striking a small length of deer antler against a conchoidal glob of obsidian.

"It's ok! I'm sure I will find some in the shower later. There's probably all sorts of stuff in here," Jane laughed and shook her ponytail. Tiny slivers of the volcanic glass sprinkled down her shoulders and onto the tarp under her camp chair. A few yards from where Sally and Jane were flintknapping, Sylvia Earle burst into uproarious laughter as she used her cell phone to film Ada Lovelace trying to toss an atlatl at a cardboard bison, quite unsuccessfully.

I walked inside the beautiful lodge at Robbers Cave State Park in Southeastern Oklahoma, with vaulted ceilings and huge windows looking out onto the glacially-carved landscape. Oklahoma Educators Evolve was putting on a special “murder mystery” workshop, wherein teachers were invited to solve the mystery of the Pleistocene megafauna extinction, while dressed up as their favorite scientist.

I sat at a table where four teachers dressed up as their favorite scientists worked with small slips of paper in front of them, in pairs. OKEE staff member Ben grinned at me. “They are getting really into it,” he whispered to me. The teachers were doing an activity where they use hand-written social media templates to create a fictional story. The templates, each a piece of “evidence”, are given to a different pair of teachers for analysis – it is an update on the Checks Lab discussed previously.

Hedy Lamarr, adorned in pearls and a long black gown, smacked her red lips together and read aloud from a paper card in front of her. Her partner, Rosalind Franklin, tried to hold back giggles as Hedy orated elegantly, “New phone. Who dis?”

Next to Hedy and Rosalind were Dian Fossey and Nikola Tesla, reading their own paper cards. “But this one is an Instagram of two cats. How does that fit in?” Dian asked Nikola.

“Maybe….it doesn’t?” Nikola said after a moment. “Let’s just set it aside for now.”

As the teachers continued to look at the paper cards, staff member Ben asked, “Alright. So after looking at the pieces of evidence provided, what do you think the story is here?” Rosalind and Hedy described the story they had extracted from the minimal clues. Ben nodded and shared that they were pretty close to the original story, then asked whether they had any questions about the activity and how to do it in their own classrooms.

“Well, I want to try to make the story content be about science if possible,” said Hedy. “Me too. At least, for my AP kids,” chimed in Nikola. “Would we just…basically do the same thing but have them use science words? Hypothesis, Theory, Law?” Hedy looked at me and Ben.

I jumped in. “Yes! That can definitely work. Tell me, how are your students with Nature of Science concepts? Like can they tell you the difference between a hypothesis, a theory, and a law?”

“Well…” Nikola sucked in some air, then sighed and looked knowingly at Dian. “Honestly, I am not sure I explain it so well to them in the first place.” Hedy and Rosalind both nodded vigorously, looking relieved that someone had said this before them, opening the doors of discussion.

“Ok. Here is one way to talk about that. It’s probably an oversimplification, but it can at least open the doors for students to think differently. Ok. So I think a lot of the time the concepts are introduced as being, like, linear – you know, if a hypothesis is good enough, it becomes a theory; and if a theory is proven, it becomes a law,” I said.

The teachers all agreed, saying that they had usually heard it explained in some similar way. I took this as a sign to continue.

"But – the thing is, putting laws onto a pedestal is pretty misleading. Laws are important because they clarify the facts – like, gravity is a force acting on us; life on this planet has changed over time; or planets move in an ellipse. But laws, as we usually teach them in science class, are not as powerful as theories. Theories have explanatory power. Laws are 'what', and theories are 'how'."

"So…to say something is '*just a theory'* – my students do all the time – that's kind of backwards. It's actually more like, it's '*just* a law' – something may be true but we can't understand it without theories," Nikola said excitedly.

"Yeah! Basically," I answered, "and again, this is just a super-simple way to explain it to students, but it can at least get them thinking about how scientific laws and theories are not the same thing – and why theories are actually really powerful. They are not just opinions."

A few more teachers had joined our table, and Ben continued the discussion when a quiet, unassuming teacher, Heather, tapped me on the shoulder and asked for a moment of my time. "I heard what you were saying about theories and laws, and it makes sense…but…well, my students are not even listening long enough to get there."

Heather and I had a long discussion about her concerns as a Christian teaching science to 5^{th} and 6^{th} grade students. She shared that students of that age seem to be more sensitive to their parents' and peers' opinions about Christianity and evolution than are younger children, who have not yet learned the social expectation that they, too, "must" pit one against the other. We began to discuss how language plays a huge role in her everyday life as a teacher trying to convey science concepts to resistant students.

To me, language and science are entangled to the point of no return, and they have been that way for centuries if not millennia. I think this is because *understanding* the universe depends on our ability to *explain* the universe, and these are complementary but distinct exercises in *thinking* versus *communicating*. This dichotomy is a prominent issue in modern science, and in my opinion is probably the most pressing problem for the continuation of human scientific endeavor.

"Scientific knowledge", like all forms of knowledge, must undergo some social fashioning before it is considered something we *know* versus something we *think.* Knowledge is constructed in part by how we conceptualize it linguistically, as discourse *is* legitimation (Bourdieu, 1991; Foucault, 1971). The content of scientific knowledge is thought to be legitimate because of its (perceived) clarity, parsimony, elegance, and precision, and so it follows that perhaps science could be made even more legitimate by communicating it with language that embodies those same qualities. Some of the most well-known characters in the history of science were devoted to making scientific knowledge meet the aesthetic of simplicity through their use of language; Linnaeus and his binomial nomenclature system that survives today is probably the best example. My point is that scientists have much incentive to communicate their work via clear, precise language.

I have spoken with several teachers who wonder whether it would not be better to just stop using the words “hypothesis”, “theory”, and “law”. And I do see their point – the demands of teaching science are already so great in Oklahoma that perhaps avoiding some language that is perceived to be contentious could work in their favor. But ultimately, I have to disagree. This is the same mistake as calling evolution the “e” word, and replacing it with “change” or “adaptation” in all public-school related documents. By doing so we normalize the rejection of the concept, simply by rejecting the word. However, many teachers may want to begin evolution-related learning journeys using other language in order to help students become comfortable and immersed in the topic, and this is a valid approach. But at a certain point, I think we must collectively put our foot down and insist on calling evolution what it is.

CHAPTER V: SUMINAGASHI

Orange and blue ink swirled across the top of the water, creating a pattern not unlike how a psychedelic marbled zebra might look, were there such a thing. Eight-year-old Pedro tilted his paintbrush carefully out of the tray full of ink and water, and put it back on the paper plate in the middle of the table. He looked up at me with huge, happy brown eyes. "I love this," he said, turning his attention back to the project in front of him, being incredibly cautious not to bump the table.

Pedro is a second-grader at a northeast Oklahoma City school. An adult supervisor in charge of him and several other children there had warned me about him as they filed into a small classroom, ready for STEAM camp. "Watch out for this one," she told me, "he *will not* sit still." As Pedro had first taken his seat, he and his friends were snickering and told me that they "*hate*" science class. Soon after, they were completely enthralled with the Japanese art of Suminagashi, or paper marbling. It may be an art, but I had tricked the kids – Suminagashi is also a science. The process of marbling paper with ink floating on water is only possible because of physical laws governing surface tension. It was the same reason we could fit dozens of drops of water on a penny without it spilling, even though we had only predicted a penny could hold two or three drops; it is the same reason a raft spider (*Dolomedes fimbriatis*, also known as the Jesus spider) can comfortably poise itself on the surface of a lake without worry of drowning.

Suminagashi requires more time, set-up, mess, and materials than most teachers are willing to deal with for small children. But I stubbornly continue to use it as a STEAM camp activity, and I encourage other teachers to try it, too. Every swirly print produced from dipping light paper into the ink-covered water comes out unique. The ink must be dropped onto the water very carefully, as a good bump to the table will send it careening to the abyss of the water below it. With many students at a table, it suddenly becomes very important to keep still, to make calm movements, and to share ink and brushes without squabbling.

Public education is like Suminagashi. Everyone must share supplies; everyone must watch their elbows and be careful not to ruin things for the student next to them. Each must produce something with the same basic materials, and yet remain unique enough to avoid being lost in a pile of paperwork. And most importantly, those in charge of the artists must allow for the seeming chaos that ensues as they create something special. In this chapter I will review the issues of personalized education, school choice, and how the Science Empowerment model uses hands-on learning approaches to create contexts for true choice.

THOUGHTS ON SCHOOL CHOICE AND SCIENCE EMPOWERMENT

Is this work a product of the "personalized learning" movement? I have been asked this question many times throughout the years I conducted fieldwork, especially when I taught engineering classes. Parents, other educators, and colleagues involved in those particular programs were keen on customizing learning experiences for children – and for a price. When I first began teaching engineering classes for children, I was not the director of those programs, nor anywhere near a person with the power to make many decisions about how the programs were run. But teaching was what I enjoyed the most, and it is what made me stay closely involved with others who do not hold my views on public education. I learned a lot about what "personalized learning" and "choice" mean to various stakeholders from teaching engineering, too – more than I could learn in local museums.

Diving into education studies in Oklahoma – specifically its science museums (of which there are few: Science Museum Oklahoma, Sam Noble Oklahoma Museum of Natural History, and Museum of Osteology – two of which are private, for-profit entities) has been difficult not only because of the anti-science social climate here, but also because there exist mostly tenuous analogs for such work. Educational visitor studies, including those that have been done in science museums (Diamond, 2016), have primarily taken place in museums that serve large urban audiences, such as the American Museum of Natural History, Smithsonian's National Museum of Natural History, and Chicago's Field Museum. These audiences tend to be college educated, upper middle class, and white. Of course these are the same demographics of many people who visit the Sam Noble Oklahoma Museum of Natural History as well, but our museum's local audience and politics of representation are distinctly different from the ones mentioned above, and so its science education must be treated as unique.

In places where formal science education is lacking, museums have the opportunity to become more than a backup plan, a supplement to book learning, or a field trip playground. Museums in such places, and of course here I mean Oklahoma, must become a necessity for public education. Oklahoma is one such place because our state is characterized by poor public funding for education, weak and unequal schools, and a reverence for private business over public need. Education is an industry here, which is evidenced by the many private and charter schools cropping up across the state.[vi]

When education becomes an industry, several things can happen (Vergardi, 1999; Stoddard and Corcoran, 2007). First, people begin to see it as a commodity ("I *have* an education") and a luxury sold in a marketplace where schools can end up falling into hierarchies based on cost rather than quality or social meaning. Second, teaching becomes an expendable profession, and in Oklahoma we have tremendous evidence of this in our barely-prepared, Teach for America-esque education workforce that means a huge shortage in qualified teachers, and our astonishingly low teacher pay (Darling-Hammond, Holtzman, Gatlin, and Heilig, 2005; Berliner & Glass, 2014; Mead, Chuong and Goodson, 2015; Fuller and Dadey, 2013). Third, education becomes inseparable from economy, such that any educational policies or ideologies will revolve around economic value. For example, Oklahoma's educational discourse is absolutely bedazzled with words like *workforce*, *pipeline*, *jobs*, *competition*, and *labor*. I know because I use them all the time in grant proposals.

It is important to point out that industrial or economic ideology in education is neither new nor necessarily negative. Many of my own research projects have probably only gotten grant funding because my proposals make frequent use of those buzzwords mentioned above. And of course, having a thriving generation of people with secure, good jobs is certainly preferable to the alternative. However, what is crucial in the case of Oklahoma is that most of our citizens are largely missing the benefits of tying education to industry. Let the aerospace industry serve as an example: Oklahoma has about 20% of America's jobs in that sector, which is a tremendous amount; these jobs pay well, offer security, and require skills that are useful in many other contexts, so the training really pays off. However, we import many of our aerospace professionals from Texas, other areas of the United States, and of course from other countries. While this is good in a global sense, the people of Oklahoma are experiencing this economy in a different (read: worse) way. An example more closely tied to paleontology's strengths is the energy industry – people in Oklahoma are in a prime position to benefit from renewable energy, but our ingrained ideas about fossil fuels prevent us from doing so.

I will turn for a moment to anthropological conceptions of schooling to illustrate how much education is tied ideologically to economy. Schools exist to create literate, educated citizens – or at least, citizens who can be productive members of society because they can contribute in some way to national economy. Schooling is thus sold as access to productive citizenship, and learning is traditionally legitimated as such only when it has occurred in these formal settings (Kuhn, 2005; Gruber et al, 2011). I am clearly biased in believing that education should not be reduced to purely economic ideologies, and this makes working in an economically valuable realm of education (STEM) all the more interesting.

HANDS-ON, MINDS-ON

The Science Empowerment model works especially well when the strengths of informal education are applied to the school classroom. In particular, engaging in "hands-on learning", as educators call it, is one of the most effective paths to bring the concepts of literacy, access, and cultural intelligence together in ways that suit children and teachers of many walks. An issue I have heard often in the field from teachers is that hands-on learning seems great, but that obtaining objects and manipulatives or specimens for classrooms is exceedingly difficult with little to no budget. One middle school science teacher shared, for example, shared with me that her entire science class budget for a school year is $100; this is for nine months and up to 75 children. A primary reason for bringing teachers into the field through Oklahoma Educators Evolve to collect their own fossils is to help combat this issue. If a teacher seeks funding for classroom materials that cannot be collected in nature, this section should help provide some literature and background that can be used in discussions and proposals. I will discuss ten particular benefits to using hands-on learning, or HOL, gathered from classrooms and other learning contexts around the state of Oklahoma.

First, hands-on learning creates situations for learners to experience tactile engagement. Tactile engagement means using the sense of touch to explore objects and concepts, and it is an important source of skill improvement, including motor skills, for developing children (Dodge, 2009). Educators have thought for many years - perhaps for more than a century - that children learn especially well when provided with manipulatives (Lucas, 2014). Maria Montessori comes to mind when thinking about pioneers in hands-on pedagogical thinking. Her work has been foundational in helping educational organizations understand how children can most successfully learn, and the institutions she inspired hold to her belief that experiential, hands-on activities are among the most engaging for children (Lillard, 1996).

While the use of visual media such as presentations, photographs, and videos can provide students with a good sense of the material they are striving to learn, object-based HOL creates even more interactive learning situations that can offer students a higher level of engagement, and perhaps a richer learning experience. One example from the field goes as follows. In administering TOLT (Test of Logical Thinking; Tobin and Capie, 1980) exams, I have found that students' abilities to apply probabilistic and combinatorial reasoning usually improve when they have access to manipulatives, versus answering the same questions with paper and pen.

In another example, I conducted a lesson on osteology with adult learners. The concept of *pathology*, damage or deformity in tissue and bone, was made much more accessible to the learners through the use of real osteological specimens that featured real pathologies. Learners were able to pick up and examine specimens, feel the differences between unaffected and pathological bone, and determine what may have caused the damage to the bone. With the opportunity to examine the bones closely and feel their texture, learners were even able to extrapolate whether the animals in question survived the event that caused their pathology.

Second, hands-on learning is a free choice enterprise. "Free choice" is a term used often by museum professionals and educators to refer to learner-driven activities (Dierking and Falk, 1998). There may be goals within a lesson or activity that are guided by teachers, but each learner may use the materials at hand to explore concepts and ideas of their own interest. The objective is not to choose what students will be interested in or how they will pursue those interests, but rather to help them acquire the skills and confidence they need to celebrate and follow their own curiosity.

The educational theorist Jean Piaget argued that children go through distinct stages of cognitive growth (Piaget, 1965). He encouraged generations of teachers to imagine a child's perspective when designing activities, considering the continuing development of their motor skills, operational abilities, and thought processes. Piaget understood that children learn best when they are able to experience and do things for themselves, which not only increases a child's knowledge base, but also helps them achieve higher levels of understanding through free-choice experiences. This applies to learners of all ages.

One example from the field that illustrates the free-choice nature of HOL is an experience with teaching engineering concepts using LEGO bricks. When given the same set of bricks and instructions to “free build”, students will generally create morphologically similar models, but models that are distinctly different from one another. For example, students will often all decide to build cars or morphologically/functionally similar vehicles, but no two cars will look quite the same by the end of the building session. Children must be given genuine choices within the parameters of a classroom in order to learn most effectively (Kuhlthau, Maniotes, Caspari, 2015), and HOL offers choices that a learner would not have access to through more traditional learning methods.

Third, hands-on learning improves spatial reasoning skills. Spatial reasoning is a mental skill that children begin to develop at a very young age (Marek and Cavallo, 1997). This skill involves how an individual deals with physical and visual stimuli, as well as how an individual visualizes concepts in their mind. Howard Gardner was one of the first education theorists to realize that everyone has different “kinds of intelligence”, though I prefer to say skills or proclivities, and that working on certain areas such as spatial intelligence will help any learner become more proficient and confident in their skills. He suggested activities focused on HOL for improving spatial intelligence or reasoning (Gardner, 1983), including building models and sculpting with clay.

For a long time, people thought that there are biological differences between boys' and girls' spatial reasoning skills. Leading science education researchers, however, have developed new ideas about why disparities in gender appear on tests of spatial reasoning. We now consider the social aspects of learning and conclude that if a learner has more exposure and opportunity to develop spatial reasoning skills, they will be stronger in this area of learning regardless of gender (Newcombe and Stieff, 2012). Hsi et. al.'s (1997) study on the importance spatial reasoning in developing engineering skills has also shown that gender disparities disappear when students are equally well-prepared in spatial reasoning.

I turn to an example from the field in which students attempt to build a gear transmission (a series of gears that fit together to work as a system). Building and investigating objects requires learners to think spatially, imagining what something might look like before it is built, imagining how to modify it to make it look or perform a certain way, or where to move pieces of a model in order to fix a problem. In a common LEGO model, a gear transmission runs along the bottom of a vehicle called the "Sweeper". The final gears in the series emerge at the front of the vehicle, where they serve to spin the "blades". All gears must be connected in order for the transmission to function and the blades to move. I often ask students to think about using different-sized gears, or even pulleys, to achieve the same effect of moving the blades on the model. Thinking about how to transfer motion from wheels to gears to a pulley requires spatial skills that students can develop more fully by testing their ideas with objects directly.

Fourth, hands-on learning builds critical thinking skills. Critical thinking is a method of analyzing and applying information. It involves using logic and reason as the basis for our decisions, and much of critical thinking can be based on observation, experience, and reflection. Critical thinking is an important skill because it helps learners discern between different kinds of information and what to do with it, which is something they must do every day as members of a vibrant and ever-changing society. Instructional theorist Jerome Bruner (1966) argued that learning happens through three modes of representation: enactive representation (action-based), iconic representation (image-based), and symbolic representation (language-based). He thought that learners go through the modes in that order, meaning that active-based learning is useful when facing new concepts and challenges. The ways in which children learn new concepts have been debated for at least a century in the United States, but the point remains that HOL can contribute to that learning.

Hands-on activities inspire *objective* learning, where children are observers of the world around them and use inductive and deductive reasoning to think about what is happening and to build their knowledge. HOL also supports constructive and connective learning theories over traditional cognitivism and behaviorism. This means that instead of seeing learning as a process of memorizing information or as automated reactions to things teachers say, learning is the social and personal process of constructing and understanding the reality in which children live. Children are better able to connect what they hear, see and experience with what they encounter with each new day.

I take an example from fieldwork in which a group of children had been learning about Newton's Laws of Motion. The First Law (*an object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force*) can be demonstrated by placing a penny on top of an index card, and then resting the card over the opening of a weighted cup. In this example, students used styrofoam cups weighted with candy. The goal of the experiment is to get the penny into the cup without actually touching it. This can be achieved by quickly flicking the index card out from under the penny, causing the penny to drop into the cup. If the card is moved too slowly, the penny will fall onto the table or other surface holding the cup. This seems counterintuitive, since many students think at first that they should move the index card slowly and carefully in order to get the penny to drop into the cup. A hands-on experiment shows them otherwise and gives them a chance to think critically about why their first methods may have failed.

Fifth, hands-on learning challenges learners to directly evaluate evidence. Evaluating evidence is a skill that every learner engages in and fine-tunes when using hands-on learning. Just as students use their critical thinking skills to recognize problems and discern possible solutions, they also think about whether their assertions are true based on what they are directly experiencing, seeing, and building. Piaget, Bruner, and other educational thinkers have shown that students learn especially well from forming their own hypotheses and testing their own, and peers', ideas.

In my experience in the field, I have faced frequently scrunched faces of frustrated students who are unsure what “evidence” is, why they should care about it, and how to use and evaluate it. One of the most important aspects of science and engineering is to be able to make mistakes and improve upon or change our ideas as we make more discoveries, and evaluating evidence is the key to doing so. In order to learn constructively, students must evaluate whether their ideas or designs are working. I think students construct knowledge by thinking about different problems and questions, and then putting their ideas to the test. For example, I have asked students to build different energy-producing apparati such as wind or hydraulic turbines. We can then capture the energy in a small battery and use it to power students’ free-built models, such as cars. The students’ job is to make predictions about what kinds of apparati will produce the most energy in a given amount of time, and then to gather evidence (support) for their hypotheses. Using actual models means that learners must look at and evaluate the evidence in front of them, going wherever it leads.

Sixth, hands-on learning is, by nature, an inclusive experience. Being inclusive means making sure that programs have something to offer for diverse and multi-talented students with a wide spectrum of interests, experiences, and goals. This is where the access and cultural intelligence factors of the Science Empowerment Model really come into play. Using objects allows learners to approach tasks and problems with a variety of skills and learning methods. Every science class is composed of a variety of students, no two alike. Howard Gardner’s Theory of Multiple Intelligences

(Gardner, 1983) is a useful way of understanding how people approach and process information – although people do not really talk about "intelligences" anymore, but rather skills and proclivities, and this is important to keep in mind. Every student has a special suite of "smarts", meaning they bring different experiences and strengths to the table. Furthermore, HOL has the capacity to support the growth of students' logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, and interpersonal intelligences, among other skills, as HOL tasks can be tailored to help students with each of those skills.

In the field, I have seen the inclusive nature of HOL by inviting Oklahoma teachers from all grade levels and subjects to come and engage in a similar task: collect and learn about Earth's history through fossils. Teachers with myriad skills and interests have participated in fossil-finding field trips that required them to do things they don't normally do. English teachers identified paleoenvironments; math teachers created stories about the places of past Oklahoma. Science teachers developed lessons in historical geology, complete with a cast of characters; Special Education teachers imagined ways to use fossil preparation and care with sensory-challenged students to teach about adaptation. High school AP chemistry teachers found meaning in stories of indigenous America's beliefs about and practices relating to fossils.

Maria Montessori ([1912] 2013) believed in a prescription of having mixed-age classrooms, pairing students by interest and ability, offering genuine choices to students about how they will spend their work time, and making sure that all of our materials are accessible and easy for children to use. I agree with these classroom values, and believe that HOL provides a great context in which students of different levels, interests, and ages can observe one another working and interact in ways that are much more difficult with traditional learning materials like textbooks.

Seventh, hands-on learning deconstructs barriers between people, interests, and skill levels. Deconstructing barriers involves identifying learner strengths and goals, creatively approaching problems, and helping learners to overcome challenges. All students have some form of barrier to different kinds of learning, and using hands-on materials can give students the tools to break down those barriers. Maria Montessori was a proponent of mixed-level, mixed-age classrooms, and the use of tools and classroom supplies directly by learners (Montessori, [1914] 2011). A group of learners of different ages and levels can engage in HOL as a way of bridging gaps in communication, understanding, attitude, and ability.

One example of this bridge as made possible by HOL is in the ability to retain information. In studies of memory, both young children and older adults have been shown to have improved memory recall of lessons that are taught in a hands-on versus demonstration or observation method (Karlsson et al, 1989; Hartman et al, 2000; Hillman, 2011). Another example of how HOL bridges gaps is in communication and language. For example, Carbo (1983) tested learners and asked about their learning style preferences, finding that learners who are weak readers have “a stronger preference for tactile and kinesthetic learning.”

“Math anxiety” is a considerable barrier for many students (Wigfield and Meece, 1988; Tobias, 1991; Ashcraft, 2002). Math anxiety is thought to be especially prominent for ESL/ELL learners, economically disadvantaged students, and minority students (Green, 1978; Gasbarra and Johnson, 2008). Researchers have identified ways of disabling math anxiety for students (Jackson and Leffingwall, 1999; Tobias, 1993; Furner and Duffy, 2002). It has also been noted that gender stereotypes (“boys are good at math; girls are good at reading”) are more common in classrooms where female teachers have math anxiety (Beilock et al, 2010). Furner and Duffy cite the use of manipulatives and HOL methods as being effective in alleviating math anxiety (2002:69). Math is not the only area of STEM that causes anxiety in students, but it is certainly a prominent topic for discussion when we want to deconstruct barriers.

Eighth, hands-on learning gives learners an invitation to think. Each day, people produce thousands of thoughts, filter those thoughts, and reflect on a selection of them. As Benedict Carey writes, “the brain is not like a muscle...it is something else altogether, sensitive to mood, to timing...to location, environment. It registers far more than we’re conscious of and often adds previously unnoticed details when revisiting a memory or learned fact” (2014). When faced with problems, our brains have hardwired ways of responding, but people are also faced with making active decisions about how to approach and handle challenges. Deciding to face problems with careful thought and reflection is, in my view, an agentive act different from traditional classroom challenges. Often in formal settings students must recall information or memorize facts rather than critically consider issues and apply them to larger conceptual frameworks. This is not necessarily a problem of instructional design (as student attitude can play a large role in how effective these practices can be), but adding manipulatives and a chance for tactile engagement can significantly improve reflection experiences for students.

Hands-on learning is an open invitation, rather than an order, to think because learners have the opportunity to answer their own questions right before their eyes. An important factor of influence in engaging in thoughtful reflection is *interest*; and interest especially plays a large role in successful science learning. There is an important place for learner play, confidence, and control in creating and sustaining interest in science concepts (Schweingruber and Fenichel, 2010), and adding hands-on activities to lessons is a great way to give students the opportunity to experience those factors.

Educational theories support the notion that HOL is a helpful tool for engaging learners in reflection and thought. Psychologist and educator Erik Erikson wrote, “There is in every child at every stage a new miracle of vigorous unfolding” (1963). He studied how children go through stages of learning and development, meeting new challenges at each stage. Children learn trust, willpower, initiative, and competence as ideal outcomes of meeting life’s early challenges. Educational theorist Lev Vygotsky thought that children have a special “zone” of development (annotated as ZDP) in which they are unable to do new tasks alone but are able to learn them with help from peers and teachers (Vygotsky, 1987). Mooney (2013) has reviewed ways in which hands-on experiences help children move from one level or stage of learning and development to the next, citing examples such as building real structures and using real tools. This sort of scaffolding has also been noted as effective for teacher professional development (Edwards, 1995).

Ninth, hands-on learning is a customized experience. This is because it will be different for each and every student, and the ways in which learners make sense of the work they do will have different meanings and effects for all of them. Even when engaging in similar projects as their classmates, students doing hands-on activities have frequent opportunities to test and modify their creations into something unique. Working from constructive and discovery models of education, new creative experiences are available to every hands-on learner. Educators can guide students through foundational tasks and projects, building up their knowledge and confidence as they continue their work into different areas of personal inquiry. It is important to offer relevant project choices to students and give them plenty of time to develop and explore their own ideas (Montessori, 2011, 2013; Kuhlthau, Maniotes, Caspari, 2015). Just as learners can customize a LEGO model or paper airplane, educators can tailor student experiences to their own interests and sense of relevance. This is an incredibly important concept because learners will need to make individual choices about their careers and lives, and they are much better prepared to do so if their education is an active, engaging, and relevant learning process.

Educational theorist Jerome Bruner wrote, “Each scientist approaches the problem from his own vantage point, and the vantage points are happily many” (1966). Learners (who are the “scientists” in this scenario) must be given opportunities and intellectual room to explore their vantage points, which HOL offers. Maria Montessori and Jean Piaget both thought that children need to discover and construct learning within their own contexts and range of ability and understanding. Montessori (2013) had the especially pertinent idea that learners need long, uninterrupted blocks of work time and appropriately-sized, real tools, as well as access to many materials, in order to effectively and freely learn. In the case of Science Empowerment in Oklahoma, the STEAM camps I have worked on are built around this concept, and learners are rarely interrupted from focused work.

Finally, hands-on learning is an excellent tool for collaboration. Learning to work together with others successfully can be difficult, and using objects in the classroom creates opportunities for students to improve intrapersonal skills (Gardner 1983). Learning is a social endeavor, and although some students may prefer to work alone, all can generally benefit from projects that inspire teamwork, collaboration, and cooperation. As Lev Vygotsky has said, “What a child can do in cooperation today, he can do alone tomorrow” (Mooney, 2013). Vygotsky thought the role of the teacher is one of “scaffolding”, in which the teacher helps to build student knowledge, connections, and abilities so that students can reach higher levels of learning. Students can also help with the task of scaffolding for each other, because watching peers and working in pairs or groups helps students extend their learning abilities and stretch their strengths (Vygotsky, 1987; Mooney, 2013).

A field example of collaboration through HOL comes from an experience I had at a summer camp. Several students were not interested in working with others, but were trying to build models that usually require two builders. Other students were more than happy to work in pairs or groups, and they solved the “lone builder” problem by offering to help organize, count, and lay out pieces as the builders put together their models. This system encourages lone builders to communicate with a peer, and even gives them a role of leadership as they direct the “organizer”.

SUMMARY

Hands-on learning (HOL) is an indispensable pedagogical method for all manner of subjects, and the Science Empowerment Model is especially effective when paired with hands-on learning approaches. To paraphrase Benedict Carey (2014), I urge educators - especially those in STEM classrooms - to consider the science of learning as less of a recipe or “list of self-help ideas”, but rather more of a system of meaning or a way of life. In other words, perhaps rather than teaching students a list of tricks to help with rote memorization of facts, we can instead encourage them to explore what works for them when it comes to learning. The use of hands-on methods in the science classroom helps us to do just this. A quote for thought:

"Like so many others, I grew up believing that learning was all self-discipline: a hard, lonely climb up a sheer rock face of knowledge to where the smart people lived. I was driven by more of a fear of falling than by anything like curiosity and wonder" (Carey, 2014)

The "climb" to knowledge should be anything but lonely, and should be driven exclusively by curiosity, wonder, and relevance. Hands-on learning can help achieve these goals, and policy makers and educators must seriously consider implementing more object-based and tactile learning in every classroom in order to gain the full benefit of using the Science Empowerment Model.

CHAPTER VI: EMPOWERMENT

"Do you think they'll frack in Boley?" thirteen-year-old Jay asked, looking at geoscience educator Alex earnestly.

"Yes. Yes, I do. This is exactly the sort of place that companies will want to frack. Somebody will come here offering lots of money to get your permission to frack on the land. And I understand if you tell them yes."

"…Would we be bad people?" high school sophomore Andre asked after a moment.

"Of course not. You are citizens and you have to make decisions, even if some of the consequences aren't great. But what I want to stress here is that this is *your* town, and *you* will make those decisions," Alex said. I was unsure about his assertion that we should talk to Boley teenagers about fracking, but I quickly realized it was an important conversation for them to have. The teenagers had become noisy with chatter, discussion, and debate about what fracking might mean for Boley, because like many other small towns in Oklahoma, the area is geologically prime for such an operation.

"Have y'all ever see the movie *2012*? That one where the Earth is about to be ruined by solar flares, and a megatsunami wipes out everything but Africa?" Alex asked. Many of the students had; they erupted in laughter and started making fun of it. “You know what people say is the craziest part about that movie? That it’s about a black geologist.”

Crickets. Silence for a moment, and then finally college freshman Laurie spoke up, “Wow. I guess I don’t know about that many black scientists. Are there really no black geologists?” Alex shrugged. “Honestly, I don’t know more than a handful myself. And I did my Geology Master’s in Philadelphia.”

As the group began listing areas of science and trying to think of people of color who work in those fields, the teens began to see the point of the conversation – that they are woefully underrepresented in science, which they had of course known – but most of them had not thought about it in those stark terms before. We ended the session by talking a bit more about how the teens could be involved in science, whether as a citizen or as a professional; we then asked whether they had seen the recent reboot of television’s *Cosmos* with Neil deGrasse Tyson. Not a single one had, so we set up a viewing space. Seventeen-year-old Jasi was the first to sit down and pay attention to the show. When Tyson came on, she squealed, “*He’s black*?!” Her friends rushed over to see. The teens ended up spending most of the afternoon there, enthralled and staring at the screen. That was in 2015; two years later, both Jasi and Laurie were STEM majors in college.

Being able to see oneself as a part of realities like the world of science is a form of empowerment. Empowerment is the antidote to anxiety, and the key to clarifying and improving science identity. Science empowerment relies on a flexible but strong scaffold of literacy, access, and cultural intelligence. Each of these three sides are necessary to construct the foundation for a positive science identity. The issue I have identified as an anthropologist is that access and literacy often exist together as a pair without cultural intelligence, making a lopsided and incomplete attempt at effective science education.

I have talked in some depth about the concept of science literacy, and how it encompasses a conglomeration of crisis, citizenship, and competition. If we agree that "science tends to be a Western cultural icon of prestige, power, and progress" (Adas, 1989; Cobern and Aikenhead, 1997), then the Science Empowerment Model is a way to help students claim science as their own. In this chapter I review how the model can look different for people doing, teaching, or learning science. I close the chapter with a discussion of hands-on learning, an approach that is especially well-suited to the Science Empowerment Model and particularly to the science learning contexts where I did my fieldwork.

TEACHING SCIENCE

After nine hours of workshopping one autumn Saturday, the sun and I hurtled steadily toward our destinations on the horizon. It had been a long weekend in northern Oklahoma, with a hundred miles of waving golden farmland between me and the highway that would take me back home. I cracked my neck once left and once right before taking a long drink of stale gas station cappuccino and pressing *play* on a used audiobook I had picked up. It was about imagination, creativity, and thinking outside the box. I couldn't mentally separate it from what I had seen and heard at the teacher workshop.

In 1977, when Carl Sagan published *Dragons of Eden* on the origins of human intelligence and Jean Piaget was advancing paradigm-shaking ideas about how learners construct knowledge, a few engineers accidentally created the single most powerful tool I use at teacher workshops. The inventors of what we now know as Post-It notes had been fumbling for half a decade with paper, adhesives, and finicky chemical formulas before they accidentally created their employer's best selling product. Forty years later, we had tried something new at Oklahoma Educators Evolve that weekend, and Post-Its took center stage in helping teachers and scientists work together to think outside their respective boxes.

Teachers had gathered early in the morning, and as their knives and forks clinked on plates of bacon and eggs, I stood at the front of the room and introduced myself and the rest of the staff. Glasses steamed from hovering above hot cups of coffee reflected my nervous face back at me. Nervous, because I always am in the moments before I dive into talking about evolution with Oklahoma teachers.

"We started the Educators Evolve program to help teachers. We know you have to teach certain standards, and we are content experts. We specialize in evolution, climate change, and related topics -" I saw two English teachers glance at each other – "but we are here to help no matter what you teach. Maybe some of you have brought evolution into your classrooms and met resistance -" teachers nod and murmur and chuckle at this – "and some of you might avoid it altogether because of that. I have heard stories from teachers around the state who feel especially anxious about teaching evolution because they are unsure about how it meshes with their religious identity, or the religions of their students. These things are all ok to think about. This is a safe space to talk about these issues. I encourage you to utilize our staff today if you have questions about this stuff – many of us teach evolution at the college level, and are happy to share our experiences with that." As I looked from face to face, I caught sight of many looks of relief, comfort, and perhaps even a hint of amusement.

With the subject broached, we spent the afternoon creating "pitches" for science programs and projects that teachers want funded in their schools and classrooms for their students. We used hundreds of Post-its to give each other notes, feedback, and encouragement; every teacher left with a large stack of them, all covered in useful scribbles. In the Science Empowerment Model, this kind of creativity can only be unleashed when teachers are able to release epistemological anxieties and allow their science curiosity to freely flow.

DOING SCIENCE

Pausing to reposition my sore legs and take a sip of water, I looked up and squinted around, taking a mental inventory of what the teachers were doing. There were only ten of us out there, but we had already spread out across the tremendous expanse of white that constitutes Oklahoma's Great Salt Plains. After a moment I was able to locate each teacher, identified only by the tops of their heads as they dug in the ground. Piles of sandy, reddish-brown sediment had accumulated all around each of them – some more than others. *Perfect bird nests*, I mused.

I pushed myself off the damp white ground and stole a lower back stretch as I slowly stood up. Grabbing my trowel and colander, I began a cautious walk over to Cass. Stepping around and over each previously dug hole was quite a feat for my clumsy nature. Cass said hello as I walked up to her, holding up something in her hand to show me. I leaned down to look, and a bright glint of sunlight reflected off the object into my eyes.

"Hey, that's a really nice one!" I plopped down near her. The crystal was one of dozens that lay all around her, each carefully pulled out of the ground. "So, how is your school year going?"

Cass brushed a coat of salt off her jeans as she sat back and smiled. "Actually, great. It's starting to slow down a bit now, so that's nice. And coming out here " - she looked around the huge floor of salt surrounding us – "is just awesome." We sat in comfortable silence for a few moments, scratching at the crunchy halite with our trowels. "Oh, you'll love this," she grinned suddenly, "I was inspired by our trip last fall, so I taught a unit on dinosaurs!

"I've been teaching for 22 years. But I never did a dinosaur unit before– I just…I didn't think I could make it…you know, relevant." Cass shrugged happily, "but they absolutely loved it, and we all learned something. They had to do a ton of research." she leaned forward again to resume digging, but kept talking excitedly. As she described the lessons to me, I felt a wave of relief. For 13 months, I had been taking teachers on field trips all around the state, half in an attempt to do the things I set out to do as a researcher, and half in hope that they would cultivate an infectious adoration for all things natural history, the radiant energy from which would be absorbed by their students. Far-fetched dreams, perhaps, but they were there all the same.

The wind blew through my sweaty, salt-matted hair, and as I scratched some sand off my scalp I asked her whether she had been doing her lessons based on the new standards. "No…" she said, not looking up from the ground, "it's a Gifted and Talented program. We don't…you know, have to teach to a test. We can make our own decisions."

"That is not something I hear teachers say very often," I ventured. It really wasn't.

"We used to have money…we used to have a lot of things," Cass sighed. "But no money now. I mean, it's ok…it's a great program. We have a lot of freedom. Nobody tells us what to do or what to teach," she glanced over at another teacher, not 20 feet from us, heightening her voice just a bit, "I'm lucky."

After several hours and a healthy crust of salt all over us, we were ready to head back to the community center for lunch. We arrived, spent some time washing our treasured crystals, and settled in to discuss local geology and how the teachers could use their new specimens in the classroom.

In the Science Empowerment Model, doing science (in this case, scientific fieldwork) is made possible by accessing and drawing upon local resources and knowledge, as teachers are able to make personal meaning from the experience by tying it to their own classrooms and students.

LEARNING SCIENCE

The road leading into Boley, Oklahoma is partly comprised of a tiny overpass that bridges a trickling creek. Early in the morning, an aquatic ecologist from the University of Oklahoma had driven his field truck over the bridge, careful not to hit a bump and break one of the dozens of aquariums nestled in the truck bed. As we unpacked the truck and set up a series of freshwater ecology experiments while the sun rose, campers became visible down the street as they skipped and ran towards us.

It was August 2015, another day of STEAM camp was about to begin, and dozens of children poured into the yard of the Well Springs building, ready to start the day. “What kinda science we doin today?” seven-year-old Kiya tugged my sleeve. “Well, I was thinkin biology! How about that?” The children squealed and began investigating the tanks and other equipment set up by our session educator from OU, Dennis. His eyes grew wide at the site of kids peering curiously into the tanks he had set up, and he became flustered with answering a string of camper questions. “Did y’all get the water from the bridge?” asked one of the teenage campers. Dennis nodded. “What’s in that water, anyway?” five year-old Jerricka inquired, pointing to the bridge. We spent the day exploring the answer to Jerricka’s question by swimming, capturing, splashing, examining, debating, reading, researching, painting, drawing, and discussing.

“So...d’you mean I can get paid to fish?” Billy tilted his head skeptically as he helped Dennis load equipment back into the truck at the end of the day.

“My job is basically what we did all day today. The difference is mostly that I record everything really carefully and keep doing it each day, and I go back to the lab sometimes to store things. Anyway - so yes, you can get paid to fish!” laughed Dennis.

“Well...now I’m not sure if I want to be an engineer or an ecologist.” Billy fell into silent contemplation. I later learned that the previous year, Billy had been expelled from school for behavioral issues. How far a child can come, in the right classroom; and perhaps not even in a classroom as we know it.

A CONVERSATION WITH OKLAHOMA'S INFORMAL SCIENCE EDUCATORS

"You never think about having to do this at work!" remarked Emily to me as she separated a glob of cotton cobwebs from some hippopotamus ribs. Carefully pulling a long stretch of cotton over a giraffe skeleton's femoral condyle, I reflected on months of watching, listening, and lending a hand around an Oklahoma museum. After all of the visitors had left on that Halloween night, I worked slowly and cautiously with staff to remove the holiday decorations and return the gallery to normal for the visitors of the next morning. Just last week, I was scrubbing fake blood off the floor of the classroom, where it had been splattered liberally for an adult murder mystery event. And a few days before that, I had helped museum educators blow up balloons for a child's cat-themed birthday party in the same room. These activities perfectly illustrate what Emily, the museum's Director of Education, meant when she said "do this at work." A museum is a special place in this way, and its staff must wear many hats – especially its educators, who have direct contact with diverse and varied publics.

It has been well established that the majority of learning does not happen in a formal classroom, despite the the tradition of asserting so through educational policy and financial attention. One of the most popular settings for informal education is the museum. This is especially true for science-related museums, which enjoy the visitorship of millions of people each year. The National Science Foundation's LIFE

Center has demonstrated what many museum educators have said or suspected: formal education only covers a relatively small portion of the average American's life, which is significant. Although formal schooling happens during influential and formative years of an individual's life, it stops for most people just as they are reaching the age where they begin to engage in politics, make serious decisions about their futures, and begin to have their own families. Informal learning goes far beyond formal schooling periods, and begins well before those years. Until only a couple of decades ago, US science education policy had not taken this fact into serious account, as evidenced by their only more recent involvement in the non-formal world of learning. But Oklahoma has been reliant on informal science education for some time, and in more depth than I had ever expected to find.

Informal educators work throughout Oklahoma. They are a tightly intertwined, interdependent network of individuals from all parts of the United States, and with myriad knowledge-bases and backgrounds. They come from many walks of life, many creeds and contexts; but they all agree on two things: 1) a deep love for science; and 2) "never" wanting to be a teacher. Here of course they are referring to public or private school classroom teachers, as have been described throughout this dissertation.

"I felt like I lost my identity," Emily told me on another day, as we ate lunch in the afternoon sun on the University of Oklahoma campus between outreach sessions at schools nearby. She continued, "As soon as I started student-teaching. I was SO excited to start – I had wanted to be a teacher since I was a kid. But then I got there…and...I mean, maybe it was the teachers they put me with?" she looked at me earnestly, like she did not want to openly trash the whole experience of being a student-teacher. "I don't know. Anyway, it was like, they just didn't *care* -"

"Students didn't care about science class?" I interrupted.

"No, well, yeah – I'll get to that – but I mean teachers." Emily sipped her iced tea and then let out a deep sigh. "So, this teacher I was assigned to – he was my mentor – it was like, his 20th year of teaching. He was just about to retire. And he didn't even try anymore. Seriously."

"Wow. How could you tell? Can you describe a typical day with him?"

"Oh god," Emily laughed, "anyone could tell. He just came in, droned on and on until the bell rang, depended totally on textbooks and 40-year-old slides. If a student struggled, he would just be like, *'oh, well, not my problem'* and keep on…you know, being a shitty teacher."

"What did you want to do differently?" I asked. Emily sat up, alert and excited to answer this question.

"Ok. So. First of all, no lectures. No being indoors! Well, I mean, unless there's been a blizzard," Emily chuckled, reminding me she is from upstate New York. "Basically just the opposite of what that guy told me to do. I want the *kids* to ask the questions. I don't want them sitting in desks. You know? I want them sitting on the tables!" She was referring to a discussion we had had the previous week in her museum classroom, where she had done an activity, among many others, about sodium bicarbonate that involved making "Alka-Seltzer rockets" with young children. The kids had been so enthralled with their experiments that by the end of class, at least half of them were sitting right on the tables where they worked, or were sprawled out on their stomachs on the tables in order to get really close to what they were doing. Their teachers, accompanying them on the field trip to the museum, repeatedly told the children to get off the tables and sit "normally" – in their seats, straight and poised.

"The worst thing is that I didn't have the power to do things how I wanted," Emily mused thoughtfully. "And when I host school field trips at the museum, I see the teachers having that same problem and lack of power."

"The power to have the kids ask questions?"

"Yes. I mean I didn't have that power in a school. But in my [museum] classroom, it's totally different. I mean, there are the standards, and I have to work with those, or else – you know, the teachers can't get funding to bring their kids on a field trip in the first place – anyway, but within the standards even, all I have to do is kind of guide them and keep asking them what they think and why. The *why* is the most important thing to me…like, if they leave my classroom knowing what evidence is, I feel like I did my job."

Emily had touched on a topic that all the teachers and educators I spoke with during my dissertation research had brought up in some way: academic standards. Another museum educator at a different Oklahoma institution, Diane, shared the same concern. Diane spent several hours one morning flitting between her computer, printer, and classroom as she prepared packets of program materials for a new class on oil and gas resources in Oklahoma. Rifling through pages of maps, she had told it would be interesting to see how the new earth science Next Generation standards would play out in the museum classroom, noting that Oklahoma elementary school teachers will probably have to rely on museums for help teaching geology, which they have not had to teach in the past. The ebb and flow of formal school changes ripple directly into the informal classroom. Even museum programs are designed with school curriculum and testing in mind, and there exists a molding of museum education around the structures that dictate formal schooling practices. Museums and science camps are at the intersection of formal and informal worlds of knowledge.

CONCEPTIONS OF CULTURAL DIFFERENCE IN AN INFORMAL ENVIRONMENT: THE CASE OF BOLEY STEAM CAMPS

The STEAM camps in Boley, Oklahoma that I have referenced throughout this dissertation have played a tremendous role in teaching me about Oklahoma science culture. Research participant recruitment began in February 2015 when funds were secured. Camp directors (myself and Suzette) traveled to Boley bimonthly to speak with resident families about the STEAM Camp project and took notice of lengthy community discussions discourse about the role of science in their lives. For example, at the past year's Boley Rodeo, for which the town is famous, Suzette and I spoke with former, current, and possibly future residents of Boley about the town's needs. Many individuals felt that science and technology, especially in terms of energy and other resources, were going to play a pivotal role in Boley's future. These conversations shaped interview question development and overall research interests and goals. Suzette's research would focus on local conceptions of science in daily life, as well as child and family interviews; mine would be focused on how our teaching staff navigated and perceived a new cultural space. To delve into these research interests, I interviewed educators pre-camp in order to gain a sense of what their teaching objectives would be; these discussions were essential to the overall research design and data instrument development. During camp, I recorded data to see how educator objectives were playing out, as well as how the teaching staff reacted to different situations. Data were primarily collected via participant observation, in ethnographic fashion (Resnick, 1972; West, 1975; Schensul and Lecompte, 1999; Frank and Uy, 2004). Post-camp, follow-up interviews with teaching staff revealed interesting conceptions of "culture", local knowledge, and community practices in Boley.

Camp participation was open and free for all Boley youth between the ages of 5 and 17, with participation for youth over the age of 13 being reserved for paid junior staff positions. These parameters yielded about 20 pre-registered campers - seven of which were present on the first morning of camp, along with two walk-in students and four junior staff members. Camp started two hours late on Monday morning as our staff took to the surrounding neighborhood, reminding parents and children about the camp, going door-to-door. By the last day of camp, the roster included forty youth, ages 2-21. Ten of these youth, all teens, volunteered to be extra staff throughout the duration of the week. Several of the teens could be found sitting on the sidewalk outside the Well Springs building at 6:30am on the last two days of camp, eagerly waiting for staff to unlock the doors and assign them tasks, though they were scheduled to begin at 8:00am.

It became clear in the first months of planning that we wanted to make a commitment to helping University of Oklahoma students (both graduate and undergraduate) learn about science education, Oklahoma students, and the importance of outreach. Without the support of the College of Arts and Sciences, this camp would not have happened, and so we wanted to select and cultivate those around us as well as ourselves. Additionally, the 2015 camp having been our first meant that we would need to be able to work closely with, and totally trust, our staff. These factors led to the hiring of OU-based staff for nearly all positions, including managers, teachers, and research assistants. From Boley we hired five teenaged students to act as camp assistants. Their role was to help in managing campers, materials, and the space available to us.

STEAM activities can consist of a fantastic array of experiments, materials, and content. A primary goal of this project was to create sessions that would tie students' school experiences into a larger picture of how science works, what science is, and how science and art intertwine. We began activity development with a thorough review of Next Generation Science Standards (NGSS) and various works dedicated to creating meaningful lessons and contexts based on NGSS (Bybee, 2014). Development was also based on known creative approaches to teaching science concepts that students would likely find relevant (Marek and Howell, 2006; Marek and Carlsen, 2010; McCann et al, 2007; Burek and Zeidler, 2015).

Dennis, whose involvement in the STEAM Camp served as his first experience with informal science education and working with children, was interested in student engagement during biology and ecology activities. He is an anatomy instructor, and reported before the camp that his college undergraduate students' engagement level is consistently about 40% in class, despite the fact that he is a five-time winner of his university's Excellence in Teaching Award. In Boley, he expected a similar or even lower rate of engagement, based on the fact that his audience would be children, and he expected them to have a much shorter attention span. Contrary to this expectation, Dennis rated Boley campers at an overall engagement level of closer to 85%. This rating is based on a number of his own criteria; pre-camp, Dennis and I created a list of Engagement Criteria, which consists of actions students take when they are actively engaged in a task. Dennis's instructor goals for the two activities recorded were: 1) to collect specimens; 2) identify and take notes on those specimens using a microscope and basic observation methods; and 3) to use those observations to create a "Boley Bioinventory". Engagement criteria include:

- Remembering and following directions
- Choosing to try different types of field equipment
- Asking relevant, unprompted questions
- Having on-topic discussions with peers and staff
- Applying information at hand to different contexts
- Verbally correcting their own misunderstandings as they went along
- Spending more time than allotted exploring something relevant
- Using equipment in a focused and correct manner
- Remembering information
- Correcting or supplying instructor with relevant local knowledge
- Self-guiding activity

Earth science educator Alex wanted to know how student beliefs and ideas would change during the process of learning and testing concepts. The main idea was to challenge typical school-based conceptions of the Scientific Method, and to see how students react to learning science when Nature of Science-based (NOS) approaches are used in teaching (McComas et al, 1998; Clough and Olson, 2004). When faced with a relevant, real question such as "*What should we build Boley's future houses and buildings out of?*", we wanted to see whether students would recognize science as a method, or as more of a *process* based on many variables (Zeidler et al, 2002; Schwartz et al, 2004).

Part of Alex's Earthquake Table activity consisted of students talking about what happens to buildings and other structures during an earthquake, and making predictions about how certain building materials might behave. Students took turns building and testing different materials on the table, including bricks, wooden blocks, and steel (represented by KNEX, flexible but strong plastic building pieces). They were then asked questions about how scientists and engineers think about their tests, and how this relates to making their own decisions about what to use as a building material on the earthquake table.

Creating a meaningful science camp experience for rural African American youth presented a suite of what can be conceptualized as “cultural challenges” for our staff, as most of our team identifies as white, middle-class, educated individuals. Short-falling or misinformed educational project attempts by well-meaning white groups and activists have a long and complex history that has been reviewed in great detail elsewhere (Delpit 1988, 1995, 2006, 2012; Kohl 1994; Bergerson, 2003; Irons, 2004; Ogbu, 2008; Nieto, 2009), and staff were exposed to these concepts for camp planning and critical discussion with the intention of avoiding the mistakes of the past. This would prove most difficult in terms of hiring content areas and corresponding education staff, for the reasons outlined below.

Selecting what scientific concepts and areas we would explore was primarily based on the goals of the camp, but also on the resources (human and otherwise) available to us. We knew two things: 1) our staff would be largely comprised of OU students; and 2) we wanted to choose topics that could be of special interest to young people in Oklahoma. These include geology, drought & climate change ecology, paleontology, and engineering, among others. The issue, of course, is that these areas of research and economy are typically completely dominated by middle-to-upper class white men, and Oklahoma is no exception to this demographic phenomenon. We had to make a choice early on about whether we would exclude areas of science that essentially do not have representation for people of color in an attempt to avoid alienating campers, or instead bring these subjects into the curriculum *because* they have little to no representation, partly in order to foster dialogue about that lack of representation and the future of diversity in these fields. Coming from the University, the content-specialist teaching staff were almost all white students in their mid to late 20s, equally male and female. Knowing fully that the incongruence between teachers/subjects and our campers would probably draw criticism, we ventured ahead with the goal of bringing seemingly out-of-reach sciences to the children of Boley. The consequences of this choice were interesting, as exemplified in post-camp interviews with staff.

Ecology educator Dennis shared that his "cultural" struggles were based not only on race, but also on his concept of effective class structure. He noted that his predetermined class plan "completely went out the window" once he entered the campers' home turf and realized how different the experience might be from a typical day at school. He admitted his discomfort with coming into a town with which he had little to no experience and having to assume a figure of some authority (teacher), especially since he is a white, middle-class university instructor and viewed himself as being an unwanted cultural outsider. "I felt apprehensive and self conscious - didn't know if it was a race thing or just my lack of experience with kids...I didn't want to yell at someone else's kids or tell them what to do...I was thinking about [it] a lot during the day," he reflected. A pleasant surprise for Dennis was the extent to which the campers became absorbed in the activities he led; working regularly with many middle-class university undergraduates who tend to become quickly disengaged and and "drudge" through their work, the Boley campers' enthusiasm and open style of asking questions were quite welcome.

Earth science educator Alex had similar personal challenges that also grew from his sense of cultural otherness. Despite having attended a mostly-black inner-city school as a child and teenager, Alex noted that he spent a lot of energy focusing on how the campers would perceive him, worrying that he would reinforce racial stereotypes if he did not quickly learn the children's authority dynamics and adjust his teaching style to meet their norms. "I decided that I had to just roll with it...since these aren't the college students I'm used to, I felt like I had no leverage on them to get them to participate...but I realized that these are rural kids. They're just going to come by [camp] when they feel like it, because they truly want to be there, not because I told them to." Alex, too, was quick to report how engaged and interested the campers seemed during the various activities he led throughout the week.

Preservice science teacher Leslie's experience at the camp echoes the other educators' sentiments: "I could connect with them, but I had challenges; I grew up in a shady one bedroom apartment in a not-so-nice neighborhood in OKC...my house was broken into...I could kind of understand...kind of connect with them, as far as not growing up with much." She went on to share that "as far as cultural differences - getting the kids to talk to me...I realized they probably didn't trust me very much. I would go to Ms. G [adult figure of authority in the community] if I needed a child to do something and they refused, because they respect her...there was a child behaving in a disruptive way and it was hard for me to speak to them in a way that they would listen and respect me, so I would go to Ms. G or the Mayor."

The Boley STEAM camps have provided a lot of context for myself and colleagues to think about the importance of informal context, especially when there are perceived or actual cultural differences between educator and learner. In the next section I will attempt to illustrate why informal contexts like science camps and outdoor fossil field trips positively disrupt the traditional authority of science and classroom teachers to make room for culturally diverse engagement. Much of what I have to say comes from the museum context, but may be easily extrapolated to suit other contexts.

INFORMAL CONTEXTS ARE NECESSARY FOR SCIENCE EMPOWERMENT

Science education has been a nationally and institutionally recognized issue in the United States since the 1950s, and programs focused on creating a more "scientifically literate" populace have been in place for at least four decades (Rudolph 2002). Our approach follows the robust program of research on the power and salience of science learning outside the classroom, and at all ages (Scribner and Cole, 1973; Falk, 2001; Bekerman et al, 2006; Feder et al, 2009; Roth and Eijck, 2010; Schweingruber and Fenichel 2010; Kim and Dopico, 2014). Informal education occurs in myriad places and contexts, and approaches to researching it can be tenuous to capture, but many researchers have made substantial headway in this area (Resnick, 1972; Dierking and Falk, 1994; Gerber et al, 1997, 2001; Martin, 2004; Katz et al, 2011; Wallace, 2013; Sasson, 2014; Zepeda, 2014). Science camps have served as interesting sites of research (Rath and Brown, 1996; Sterling et al, 2007; Bischoff et al, 2008; Fields, 2009), and this project adds to that growing body of literature.

Until relatively recently, science education initiatives such as the one presented here have largely followed a STEM (science, technology, engineering, mathematics) framework. Now, art is being included much more frequently in program curricula. The STEAM (science, technology, engineering, art, mathematics) program design is based on the following concepts: 1) art is both a natural and essential part of science; 2) art and science are not mutually exclusive, but rather depend on one another; and 3) art and science are intersect in ways that require similar skills, motivations, and a variety of perspectives (Mallow, 1981; Ede, 2012; Sousa and Pilecki, 2013; La Haye and Naested, 2014). The STEAM approach has been successful in Oklahoma; for example, in 2014 the Oklahoma Afterschool Network took on a highly successful project that tested the efficacy of using STEAM curriculum to raise elementary students' reading scores.

The STEAM approach is a cohesive, inclusive way of bringing science literacy and appreciation to students, especially if those students belong to non-dominant cultural groups that have traditionally been excluded from the sciences. Public educational outreach has not been a primary goal of cultural anthropologists, especially within the academy, and certainly not through such efforts as science camps. However, this project is based on the idea that learning science is an intimately cultural experience and that perhaps anthropology's unique perspectives and tools might elucidate issues in local science education (Maddock, 1981; Wertsch, 1986; Cobern, 1991; Aikenhead, 1996; Cobern and Aikenhead, 1997; Aikenhead and Jegede, 1999; Lemke, 2001).

A refresher on informal and formal schooling may be helpful here. Different kinds of classrooms have different goals, and the two dominant pedagogical categories for consideration here are *formal* and *informal*. I take "formal" to mean knowledge acquisition that is institutionally tested, and "informal" to mean learning that is not tested. This is an infinitely broad category, and I have therefore narrowed my focus to museum learning. The difficult question facing today's science researchers interested in the informal classroom is exactly *how* to conduct a study of gender or class equity. I have designed a few concepts for how best to do this, and will review them after presenting a brief argument for why the natural history museum is an excellent place to conduct science education fieldwork.

I believe that the future of American science education and literacy is, for many children who face obstacles to good schooling, in the informal classroom. It is another topic entirely to fully describe my basis for this claim, but I hope it will suffice to note that: 1) formal, public institutions of primary and secondary education are becoming less effective, especially as they take on a more prominent role as "tester" rather than "teacher"; 2) a more inclusive, less classist, and higher-access locus of education in America has long been, and increasingly continues to be, the *museum*; and 3) modern science museum pedagogy could be in a better position than formal education to readily incorporate feminist perspectives – for example, when I attended George Washington University's Museum Studies graduate program, every student (save one or two) of exhibition design and development, as well as museum education, was female and most were feminists; this can translate to a more feminist future in museum education and exhibition approaches, though we must certainly find ways of measuring this impact in the future.

Most adults learn proportionally more science *after* they leave formal schooling (Meinwald and Hildebrand, 2010:241), but I believe the foundation for doing so is rooted in early access, exposure, and meaningful engagement with science. Education researchers have not yet sufficiently measured how much learning is done in formal settings versus informal, and that it would be an incredibly complex task to try to make claims about *where* adults may have learned a concept. Though many would report having learned a concept in college, this certainly does not examine the incredibly convoluted, mosaic nature of contemporary learning, in which one might absorb science in all manner of contexts outside of the classroom, but then only be tested on this knowledge *within* the classroom, where "learning" is measured. Modern education is too cumulative for us to make such rigid category assumptions of science learning.

When considering how to go about implementing and measuring a feminist approach to STEM education, researchers will need to be equipped with more than the basic ethnographic toolkit. Here I cover three brief conceptions of how to successfully approach conducting STEM education research successfully between a researcher and a teacher. First, teachers must be autonomous and self-regulating if a researcher wishes to glean any useful information from them in the informal classroom. For example, the educator must be willing to report on and evaluate their own behavior, which may be more easily accomplished in a museum classroom than at a formal school. If the educators are not willing to help a researcher access the museum classroom or undertake some of the creative measurements and observations themselves, then research may not be possible. The museum classroom presents an interesting challenge because educators are generally seeing different sets of students throughout the day, and will rarely see the same student twice; this could actually reduce biases in the classroom.

Second, since the museum is a trove of educational objects, the researcher must utilize this to their advantage and study how learners chose to operate in this unique informal setting. Do girls prefer to read text panels, or to pick objects up? Do boys use interactive modules without reading? If students hesitate to touch objects, can we ask them to comment on this hesitation? Rate of engagement can be measured in the museum, in that a researcher can track gender differences in object handling, reading, inquiry, or other activity. We also have methods for tracking visitors/students in their chosen exhibit pathways, which can be quite revealing of their motivations and interests. This is one way to verify whether a young girl reporting no interest in STEM fields is revealing a true picture of herself.

Third, issues of class can be tracked and observed in the museum setting. For example, many museums have certain days designated as offering free admission; this can extend to all visitors, or sometimes just to city residents, etc. In my experience as a museum professional, "free day" is one of the only opportunities for residents of underprivileged areas and members of marginalized classes to gain access to the museum. Another source of information on peripheral science learners could be notable differences in the behavior of students whose schools or camps can only afford to pay for outreach, rather than a full museum visit for the students. This means that the museum is paid some relatively small sum to send educators and objects to a school, public library, or camp in order to overcome the (often insurmountable) cost of sending several busloads of students to a museum for a field trip. Class lines are drawn clearly for the museum researcher in this case, and we have yet to utilize this structure for STEM research.

The informal classroom may present researchers with new and highly informative opportunities to explore issues of gender and class in STEM education. Before we can unlock the potential of such settings, however, we must examine our current STEM practices and identify the interwoven and sometimes invisible frameworks of sexism and classism that continue to buttress STEM "inclusion" efforts. Interviews with several informants directly involved with gender issues and STEM education, both formal and informal, have revealed a pattern of the "aware but unable scientist", in which participants in STEM fields know that there is gender disparity, and believe STEM is in crisis in America, but cannot reconcile how to navigate these problems in the modern classroom or workplace. Beyond being interlaced into how we train the next generation of scientists and educators, feminist resources and anthropological approaches must also be made readily available and accessible for educators, scientists, researchers, and other interlocutors in the popular science literacy discourse.

STEM is expanding to women in both the classroom and the workplace, but perhaps this has more to do with garnering a reserve labor force than a being a true effort to redistribute the social capital that comes with scientific literacy. The educated citizen is an elusive character on the political-economic stage, wherein that citizen represents valuable human capital in a political economy based on normative STEM value placement. Our focus on STEM as an economic crisis should encompass more objective evaluations of the situation, and also engage with liberal suggestions for how to treat the perceived science literacy emergency in the future. If caring about science is the best thing for the public, we must learn to actually include epistemes of the public into our efforts.

Anthropology is in an incredibly important position to speak on the topic of STEM access, education, and careers. We must be the future of STEM discourse in America if those perpetuators of science literacy necessity are truly interested in gender equity. I pose the question: if we are really so interested in bringing femininity into science, why are so few anthropologists commenting publicly on this topic? I feel that this may, perhaps, have something to do with postmodernist notions of what science *is*. A dismissive attitude of scientific methodology and approaches to knowledge production may have precluded the lack of anthropological literature on the topic of STEM. Anthropologists must step forward to create a culture of feminist perspectives to STEM learning in order to truly correct for gender disparity and classism, as well as racism.

EMPOWERING ANTHROPOLOGISTS WHO WANT TO WORK IN EDUCATION

A fellow graduate student told me, on an absurdly hot day in the middle of summer STEAM camps, that his day was much better than mine. He was working at an archaeological site in a different state, and I had sent him a cell phone photo I took of my 2nd graders doing Suminagashi. His was a positively ‘academic’ reaction - he sent back a photo of his field work (potsherds in dirt?). I asked if by “better” he meant more important. He did not answer.

Throughout the duration of my time researching and writing this dissertation, a revolving door of scientists and colleagues in anthropology have made comments (usually unsolicited) on the work I have chosen to engage in as a scholar and an activist. "*But don't you want to be a professor?"* they asked earnestly. "*But what will you do for actual fieldwork?"*

Many months later I am still bothered by these comments. Why do academics consistently seem to devalue educational "delivery"? It is often men, like my colleague; and perhaps just as often, it is men who are professional scientists. Why is it that being in the presence of learners - especially children - is supposed to be a job we, the "highly educated", avoid as our resume expands? Why is it seen as domestic, or as a service industry? A stepping stone to "something better"? Women's work?

If nothing else, my fieldwork confirmed the suspicion that most teachers are women, and that this fact has real consequences on labor, stress, health, and economy. I have heard plenty of reasons: "women are more drawn to caring for young children", "women are more patient", "teaching is like babysitting and women are better at that". I used to dismiss these claims as plain sexism, but my fieldwork made me think deeply about this phenomenon and parse out the reasons it may be so - that most teachers are women, and what this means for the profession.

A number of heteronormative dialogues are happening in STEM education. For example, conventional wisdom holds that men have greater spatial reasoning abilities than their female counterparts. Spatial reasoning is a highly regarded skill in

STEM, as it is thought to relate directly to other forms of normatively valued thought (logic or "scientific" reasoning). Whether this is specifically a male skill was not in question until recently, as a critical approach has been taken to seriously question the "facts" put forth by psychology, biology, and other fields about sexually contingent "cognitive abilities". In 2005, the president of Harvard University publicly asserted: "women inherently have poorer cognitive abilities related to science than do men" (Rosser, 2008:155). Classic testing models (paper-and-pencil) have supported this notion throughout history, only buttressing the androcentric argument against the abilities of women. However, we now know that abilities such as spatial reasoning are socially culturally contingent, in that processes of socialization are what actually determine spatial abilities, rather than solely biological sex differences (Newcombe and Stieff, 2012).

We also know that the disparity in STEM interest between males and females happens relatively late in childhood. Eighth grade girls and boys show comparable scores in STEM, but at that point, girls are less likely to pursue these fields as careers (Catsambis, 1995). The movement to get girls involved in STEM early in life has expanded tremendously in the United States in recent years, and as a feminist STEM researcher I value this as a very positive trend. It must be noted, however, that the approach to bringing girls into STEM has followed rather sexist lines. For example, much of what is available for girls in STEM is contingent upon their separation from male contemporaries.

Rather than structuring efforts to better include girls in STEM learning in existing classrooms, segregation has become the dominant method, wherein girls can attend special STEM camps, classes, conferences, and clubs outside of school. Male teachers and classmates, therefore, are not necessarily learning to include women in STEM, or to change their own behaviors in order to create a gender-fair classroom. It has long been noted that teachers, both male and female, execute gender bias in teaching science (Shepardson and Pizzini, 1992). For example, science teachers tend to show girls how to do an experiment or assignment, whereas they actively lead boys through the exercise via continuous inquiry. Whether they are doing this consciously is somewhat irrelevant, in that the underlying cause is socialized sexism, and the only way to kill that weed will be at the root.

In addition to this trend of separating girls and boys, the growing advent of girls' STEM inclusion has created occasion for many primary and secondary level educators to confer and discuss the future of STEM. The common goal is noble enough: include more girls in STEM, and someday America will have innumerable female engineers and chemists. I would like to share a personal experience, chosen from dozens like it, that best illustrates my point about science educators failing to understand and implement a feminist approach to what is supposedly a sexist problem.

At one of the many STEM professional development events I have attended, there was extensive conversation between male and female STEM educators about how to apply girls' "inherent soft skills" to science in the classroom. Suggestions were made that classroom science should highlight more opportunities for communication and emotion-based sharing – "so that girls could participate". While one can see the immediate positivity of these suggestions, in that girls may indeed find more opportunities to participate, it is also clear that this approach to STEM equality is based on sexist beliefs and rhetoric. I take issue with the term "soft skills", especially when it is juxtaposed with terms like "hard sciences". The inherently phallocentric nature of these linguistic choices is difficult to avoid in conversation with the typical science educator, but I believe that their use and ideological following could be contributing more to the problem of gender disparity in STEM than to the solution.

The mosaic of skills employed by the best contemporary scientists is necessarily rich, diverse, and ever evolving. With the challenges of today's STEM researchers, to continue believing that a skill can either be "soft" or "hard" is nothing short of ludicrous, and altogether counterproductive for these fields. One example of this kind of discourse is drawn from the literature, in which a study was conducted at the University of Oklahoma. The Industrial Engineering department at OU appears to have been one of the first to statistically achieve gender equity, and some female members of that department informed the study. It was reported that the field is often called "Imagineering", or "Imaginary engineering", because industrial engineering calls for the use of communicative and interpersonal skills – women's "soft" skills (Harris et al, 2004). One would be hard-pressed to find an excuse for not having communication skills in today's highly politicized, funding-contingent, and competitive science world, where research funding may be revoked at any moment, for as simple a reason as the grant agency does not understand the scientist's future research plans and goals.

A colleague of mine does teacher professional development workshops all over the country – she has built a career doing it. Just before one of her regular trips to Oklahoma in late 2016, she became sick with the flu and had to cancel three days' worth of workshops. An elementary teacher I was speaking with, Kailey, who had been signed up for the workshops for six months in advance, told me about her deep frustration with the situation.

"I can't believe she cancelled. I had a sub!...it is so hard to line it all up," Kailey had told me over coffee, clearly disappointed. I nodded and empathized with her, saying that having people cancel important plans and meetings can be obnoxious. She smirked and told me, "I mean, you might not know – you are newer to the school game, like the public school game – but to cancel something with that many teachers, and subs, and principals who approved the time…it's *scandalous*." One of her eyebrows arched delicately over her tired eyes. I smiled. "No, seriously. We are not a profession that stays home when we're sick. We can't. We can't miss work for anything – unless, you know, it's for work!" Kailey chuckled. Curious, I asked her what she thought about the recent Day Without A Woman, a national women's protest of President Donald Trump's administration. On a Tuesday earlier in the month, hundreds of thousands of women all over the country had abstained from work – whether domestic labor, or economic.

"Ugh." Kailey took a deep drink of coffee and shook her head. "Just, no." I pressed for more.

"Ok, so school is the only place that a lot of kids get to have a meal – sometimes their only real meal of the day. We can't take that away. Other people can protest, but it's like, inappropriate for us [public school employees]," she shrugged her shoulders.

"So if you and your coworkers protested, you're saying kids wouldn't eat?" I pushed.

"Yes! Literally."

"How many women work in your school?"

Kailey had a blank look on her face for a moment, then scrunched her eyebrows. "Well…all of us."

"*All*?"

"Yeah. I mean," she looked up at the ceiling as she listed off people who work in her school, "the principal…vice principal…secretaries…school nurse." She took a sip of coffee as she thought about it. "Of course all the teachers. Most of the custodians, too, actually. Oh! And the lunch ladies. The librarian. The GTC [Gifted & Talented educator}…um. Oh god, even the bus drivers! Yeah. The whole school would be closed, if women did a strike." Kailey sunk into contemplation, her eyes wide at the realization.

I had read about a few schools on the East Coast that were forced to close completely on the Day Without A Woman, because that exact scenario had happened. Articles on the Internet always have their trolls, but I had been surprised to read articles and comments by female teachers, too, who thought it was completely irresponsible, immature, and selfish for teachers to strike. *If you really care about your students, you won't let them miss a day of school*, people wrote. Kailey seemed to share this attitude.

"Like…I support the sentiment. It means a lot. The symbolism…I mean, it's important," she said, tipping back her mug that had now been empty for a few minutes. She looked into the empty cup, then back at me. "But it's not something I could personally do. My kids need me."

I totally understood what she meant. I was also unable to participate in the protest, even though I supported it and encouraged friends to do it, if they could. But my whole office would have been empty if our all-female educational research team had participated. As I scrolled through social media later, I saw a comment that struck me as representing what Kailey had expressed:

"I am choosing NOT to [protest]. As a woman in a field that is underrepresented by women (I teach Math and Physics at the collegiate level in a very red state)…I NEED to be in that classroom…I had ZERO female math or physics professors while in college."

CONCLUSION

Being an effective science teacher requires more than a college education, years of practice, and a considerable level of content mastery. As I have attempted to illustrate in this dissertation, it also requires the hard work of forming a positive science identity, which many teachers are never given the space to do. Being an effective and confident science teacher means being comfortable with knowing the limits of one's content knowledge. Being able to gracefully be wrong or admit to not knowing an answer, it turns out, is just as important as being able to find the answer. Aspects of teacher identity, and the expectations of social communities related to those identities, relegate teachers to Red Queens, running as fast as they can just to stay in place.

"FUTURE" RESEARCH HAS TO BE "RIGHT AWAY" RESEARCH

I don't expect the sun to blister my neck in March. But there I sat, my skin reddening all the same, as I used one hand to shade my eyes and the other to pick tiny pebbles out of the sand. The Arkansas River was so low in Tulsa that I could walk right out into the middle and barely get my feet wet. My boots were covered in stinking, fetid mud though. I moved them out of where the breeze blew the reek right into my nose. Nearby, an older gentleman, Doug, was combing the sand bar with a broken fishing rod he had found. He had worked in public education for 41 years before retiring in 2011, and now spent many warm *days sifting through little sections of Earth, looking for signs of past life to collect. He was working silently until all of a sudden.*

"A BONE!" Doug called to me. I heaved myself off the ground to go see. I took it and weighted it in my hands. Much too heavy to be modern, but not completely fossilized. I could tell because on the distal end, where a narrow chip of bone had broken off, some the spongy pores of the bone were still hollow and pale – darker minerals had not yet replaced the original bone. It looked like a humerus of some big mammal – probably bovine.

"Awesome! Bison? Pleistocene?…we'll check the USGS website when I have cell signal," I told my companion. We examined it a bit longer and then took pictures of it from several angles before dropping it back on the ground with a dull thud. Doug looked a little disappointed, but knew we had to leave it there. Vertebrate fossils are not legal to collect on public land without a permit. We will come back with the team and the right paperwork soon, I thought. Doug and I had spent the afternoon scouting out new fossil sites where we could take teachers for Oklahoma Educators Evolve workshops in the future.

After directing more than a dozen professional development workshops over the previous 24 months, I was ready for a break. But I knew one thing for sure: in education, there are no breaks.

As of late March 2017, Oklahoma's Senate is reviewing Bill 393, the Oklahoma Science Education Act, which "would empower science denial in the classroom" by allowing science teachers to present topics as controversial or undecided by science. The topics in question, of course, are evolution and climate change.[vii] We may fight such policies from existing; we may call our representatives and explain the issue we take with bills like SB393. To do so is both necessary and right. I am choosing, as other scientists might, to bypass that red tape altogether by going straight to teachers and working to improve their confidence and build a positive science identity. Using the science empowerment model with teachers creates a resilience and immunity to political distractions and legislation that serves to put doubt and anxiety into the heads of teachers.

Science denial in politics and social life is a feminist issue, because the people who maintain the process of science education in this country are female. They are underpaid, overworked, overlooked, an underappreciated. They face health and stress issues in order to support a system that often works against them, because their life's work is active empathy (teaching), and they will not risk that. Political attitudes that lead to the loss of funding and other support for science education are a feminist issue. Science denial by public officials and personalities only adds to the internal identity conflict that many of them experience as Christians and science teachers. Would legislators presume to tell an equivalent, but male-dominated, field how to do their jobs? After what I have seen in the field these past years, I have my doubts.

OKLAHOMA, TODAY AND TOMORROW

Being a teacher is a time-consuming, and perhaps soul-consuming challenge to undertake. Teachers in Oklahoma run on passion and empathy as much as, or more than, they run on coffee. Teaching science obscures the picture even more.

In mid-2016, I visited an elementary school called Moon Academy for an afternoon of teaching classes focused on aviation and the forces of flight. As the children assigned to me entered the gymnasium where I had some supplies set up, I immediately recognized two faces: Evie and Chance, children whom I had met two years before in an afterschool program. At that time I had been teaching LEGO engineering classes, and when Evie and Chance saw me in the gymnasium, they grinned and ran over to me: "The LEGO Lady! She's here!" The children looked astonished but pleased that I remembered their names as I said hello and asked how school was going. They introduced their classmates to me and we proceeded to spend a pleasant afternoon making different types of paper aircraft and discussing the physics that makes them fly (or more accurately, glide).

Fast forward to March 2017, where I sat in an office and took a moment of rest after doing a presentation for preservice teachers at a local university. The presentation was about a study I participated in at Moon the year I met Chance and Evie, 2014. The Oklahoma Afterschool Network and Moon Academy organized a three-week program for local elementary-age children who had failed the state reading test the semester before; Moon had also received an “F” ranking in 2012-2013 from the Oklahoma State Department of Education.

For twenty days, children arrived each morning to a hot breakfast and guided literacy time before spending the day rotating between hands-on classes. My engineering class was one of them; the kids also took Spanish and Arabic, music, sculpting, dance, biology, and other classes. Two or three large blocks of time were spent on intensive reading each day, with content related to the science and art classes they took.

At the culmination of the program, the children held a showcase for parents, community members, local news agencies, the state superintendent, and the mayor of Oklahoma City. I was proud when I heard children explaining gear ratios and other phenomena of simple machines to the Mayor. The children then re-took the reading exam, as well as a math exam, before being released for the summer. Reading scores increased dramatically, as well as math scores.[viii]

As I had described these 2014 outcomes to the preservice teachers in my early 2017 presentation, they were amazed that reading scores could increase so much with the majority of program time spent doing art and science projects. When speaking with these future teachers, I used the example of Moon as a model for science empowerment-based educational programming because: it had involved working with the local community closely and including socially relevant activities the children could excel in that are not normally done in elementary schools in Oklahoma, such as Spanish and Arabic language classes (*cultural intelligence*); conducting low-cost, replicable learning activities right at the kids' local school and using outdoor spaces in their own neighborhood (*access*); and working with the students' regular school teachers to design the program to blend well with what they already know and like as learners (*literacy*).

Not long after I gave that presentation in early 2017, a news article crossed my computer screen. Northeastern Oklahoma City is "bracing for another round of school closures, a process that has plagued the predominantly black neighborhoods for generations and left abandoned schools scattered throughout the community."[ix] Moon Academy is likely to be one of those to close.

It is absolutely imperative that scientists and cultural anthropologists around the country engage in more community-based, culturally intelligent educational programming. It does not have to be informal, though this is sometimes the easiest way. It does not have to cost much money. What it does require is labor and commitment. Cultural anthropologists have the tools to amplify the voices of the marginalized and create spaces that are empowering and meaningful for learners of all kinds. And do not forget teachers – in my view, every teacher should know a scientist and a cultural anthropologist personally (and often one person covers both of those identities, depending on their self-concept).

I will close with a favorite quote about education that I think perfectly sums up why cultural anthropology, through development of the Science Empowerment Model, has a responsibility and opportunity to make science education better:

"When those who have power to name and to socially construct reality...when someone with the authority of a teacher, say, describes the world and you are not in it, there is a moment of psychic disequilibrium, as if you looked into a mirror and saw nothing." (Adrienne Rich 1986:199)

BIBLIOGRAPHY

Adas, M. (1989). Machines as the Measure of Men: Science. *Technology, and Ideologies of Western Dominance (Ithaca, NY, 1989)*, *285*.

Aikenhead, G. S. (1996). Science Education: Border Crossing into the Subculture of Science. *Studies in Science Education*, *27*, 1-52.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of research in science teaching*, *36*(3), 269-287.

Anderson, B. (2006). *Imagined communities: Reflections on the origin and spread of nationalism*. Verso Books.

Anderson, G. L. (1989). Critical ethnography in education: Origins, current status, and new directions. *Review of educational research*, *59*(3), 249-270.

Anderson, V. L., Levinson, E. M., Barker, W., & Kiewra, K. R. (1999). The effects of meditation on teacher perceived occupational stress, state and trait anxiety, and burnout. *School Psychology Quarterly*, *14*(1), 3.

Anelli, C. (2011). Scientific literacy: What is it, are we teaching it, and does it matter. *American Entomologist*, *57*(4), 235-244.

Appadurai, A. (2000). Grassroots globalization and the research imagination. *Public culture*, *12*(1), 1-19.

Armelagos, G. J. (1995). Race, reason, and rationale. *Evolutionary Anthropology: Issues, News, and Reviews*, *4*(3), 103-109.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. Current directions in psychological science, 11(5), 181-185.

Asher, R. J. (2012). *Evolution and belief: confessions of a religious paleontologist*. Cambridge University Press.

Austin, V., Shah, S., & Muncer, S. (2005). Teacher stress and coping strategies used to reduce stress. *Occupational therapy international*, *12*(2), 63-80.

Avery, L. M. (2013). Rural science education: Valuing local knowledge. *Theory Into Practice*, *52*(1), 28-35.

Ayers, W. (2008). *City kids, city schools: More reports from the front row*. The New Press.

Baker, D., & Koolmatrie, J. (1994). World view and communication: Neglected issues in Aboriginal tertiary education. Paper presented at the National Aboriginal and Torres Strait Islander higher education conference, Fremantle, Western Australia

Baker, L. D. (1998). *From savage to Negro: Anthropology and the construction of race, 1896-1954*. Univ of California Press.

Bakhtin, M. (1998). Discourse in the Novel. *Literary theory: An anthology*, 32-44.

Bar-Haim, G., & Wilkes, J. M. (1989). A cognitive interpretation of the marginality and underrepresentation of women in science. *The Journal of Higher Education*, *60*(4), 371-387.

Basso, K. H. (1996). *Wisdom sits in places: Landscape and language among the Western Apache*. UNM Press.

Battiste, M. (1986). Micmac literacy and cognitive assimilation. In J. Barman, Y. Herbert, & McCaskell (editors), Indian education in Canada, Vol. 1: The legacy. Vancouver, BC: University of British Columbia.

Bauer, M. W. (2009). The evolution of public understanding of science—discourse and comparative evidence. *Science, technology and society*, *14*(2), 221-240.

Beauchamp, G. A. (1968). Curriculum theory. The Kagg Press.

Beijaard, D., Meijer, P. C., & Verloop, N. (2004). Reconsidering research on teachers' professional identity. *Teaching and teacher education*, *20*(2), 107-128.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*, *107*(5), 1860-1863.

Bekerman, Z., Burbules, N. C., & Silberman-Keller, D. (2006). *Learning in places: The informal education reader* (Vol. 249). Peter Lang.

Bergerson, A. A. (2003). Critical race theory and white racism: Is there room for white scholars in fighting racism in education?. *International Journal of Qualitative Studies in Education*, *16*(1), 51-63.

Berezow, A. B., & Campbell, H. (2012). *Science left behind: Feel-good fallacies and the rise of the anti-scientific left*. PublicAffairs.

Berliner, D. C., & Glass, G. V. (Eds.). (2014). *50 myths and lies that threaten America's public schools: The real crisis in education*. Teachers College Press.

Biehl, J. G., Good, B., & Kleinman, A. (2007). *Subjectivity: ethnographic investigations* (Vol. 7). Univ of California Press.

Bischoff, P. J., Castendyk, D., Gallagher, H., Schaumloffel, J., & Labroo, S. (2008). A Science Summer Camp as an Effective Way to Recruit High School Students to Major in the Physical Sciences and Science Education. *International Journal of Environmental and Science Education*, *3*(3), 131-141.

Bornmann, L., Mutz, R., & Daniel, H. D. (2007). Gender differences in grant peer review: A meta-analysis. *Journal of Informetrics*, *1*(3), 226-238.

Bourdieu, P. (1991). *Language and symbolic power*. Polity Press.

Brace, C. L. (1971). Race and Intelligence. American Anthropological Association.

Brace, C. L. (2005). " Race" is a four-letter word: the genesis of the concept. Oxford University Press.

Brodkin, K. (1998). *How Jews became white folks and what that says about race in America*. Rutgers University Press.

Bronfenbrenner, U. (1972). Is 80% of intelligence genetically determined. *Influences on human development*, 118-127.

Brownlow, S., Jacobi, T., & Rogers, M. (2000). Science anxiety as a function of gender and experience. *Sex Roles*, *42*(1-2), 119-131.

Bruner, J. S. (1966). *Toward a theory of instruction* (Vol. 59). Harvard University Press.

Brunn, S. D. (Ed.). (2015). *The changing world religion map: Sacred places, identities, practices and politics*. Springer.

Burke, R. J., & Mattis, M. C. (Eds.). (2007). *Women and minorities in science, technology, engineering, and mathematics: Upping the numbers*. Edward Elgar Publishing.

Bybee, R. W. (2001). Teaching about evolution: Old controversy, new challenges. *BioScience*, *51*(4), 309-312.

Bybee, R. W., & Sund, R. B. (1982). *Piaget for educators*. Waveland Press.

Bystydzienski, J. M., & Bird, S. R. (Eds.). (2006). *Removing barriers: Women in academic science, technology, engineering, and mathematics*. Indiana University Press.

Carbo, M. (1983). Research in reading and learning style: Implications for exceptional children. *Exceptional Children*.

Carey, B. (2014). *How We Learn: The Surprising Truth About When, Where and Why It Happens*. Pan Macmillan.

Caringi, J. C., Stanick, C., Trautman, A., Crosby, L., Devlin, M., & Adams, S. (2015). Secondary traumatic stress in public school teachers: Contributing and mitigating factors. *Advances in School Mental Health Promotion*, *8*(4), 244-256.

Carmichael, S. B., Martino, G., Porter-Magee, K., & Wilson, W. S. (2010). The State of State Standards--and the Common Core--in 2010. *Thomas B. Fordham Institute*.

Catsambis, S. (1995). Gender, race, ethnicity, and science education in the middle grades. *Journal of research in science teaching*, *32*(3), 243-257.

Cavallo, A. M., & McCall, D. (2008). Seeing may not mean believing: examining students' understandings & beliefs in evolution. *The American Biology Teacher*, *70*(9), 522-530.

Chen, M., & Miller, G. (1997). Teacher Stress: A Review of the International Literature.

Chiesa, A., & Serretti, A. (2009). Mindfulness-based stress reduction for stress management in healthy people: a review and meta-analysis. *The journal of alternative and complementary medicine*, *15*(5), 593-600.

Clifford, J. (1988). *The predicament of culture*. Harvard University Press.

Clough, M. P., & Olson, J. K. (2004). The Nature of Science: Always Part of the Science Story. *The Science Teacher*, *71*(9), 28.

Cobern, W. W. (1991). Contextual Constructivism: The Impact of Culture on the Learning and Teaching of Science.

Cobern, W. W., & Aikenhead, G. (1998). Cultural aspects of learning science. Western Michigan University Press.

Conn, S. (2000). *Museums and American intellectual life, 1876-1926*. University of Chicago Press.

Costa, V. B. (1995). When science is "another world": Relationships between worlds of family, friends, school, and science. *Science education*, *79*(3), 313-333.

Darling-Hammond, L., Holtzman, D. J., Gatlin, S. J., & Heilig, J. V. (2005). Does teacher preparation matter? Evidence about teacher certification, Teach for America, and teacher effectiveness. *education policy analysis archives*, *13*(42), n42.

DeBoer, G. E. (1991). *A History of Ideas in Science Education: Implications for Practice*. Teachers College Press, 1234 Amsterdam Avenue, New York, NY 10027.

Dee, T. S. (2005). A teacher like me: Does race, ethnicity, or gender matter?. *The American economic review*, *95*(2), 158-165.

Delpit, L. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard educational review*, *58*(3), 280-299.

Delpit, L. (2006). *Other people's children: Cultural conflict in the classroom*. The New Press.

Delpit, L. (2012). *" Multiplication Is for White People": Raising Expectations for Other People's Children*. The New Press.

Denzin, N. K. (2001). The reflexive interview and a performative social science. *Qualitative research*, *1*(1), 23-46.

Devlin, B., Daniels, M., & Roeder, K. (1997). The heritability of IQ. *Nature*, *388*(6641), 468-471.

Devlin, B., Fienberg, S. E., Resnick, D. P., & Roeder, K. (Eds.). (2013). *Intelligence, genes, and success: Scientists respond to The Bell Curve*. Springer Science & Business Media.

Dewey, J. (1916). Education and democracy. New York: Macmillan.

Diamond, J., Horn, M., & Uttal, D. H. (2016). Practical evaluation guide: Tools for museums and other informal educational settings.

Dierking, L. D., & Falk, J. H. (1998, April). Understanding free-choice learning: A review of the research and its application to museum web sites. In *Museums and the Web* (pp. 97-99).

Dierking, L. D., & Falk, J. H. (2009). Learning for life: The role of free-choice learning in science education. *World of science education: North America*, 179-206.

Dodge, J. (2009). *25 Quick Formative Assessments for a Differentiated Classroom: Easy, Low-Prep Assessments That Help You Pinpoint Students' Needs and Reach All Learners*. New York: Scholastic Inc..

Doucette-Frederickson, J.A. Partnerships in Paleoenthusiasm. Journal of Museum Studies 9(1), 2015.

Doucette-Frederickson, J.A. Fieldnotes. 2014-2017.

Duranti, A. (2009). *Linguistic anthropology: A reader* (Vol. 1). John Wiley & Sons.

Ede, S. (2012). *Art and science*. IB Tauris.

Ede, A., & Cormack, L. B. (2012). *A History of Science in Society: From the ancient Greeks to the scientific revolution* (Vol. 1). University of Toronto Press.

Edwards, A. (1995). Teacher education: partnerships in pedagogy?. *Teaching and Teacher education*, *11*(6), 595-610.

Ehrenberg, R. G., Goldhaber, D. D., & Brewer, D. J. (1995). Do teachers' race, gender, and ethnicity matter? Evidence from the National Educational Longitudinal Study of 1988. *ILR Review*, *48*(3), 547-561.

Eick, C. J. (2000). Inquiry, nature of science, and evolution: The need for a more complex pedagogical content knowledge in science teaching. *Electronic Journal of Science Education*, *4*(3).

Emdin, C. (2016). *For White Folks Who Teach in the Hood... and the Rest of Y'all Too: Reality Pedagogy and Urban Education*. Beacon Press.

Erikson, Erik. (1966). "Eight ages of man." *Klassiekers van de kinder-en jeugdpsychiatrie* (p. 258).

Erikson, E. H. (1950) 1963. *Childhood and Society*. 2nd ed. New York: W.W. Norton & Company.

Erickson, F. (1984). What makes school ethnography 'ethnographic'?. *Anthropology & Education Quarterly*, *15*(1), 51-66.

Falk, J. H. (2001). Free-Choice Science Education: How We Learn Science outside of School. Ways of Knowing in Science and Mathematics Series. Teachers College Press.

Falk, J. H., & Dierking, L. (1984). Public Institutions for Personal Leaming. *Establishing a Research Agenda*.

Falk, J. H., & Dierking, L. D. (2016). *The museum experience revisited*. Routledge.

Farber, B. A. (1991). *Crisis in education: Stress and burnout in the American teacher*. Jossey-Bass.

Farenga, S. J., & Joyce, B. A. (1999). Intentions of young students to enroll in science courses in the future: An examination of gender differences. *Science Education*, *83*(1), 55-75.

Feder, M. A., Shouse, A. W., Lewenstein, B., & Bell, P. (Eds.). (2009). *Learning Science in Informal Environments:: People, Places, and Pursuits*. National Academies Press.

Fernbach, P. M., Rogers, T., Fox, C. R., & Sloman, S. A. (2013). Political extremism is supported by an illusion of understanding. *Psychological science*, *24*(6), 939-946.

Fields, D. A. (2009). What do Students Gain from a Week at Science Camp? Youth perceptions and the design of an immersive, research-oriented astronomy camp. *International Journal of Science Education*, *31*(2), 151-171.

Fish, J. M. (Ed.). (2013 [2001]). Race and intelligence: Separating science from myth. Routledge.

Foley, D. E. (1991). Reconsidering anthropological explanations of ethnic school failure. *Anthropology & Education Quarterly*, *22*(1), 60-86.

Foley, D. A., Levinson, B. A., & Hurtig, J. (2000). Chapter 2: Anthropology Goes Inside: The New Educational Ethnography of Ethnicity and Gender. *Review of research in education*, *25*(1), 37-98.

Foucault, M. (1971). Orders of discourse. *Information (International Social Science Council)*, *10*(2), 7-30.

Francis, B. (2000). The gendered subject: students' subject preferences and discussions of gender and subject ability. *Oxford Review of Education*, *26*(1), 35-48.

Frank, C. R., & Uy, F. L. (2004). Ethnography for teacher education. *Journal of Teacher Education*, *55*(3), 269-283.

Fraser, S. (Ed.). (1995). *The bell curve wars: Race, intelligence, and the future of America*. Basic Books.

Fuller, E. J., & Dadey, N. (2013). REVIEW OF EVALUATION OF TEACH FOR AMERICA IN TEXAS SCHOOLS.

Furner, J. M., & Duffy, M. L. (2002). Equity for all students in the new millennium: Disabling math anxiety. *Intervention in School and Clinic*, *38*(2), 67-74.

Galton, F. (1869). *Hereditary genius: An inquiry into its laws and consequences* (Vol. 27). Macmillan.

Gardner, H. (2011). *Frames of mind: The theory of multiple intelligences*. Basic books.

Garrison, M. J. (2009). *A measure of failure: The political origins of standardized testing*. SUNY Press.

Gasbarra, P., & Johnson, J. (2008). Out before the Game Begins: Hispanic Leaders Talk about What's Needed to Bring More Hispanic Youngsters into Science, Technology and Math Professions. *Public Agenda*.

Geertz, C. (1973). *The interpretation of cultures: Selected essays* (Vol. 5019). Basic books.

George, M. (2001). And then God created Kansas? The evolution/creationism debate in America's public schools. *University of Pennsylvania Law Review*, *149*(3), 843-872.

Gerber, B. L., Marek, E. A., & Cavallo, A. M. (1997). Development of an informal learning assay. *DOCUMENT RESUME*, 393.

Gerber, B. L., Marek, E. A., & Cavallo, A. M. (2001). Development of an informal learning opportunities assay. *International Journal of Science Education*, *23*(6), 569-583.

Giberson, K. W., & Collins, F. S. (2011). *The language of science and faith: Straight answers to genuine questions*. InterVarsity Press.

Gilbert, J., & Calvert, S. (2003). Challenging accepted wisdom: looking at the gender and science education question through a different lens. *International Journal of Science Education*, *25*(7), 861-878.

Gilpin, R. (2011). *Global political economy: Understanding the international economic order*. Princeton University Press.

Gold, Y., & Roth, R. A. (2013). *Teachers managing stress & preventing burnout*. Routledge.

Green, R. (1978). Math Avoidance: A Barrier to American Indian Science Education and Science Careers. *BIA Education Research Bulletin*, *6*(3), 1-8.

Gregory, J., & Miller, S. (2000). *Science in public*. Basic Books.

Gupta, A., & Ferguson, J. (1992). Beyond “culture”: Space, identity, and the politics of difference. *Cultural anthropology*, *7*(1), 6-23.

Gurian, E. H. (2006). *Civilizing the museum: The collected writings of Elaine Heumann Gurian*. Taylor & Francis.

Haladyna, T., & Shaughnessy, J. (1982). Attitudes toward science: A quantitative synthesis. *Science Education*, *66*(4), 547-563.

Hall, C. C., Ariss, L., & Todorov, A. (2007). The illusion of knowledge: When more information reduces accuracy and increases confidence. *Organizational Behavior and Human Decision Processes*, *103*(2), 277-290.

Hammer, Ø., Harper, D. A. T., & Ryan, P. D. (2008). PAST—PAlaeontological STatistics, ver. 1.87. *Zuerich, Switzerland*.

Harding, S. (Ed.). (1993). *The" racial" economy of science: Toward a democratic future*. Indiana University Press.

Hargreaves, D. (1980). The occupational culture of teachers. *Teacher strategies*, 125-148.

Harris, B. J., Rhoads, T. R., Walden, S. E., Murphy, T. J., Meissler, R., & Reynolds, A. (2004). Gender equity in industrial engineering: A pilot study. *NWSA Journal*, *16*(1), 186-193.

Harrison, H. L. (2007). *The Temple and the Forum: The American Museum and Cultural Authority in Hawthorne, Melville, Stowe, and Whitman*. University Alabama Press.

Hartman, B.A., Kopp Miller, B., & Nelson, D.L. (2000). The effects of hands-on occupation versus demonstration on children's recall memory. American Journal of Occupational Therapy. 54, 477-483.

Hawkins, J., & Pea, R. D. (1987). Tools for bridging the cultures of everyday and scientific thinking. *Journal of Research in Science teaching*, *24*(4), 291-307.

Hazen, R. M., & Trefil, J. (2009). *Science matters: Achieving scientific literacy*. Anchor.

Hein, G. E. (2002). *Learning in the Museum*. Routledge.

Henriques, M. H., & dos Reis, R. P. (2015). Framing the palaeontological heritage within the geological heritage: an integrative vision. *Geoheritage*, *7*(3), 249-259.

Herrnstein, R. J., & Murray, C. (1994). The bell curve: The reshaping of American life by differences in intelligence. *New York: Free*.

Heywood, P. (2012). Anthropology and What There Is: Reflections on 'Ontology'. *Cambridge Anthropology*, *30*(1), 143.

Hillman, C. N. (2011). The effects of hands-on learning versus learning by demonstration on memory in community dwelling older adults.

Hirschfeld, L. A. (1995). Do children have a theory of race?. *Cognition*, *54*(2), 209-252.

Hodson, D. (1993). In search of a rationale for multicultural science education. *Science education*, *77*(6), 685-711.

Holbraad, M., Pedersen, M. A., & de Castro, E. V. (2014). The politics of ontology: Anthropological positions. *Cultural Anthropology*, *13*.

Hooper-Greenhill, E. (1999). *The educational role of the museum*. Psychology Press.

Hooper-Greenhill, E. (2007). *Museums and education: Purpose, pedagogy, performance*. Routledge.

Hsi, S., Linn, M. C., & Bell, J. E. (1997). The role of spatial reasoning in engineering and the design of spatial instruction. *Journal of Engineering Education*, *86*(2), 151-158.

Hymes, D. H. (2003). *Now I know only so far: Essays in ethnopoetics*. U of Nebraska Press.

Illich, I. (1973). Deschooling society. Harmondsworth, Middlesex.

Immerwahr, J. (2000). Great Expectations: How the Public and Parents--White, African American and Hispanic--View Higher Education.

Irons, P. (2004). *Jim Crow's Children: The Broken Promise of the Brown Decision*. Penguin.

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *The Mathematics Teacher*, 583-586.

Jaffe, M. (2001). *The gilded dinosaur: the fossil war between ED Cope and OC Marsh and the rise of American science*. Three Rivers Press

Jegede, O. J. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics education in Africa.

Jensen, A. (1969). How much can we boost IQ and scholastic achievement. *Harvard educational review*, *39*(1), 1-123.

Jensen, A. (1973). Educability and Group Differences. Harper and Rowe.

Jensen, A. R. (1998). The g factor: The science of mental ability.

Jensen, A. (2011). *Educational differences* (Vol. 182). Routledge.

Johns, M., Schmader, T., & Martens, A. (2005). Knowing is half the battle teaching stereotype threat as a means of improving women's math performance. *Psychological Science*, *16*(3), 175-179.

Johnson, M. (1967). Definitions and models in curriculum theory. *Educational theory*, *17*(2), 127-140.

Kanno, Y., & Norton, B. (2003). Imagined communities and educational possibilities: Introduction. *Journal of language, identity, and education*, *2*(4), 241-249.

Karlsson, T., Backman, L., Herlitz, A., Nilsson, L. G., Winbald, B., & Osterlind, P.O. (1989). Memory improvements at different stages of Alzheimer's disease. Neuropsychlogia, 27, 737-742.

Karp, I. (2006). *Museum frictions: public cultures/global transformations*. Duke University Press.

Karp, I. (2012). *Exhibiting cultures: The poetics and politics of museum display*. Smithsonian Institution.

Karp, I., Kreamer, C. M., & Levine, S. (Eds.). (2013). *Museums and communities: The politics of public culture*. Smithsonian Institution.

Katz, P., McGinnis, J. R., Hestness, E., Riedinger, K., Marbach-Ad, G., Dai, A., & Pease, R. (2011). Professional identity development of teacher candidates participating in an informal science education internship: A focus on drawings as evidence. *International Journal of Science Education*, *33*(9), 1169-1197.

Kelly, A. (1985). The construction of masculine science. *British Journal of sociology of education*, *6*(2), 133-154.

Kezar, A. J., Chambers, A. C., & Burkhardt, J. C. (Eds.). (2015). *Higher education for the public good: Emerging voices from a national movement*. Wiley & Sons.

Kiefer, A. K., & Sekaquaptewa, D. (2007). Implicit stereotypes and women's math performance: How implicit gender-math stereotypes influence women's susceptibility to stereotype threat. *Journal of Experimental Social Psychology*, *43*(5), 825-832.

Kim, M., & Dopico, E. (2014). Science education through informal education. *Cultural Studies of Science Education*, 1-7.

Kincheloe, J. L., Steinberg, S. R., & Gresson III, A. D. (1997). Measured Lies: The Bell Curve Examined. St. Martin's Press.

Klineberg, O. (1935). Race differences. Oxford: Harper.

Kohl, H. (1994). I won't learn from you. *Confronting student resistance in our classrooms. Teaching for Equity and Social Justice*, 134-135.

Kolb, D. A. (2014). *Experiential learning: Experience as the source of learning and development*. FT press.

Kozol, J. (2012). *Savage inequalities: Children in America's schools*. Broadway Books.

Kubli, F. (2005). Science teaching as a dialogue–Bakhtin, Vygotsky and some applications in the classroom. *Science & Education*, *14*(6), 501-534.

Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2015). *Guided Inquiry: Learning in the 21st Century: Learning in the 21st Century*. ABC-CLIO.

Kuhn, D. (2005). *Education for thinking*. Harvard University Press.

Kyriacou, C. (2001). Teacher stress: Directions for future research. *Educational review*, *53*(1), 27-35.

La Haye, R., & Naested, I. (2014). Mutual Interrogation: A Celebration of Alternate Perspectives for Visual Art and Math Curriculum. *Canadian Review of Art Education: Research & Issues*, *41*(2).

Lakoff, G., & Johnson, M. (2008). *Metaphors we live by*. University of Chicago press.

Ladson-Billings, G. (2006). It's not the culture of poverty, it's the poverty of culture: The problem with teacher education. *Anthropology & Education Quarterly*, *37*(2), 104-109.

Lancy, D. F., Bock, J. C., & Gaskins, S. (2010). *The anthropology of learning in childhood*. Rowman & Littlefield.

Larson, J. O. (1995). Fatima's rules and other elements of an unintended chemistry curriculum. Paper presented at the annual meeting of the American Educational Research Association San Francisco, CA.

Latour, B. (1990). Postmodern? No, simply amodern! Steps towards an anthropology of science. *Studies in History and Philosophy of Science Part A*, *21*(1), 145-171.

Lawson, A. E., & Renner, J. W. (1975). Relationships of science subject matter and developmental levels of learners. *Journal of Research in Science Teaching*, *12*(4), 347-358.

Lawson, A. E., & Wollman, W. T. (1976). Encouraging the transition from concrete to formal cognitive functioning-an experiment. *Journal of Research in Science Teaching*, *13*(5), 413-430.

LeCompte, M. D., & Millroy, W. L. (Eds.). (1992). *The handbook of qualitative research in education*. Academic Press.

LeCompte, M. D., & Schensul, J. J. (2010). *Designing & conducting ethnographic research: An introduction* (Vol. 1). Rowman Altamira.

LeCompte, M. D., Tesch, R., & Goetz, J. P. (1993). *Ethnography and qualitative design in educational research*. Academic Press.

Lee, E. (2004). American gatekeeping: race and immigration law in the twentieth century. *Not just black and white: Historical and contemporary perspectives on immigration, race, and ethnicity in the United States*, 119-144.

Lee, O., & Luykx, A. (2007). Science education and student diversity: Race/ethnicity, language, culture, and socioeconomic status. *Handbook of research on science education*, 171-197.

Lederman, M., & Bartsch, I. (2001). *The gender and science reader*. Psychology Press.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of research in science teaching*, *38*(3), 296-316.

Lett, J. W. (1997). *Science, reason, and anthropology: The principles of rational inquiry.* Rowman & Littlefield.

Levinson, B. A., & Holland, D. (1996). The cultural production of the educated person: An introduction. *The cultural production of the educated person: Critical ethnographies of schooling and local practice*, 1-54.

Levinson, B. A., & Pollock, M. (2016). *A Companion to the Anthropology of Education*. John Wiley & Sons.

Lewandowsky, S., Ballard, T., Oberauer, K., & Benestad, R. (2016). A blind expert test of contrarian claims about climate data. *Global Environmental Change*, *39*, 91-97.

Lewis, O. (1971). The culture of poverty. *Poor Americans: How the white poor live*, 20-26.

Lillard, P. P. (1996). *Montessori today: A comprehensive approach to education from birth to adulthood*. Random House LLC.

Lips, H. M. (1992). Gender-and science-related attitudes as predictors of college students' academic choices. *Journal of Vocational Behavior*, *40*(1), 62-81.

Loewen, J. W. (2005). *Sundown towns: A hidden dimension of American racism*. The New Press.

Long, B. C. (1988). Stress management for school personnel: Stress-inoculation training and exercise. *Psychology in the Schools*, *25*(3), 314-324.

Lucas, C. (2014). Create hands-on learning manipulatives to enhance basic skills. *Texas Child Care Quarterly, 37*(4).

MacIvor, M. (1995). Redefining science education for aboriginal students. In M. Battiste, & J. Barman (editors), First Nation education in Canada: The circle unfolds. Vancouver, BC: University of British Columbia.

MacLure, M. (1993). Arguing for your self: Identity as an organising principle in teachers’ jobs and lives. *British educational research journal*, *19*(4), 311-322.

Maddock, M. N. (1981). Science Education: An Anthropological Viewpoint. *Studies in Science Education*, *8*, 1-26.

Madrigal, L. (2012). *Statistics for Anthropology.* Cambridge University Press.

Maier, S. J., & Marek, E. A. (2006). The learning cycle: A reintroduction. *The Physics Teacher*, *44*(2), 109-113.

Malinowski, B. (2013). *Coral Gardens and Their Magic: The Description of Gardening [1935]*. Routledge.

Mallow, J. V. (1978). A science anxiety program. *American Journal of Physics*, *46*(8), 862-862.

Mallow, J. V. (1981). Science anxiety: Fear of science and how to overcome it.

Mallow, J. V. (2006). Science anxiety: research and action. *Handbook of college science teaching*, 325-349.

Mallow, J. V., & Greenburg, S. L. (1983). Science anxiety and science learning. *The Physics Teacher*, *21*(2), 95-99.

Marek, E. A. (2008). Why the learning cycle? *Journal of Elementary Science Education*, *20*(3), 63-69.

Marek, E. A., & Cavallo, A. M. (1997). *The learning cycle: Elementary school science and beyond.* Heinemann.

Marstine, J. (Ed.). (2008). *New museum theory and practice: an introduction*. John Wiley & Sons.

Martin, L. M. (2004). An emerging research framework for studying informal learning and schools. *Science Education*, *88*(S1), S71-S82.

McBeth, S. J. (1983). *Ethnic Identity and the Boarding School Experience of West-Central Oklahoma American Indians*. University Press of America.

McComas, W. F., Almazroa, H., & Clough, M. P. (1998). The nature of science in science education: An introduction. *Science & Education*, *7*(6), 511-532.

McCann, F. F., Marek, E. A., Pedersen, J. E., & Falsarella, C. (2007). CLSI: COOL LIFE SCIENCE INVESTIGATIONS. *Science and Children*, *45*(4), 26.

McLean, K. M. (1993). *Planning for people in museum exhibitions* (Vol. 1). Association for Science-Technology Centers Incorporated.

McLean, K. (1999). Museum exhibitions and the dynamics of dialogue. *Daedalus*, *128*(3), 83-107.

McLean, K. (2007). Do museum exhibitions have a future?. *Curator: The Museum Journal*, *50*(1), 109-121.

McLean, K., & Pollock, W. (Eds.). (2007). *Visitor voices in museum exhibitions*. Association of Science-Technology Centers Incorporated

McManus, S. D. (2013). A Curriculum of Experiences: Environmental Elements That Facilitate or Mediate Stress, Compassion Fatigue and Burnout among Educators.

McReynolds, E. C. (1960). *Oklahoma: a history of the Sooner state*. University of Oklahoma Press.

Mead, S., Chuong, C., & Goodson, C. (2015). Exponential growth, unexpected challenges: How Teach For America grew in scale and impact. *Sudbury, MA: Bellwether Education Partners*.

Meinwald, J., & Hildebrand, J. G. (Eds.). (2010). Science and the educated American: A core component of liberal education. American Academy of Arts and Sciences.

Mercier, H., & Sperber, D. (2017). *The enigma of reason*. Harvard University Press.

Miner, H. C. (1976). *The Corporation and the Indian: Tribal Sovereignty and Industrial Civilization in Indian Territory, 1865-1907*. Univ of Missouri Press.

Montagu, A. (2002). Race and IQ. Oxford University Press.

Montagu, A. (2001). Man's most dangerous myth: The fallacy of race.

Montessori, M. (2011). *Dr. Montessori's own handbook*. Schocken.

Montessori, M. (2013). *The montessori method*. Transaction Publishers.

Mooney, C. G. (2013). *Theories of Childhood: An Introduction to Dewey, Montessori, Erikson, Piaget & Vygotsky*. Redleaf Press.

Mooney, C., & Kirshenbaum, S. (2010). *Unscientific America: How scientific illiteracy threatens our future*. Basic Books.

Mullins, D. W. (1995). The science literacy crisis, philosophical issues, and the origin sciences. *Origins of Life and Evolution of Biospheres*, *25*(5), 495-510.

Nagel, L., & Brown, S. (2003). The ABCs of managing teacher stress. *The clearing house*, *76*(5), 255-258.

Newcombe, N. S., & Stieff, M. (2012). Six myths about spatial thinking. *International Journal of Science Education*, *34*(6), 955-971.

Nieto, S. (2002). Profoundly multicultural questions. *Educational Leadership*, *60*(4), 6-10.

Nieto, S. (2009). *Language, culture, and teaching: Critical perspectives*. Routledge.

Noguera, P. A. (2009). *The trouble with black boys:... And other reflections on race, equity, and the future of public education*. John Wiley & Sons.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., ... & Kesebir, S. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences*, *106*(26), 10593-10597.

Nyhan, B., & Reifler, J. (2010). When corrections fail: The persistence of political misperceptions. *Political Behavior*, *32*(2), 303-330.

O'Brien, L. T., & Crandall, C. S. (2003). Stereotype threat and arousal: Effects on women's math performance. *Personality and Social Psychology Bulletin*, *29*(6), 782-789.

Ogawa, M. (1995). Science education in a multiscience perspective. *Science Education*, *79*(5), 583-593.

Ogbu, J. U. (1974). The next generation: An ethnography of education in an urban neighborhood.

Ogbu, J. U. (1992). Understanding cultural diversity and learning. *Educational researcher*, *21*(8), 5-14.

Ogbu, J. U. (2003). *Black American students in an affluent suburb: A study of academic disengagement*. Routledge.

Oliver, J. S. (2007). Rural science education. *Handbook of research on science education*, 345-369.

O'loughlin, M. (1992). Rethinking science education: Beyond Piagetian constructivism toward a sociocultural model of teaching and learning. *Journal of research in science teaching*, *29*(8), 791-820.

Ortner, S. B. (1972). Is female to male as nature is to culture?. *Feminist studies*, *1*(2), 5-31.

Pacas, J. D. (2011). Does Race Matter?: How Having a Teacher of One's Own Race Affects Test Scores.

Pineau, E. L. (1994). Teaching is performance: Reconceptualizing a problematic metaphor. *American Educational Research Journal*, *31*(1), 3-25.

Neves de Jesus, S., & Conboy, J. (2001). A stress management course to prevent teacher distress. *International Journal of Educational Management*, *15*(3), 131-137.

Nieto, S. M. (2002). Profoundly multicultural questions. *Educational Leadership*, *60*(4), 6-10.

Nisbet, M. C., & Mooney, C. (2009). Framing science. *Science*, *316*.

Noguera, P. A. (2009). *The trouble with black boys:... And other reflections on race, equity, and the future of public education*. John Wiley & Sons.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., ... & Kesebir, S. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences*, *106*(26), 10593-10597.

O'Neill, S. P. (2015). Sapir–Whorf Hypothesis. *The International Encyclopedia of Language and Social Interaction*.

Piaget, J. (1965). The stages of the intellectual development of the child. *Educational psychology in context: Readings for future teachers*, 98-106.

Prilleltensky, I., Neff, M., & Bessell, A. (2016). Teacher Stress: What It Is, Why It's Important, How It Can be Alleviated. *Theory Into Practice*, *55*(2), 104-111.

Quinn, D. M., & Spencer, S. J. (2001). The interference of stereotype threat with women's generation of mathematical problem-solving strategies. *Journal of Social Issues*, *57*(1), 55-71.

Rabalais, M. E. (2014). *STEAM: A National Study of the Integration of the Arts Into STEM Instruction and its Impact on Student Achievement*. UNIVERSITY OF LOUISIANA AT LAFAYETTE.

Rahm, J., & Charbonneau, P. (1997). Probing stereotypes through students' drawings of scientists. *American Journal of Physics*, *65*(8), 774-778.

Rath, A., & Brown, D. E. (1996). Modes of engagement in science inquiry: A microanalysis of elementary students' orientations toward phenomena at a summer science camp. *Journal of Research in Science Teaching*, *33*(10), 1083-1097.

Ravitch, D. (2016). *The death and life of the great American school system: How testing and choice are undermining education*. Basic Books.

Ravitch, D. (2010). The myth of charter schools. *The New York Review of Books*, *11*.

Ravitch, D. (2013). *Reign of error: The hoax of the privatization movement and the danger to America's public schools*. Vintage.

Reedy-Maschner, K. L. (2010). *Aleut identities: tradition and modernity in an indigenous fishery* (Vol. 61). McGill-Queen's Press-MQUP.

Renner, J. W., & Marek, E. A. (1990). An educational theory base for science teaching. *Journal of Research in Science Teaching*, *27*(3), 241-246.

Resnick, Lauren B. "Teacher behaviour in the informal classroom." *Journal of Curriculum Studies* 4, no. 2 (1972): 99-109.

Richardson, K. M., & Rothstein, H. R. (2008). Effects of occupational stress management intervention programs: a meta-analysis.

Roeser, R. W., Schonert-Reichl, K. A., Jha, A., Cullen, M., Wallace, L., Wilensky, R., ... & Harrison, J. (2013). Mindfulness training and reductions in teacher stress and burnout: Results from two randomized, waitlist-control field trials. *Journal of Educational Psychology*, *105*(3), 787.

Rosenau, J. (2012). Science denial: A guide for scientists. *Trends in microbiology*, *20*(12), 567-569.

Roth, W. M., & Eijck, M. V. (2010). Fullness of life as minimal unit: Science, technology, engineering, and mathematics (STEM) learning across the life span. *Science Education*, *94*(6), 1027-1048.

Rozenblit, L., & Keil, F. (2002). The misunderstood limits of folk science: An illusion of explanatory depth. *Cognitive science*, *26*(5), 521-562.

Rudolph, J. L. (2002). *Scientists in the classroom: The cold war reconstruction of American science education*. Macmillan.

Rutledge, M. L., & Mitchell, M. A. (2002). High school biology teachers' knowledge structure, acceptance & teaching of evolution. *The American Biology Teacher*, *64*(1), 21-28.

Sagan, C. (1977). The dragons of Eden: speculations on the origins of human intelligence. *New York: Ballantine*.

Sagan, C. (1995). Wonder and skepticism. *Skeptical Inquirer*, *19*(1), 24-30.

Sandoval, W. A., & Morrison, K. (2003). High school students' ideas about theories and theory change after a biological inquiry unit. *Journal of research in science teaching*, *40*(4), 369-392.

Sapir, E., & Mandelbaum, D. G. (1985). *Selected writings of Edward Sapir in language, culture and personality* (Vol. 342). Univ of California Press.

Sasson, I. (2014). The role of informal science centers in science education: attitudes, skills, and self-efficacy. *Journal of Technology and Science Education*, *4*(3), 167-180.

Schensul, S. L., Schensul, J. J., & LeCompte, M. D. (1999). *Essential ethnographic methods: Observations, interviews, and questionnaires* (Vol. 2). Rowman Altamira.

Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology*, *38*(2), 194-201.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological review*, *115*(2), 336.

Schwab, J. J. (1969). The practical: A language for curriculum. *The School Review*, *78*(1), 1-23.

Schwartz, R. S., Lederman, N. G., & Crawford, B. A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science education*, *88*(4), 610-645.

Schweingruber, H. A., & Fenichel, M. (2010). *Surrounded by Science: Learning Science in Informal Environments*. National Academies Press.

Scribner, S., & Cole, M. (1973). Cognitive consequences of formal and informal education. *Science*, *182*(4112), 553-559.

Shepardson, D. P., & Pizzini, E. L. (1992). Gender bias in female elementary teachers' perceptions of the scientific ability of students. *Science Education*, *76*(2), 147-153.

Shields, C. M. (2007). *Bakhtin primer* (Vol. 14). Peter Lang.

Simon, N. (2010). *The participatory museum*. Museum 2.0.

Skagen, T., Torras, M. C., Blaabjerg, N. J., & Hansen, T. V. What is empowerment?.

Solomon, J. (1987). Social influences on the construction of pupil's understanding of science. Studies in Science Education, 14, 63-82.

Sousa, D. A., & Pilecki, T. (2013). *From STEM to STEAM: Using brain-compatible strategies to integrate the arts*. Corwin Press.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of experimental social psychology*, *35*(1), 4-28.

Spindler, G. D. (1987). Education and cultural process: Anthropological approaches. Waveland Press.

Spindler, G. (1994). Pathways to cultural awareness: Cultural therapy with teachers and students. Corwin Press.

Steele, C. M., Spencer, S. J., & Aronson, J. (2002). Contending with group image: The psychology of stereotype and social identity threat. *Advances in experimental social psychology*, *34*, 379-440.

Sterling, D. R., Matkins, J. J., Frazier, W. M., & Logerwell, M. G. (2007). Science camp as a transformative experience for students, parents, and teachers in the urban setting. *School Science and Mathematics*, *107*(4), 134-147.

Sternberg, R. J. (1999). *Thinking styles*. Cambridge University Press.

Stoddard, C., & Corcoran, S. P. (2007). The political economy of school choice: Support for charter schools across states and school districts. *Journal of Urban Economics*, *62*(1), 27-54.

Tobias, S. (1991). Math mental health: Going beyond math anxiety. *College Teaching*, *39*(3), 91-93.

Tobias, S. (1993). Overcoming math anxiety.

Tobin, K. G., & Capie, W. (1980). The Test of Logical Thinking: Development and Applications.

Tobin, J., & Davidson, D. (1990). The ethics of polyvocal ethnography: Empowering vs. textualizing children and teachers. *International Journal of Qualitative Studies in Education*, *3*(3), 271-283.

Traweek, S. (1992). Border crossings: Narrative strategies in science studies and among physicists in Tsukuba Science City, Japan. In A. Pickering (editor), Science as practice and culture. Chicago: University of Chicago Press.

Trefil, J. (2007). Why Science?. *Teachers College Press*.

Vygotsky, L. S. (1967). Play and its role in the mental development of the child. *Journal of Russian and East European Psychology*, *5*(3), 6-18.

Walker-Tileston, D., & Darling, S. (2015). Why culture counts: Teaching children in poverty. Solution Tree Press.

Wallace, C. S. (2013). Promoting shifts in preservice science teachers' thinking through teaching and action research in informal science settings. *Journal of Science Teacher Education*, *24*(5), 811-832.

Washburn, S. L. (1944). Thinking about race. *Science Education*, *28*(2), 65-76.

Wegerif, R. (2011). Towards a dialogic theory of how children learn to think. *Thinking Skills and Creativity*, *6*(3), 179-190.

Weil, S. (2012). *Making museums matter*. Smithsonian Institution.

Weinstein, M. (1998). Playing the paramecium: Science education from the stance of the cultural studies of science. *Educational Policy*, *12*(5), 484-506.

Wertsch, J. V. (1986). *Culture, communication, and cognition: Vygotskian perspectives*. CUP Archive.

West, W.G. "Participant observation research on the social construction of everyday classroom order." *Interchange* 6, no. 4 (1975): 35-43.

White, L. (2014). Ethnic Matching and the Achievement Gap: Seeking a Deeper Understanding.

Wigfield, A., & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology*, *80*(2), 210.

Winzelberg, A. J., & Luskin, F. M. (1999). The effect of a meditation training in stress levels in secondary school teachers. *Stress and Health*, *15*(2), 69-77.

Woolgar, S. (1989). Representation, cognition and self: What hope for an integration of psychology and sociology?. In *The cognitive turn* (pp. 201-223). Springer Netherlands.

Yates, T. B., & Marek, E. A. (2013). Is Oklahoma really OK? A regional study of the prevalence of biological evolution-related misconceptions held by introductory biology teachers. *Evolution: Education and Outreach*, *6*(1), 6.

Yates, T. B., & Marek, E. A. (2014). Teachers teaching misconceptions: a study of factors contributing to high school biology students' acquisition of biological evolution-related misconceptions. *Evolution: Education and Outreach*, *7*(1), 7.

Yates, T. B., & Marek, E. A. (2015). A Study Identifying Biological Evolution-Related Misconceptions Held by Prebiology High School Students. *Creative Education*, *6*(08), 811.

Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas. *Science education*, *86*(3), 343-367.

Zepeda, S. J. (2014). *The instructional leader's guide to informal classroom observations*. Routledge.

[i] http://www.pewforum.org/religious-landscape-study/

https://www.washingtonpost.com/blogs/govbeat/wp/2015/02/26/the-religious-states-of-america-in-22-maps/

http://www.gallup.com/poll/148427/say-bible-literally.aspx

http://www.slate.com/articles/health_and_science/human_nature/2014/12/creationism_poll_how_many_americans_believe_the_bible_is_literal_inerrant.html

http://hirr.hartsem.edu/megachurch/database.html

[ii] https://libraries.ok.gov/literacy/facts-statistics/

[iii] Anautics Inc. Report, 2010:
https://www.ok.gov/OAC/documents/Final%20Exec%20Summary-6-1-2011.pdf

[iv] https://www.washingtonpost.com/news/the-fix/wp/2016/07/18/rep-steve-king-wonders-what-sub-groups-besides-whites-made-contributions-to-civilization/?utm_term=.579683c1d6a2

[v] Organization for Economic Co-Operation and Development, 2016
[vi] http://sde.ok.gov/sde/current-charter

[vii] https://ncse.com/news/oklahoma;
http://webserver1.lsb.state.ok.us/cf_pdf/2017-18%20INT/SB/SB393%20INT.PDF

[viii] http://okafterschool.org/wp-content/uploads/2014/11/STEAM-Case-STudy-1.pdf

[ix] http://newsok.com/northeast-okc-braces-for-another-round-of-school-closures/article/5542275

APPENDIX A: SURVEY DATA

Agreement Question Data: All Respondents (n=152)

	Strongly Disagree (1)	Disagree (2)	Neutral/Not Sure (3)	Agree (4)	Strongly Agree (5)
Science and technology endeavors should be publicly funded.	0.00% 0	1.28% 1	6.41% 5	23.08% 18	69.23% 54
Technology endeavors should be publicly funded.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0
I would prefer to do experiments than to read about them.	0.00% 0	2.56% 2	11.54% 9	50.00% 39	35.90% 28
Modern scientific discoveries are doing more harm than good.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0
I would like to be given a science book or piece of scientific equipment as a gift.	0.00% 0	0.00% 0	5.13% 4	35.90% 28	58.97% 46
Americans do more important science than professionals from other countries.	11.39% 9	35.44% 28	48.10% 38	5.06% 4	0.00% 0
Scientists earn a lot of money.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0
Scientists should generally have access to all specimens.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0
I consider myself to be scientifically literate.	0.00% 0	1.27% 1	3.80% 3	35.44% 28	59.49% 47
Scientists usually make bad teachers.	20.25% 16	45.57% 36	27.85% 22	6.33% 5	0.00% 0
You can only call yourself a "scientist" if you do professional scientific research as a job.	37.97% 30	44.30% 35	12.66% 10	5.06% 4	0.00% 0
Scientists do a good job of exploring diverse perspectives.	0.00% 0	11.39% 9	37.97% 30	41.77% 33	8.86% 7
Scientists need to take responsibility for teaching science to the public.	0.00% 0	6.33% 5	15.19% 12	48.10% 38	30.38% 24
Money strongly influences what scientists do.	1.27% 1	5.06% 4	11.39% 9	58.23% 46	24.05% 19
Scientists cannot be religious.	60.26% 47	33.33% 26	3.85% 3	1.28% 1	1.28% 1
Historically, discoveries in science did more harm than good.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0
I would like to work in a laboratory.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0

If science reveals something socially controversial, we should avoid it.	**73.42%** 58	**25.32%** 20	**1.27%** 1	**0.00%** 0	**0.00%** 0
Some cultures cannot do science.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Thinking like a scientist is something people can learn.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Thinking like a scientist is innate - a person is either born with it or not.	**45.57%** 36	**49.37%** 39	**1.27%** 1	**1.27%** 1	**2.53%** 2
Science is objective, so it does not matter who is doing it - the answers would be the same.	**15.19%** 12	**32.91%** 26	**10.13%** 8	**31.65%** 25	**10.13%** 8
Some cultures are better at science than others.	**18.99%** 15	**37.97%** 30	**21.52%** 17	**20.25%** 16	**1.27%** 1
Men and women are equally good at science.	**0.00%** 0	**1.27%** 1	**0.00%** 0	**22.78%** 18	**75.95%** 60
A teacher inspired me to like science.	**1.27%** 1	**13.92%** 11	**10.13%** 8	**39.24%** 31	**35.44%** 28
A teacher discouraged me from liking science.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Science helps to make life better for humanity.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
I chose to teach science because I think it is the most important school subject.	**6.33%** 5	**21.52%** 17	**22.78%** 18	**35.44%** 28	**13.92%** 11
I think many of my students could excel in science careers.	**0.00%** 0	**2.53%** 2	**2.53%** 2	**51.90%** 41	**43.04%** 34
I consider myself to be a scientist.	**0.00%** 0	**8.86%** 7	**2.53%** 2	**45.57%** 36	**43.04%** 34
When I form an opinion, scientific evidence is the most important factor.	**0.00%** 0	**3.80%** 3	**5.06%** 4	**55.70%** 44	**35.44%** 28
It takes too many years of education to become a professional scientist.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
I understand the scientific peer review process.	**0.00%** 0	**2.53%** 2	**5.06%** 4	**43.04%** 34	**49.37%** 39
I trust scientists.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Scientific knowledge is the closest thing we have to the truth.	**2.53%** 2	**8.86%** 7	**21.52%** 17	**41.77%** 33	**25.32%** 20
I encourage all my students to pursue science careers equally.	**0.00%** 0	**9.09%** 7	**6.49%** 5	**50.65%** 39	**33.77%** 26
I am too extroverted to be a scientist.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0

Agreement Data: NATIONAL Respondents (n=92)

	Strongly Disagree (1)	Disagree (2)	Neutral/Not Sure (3)	Agree (4)	Strongly Agree (5)
Science and technology endeavors should be publicly funded.	**0.00%** 0	**1.28%** 1	**6.41%** 5	**23.08%** 18	**69.23%** 54
Technology endeavors should be publicly funded.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
I would prefer to do experiments than to read about them.	**0.00%** 0	**2.56%** 2	**11.54%** 9	**50.00%** 39	**35.90%** 28
Modern scientific discoveries are doing more harm than good.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
I would like to be given a science book or piece of scientific equipment as a gift.	**0.00%** 0	**0.00%** 0	**5.13%** 4	**35.90%** 28	**58.97%** 46
Americans do more important science than professionals from other countries.	**11.39%** 9	**35.44%** 28	**48.10%** 38	**5.06%** 4	**0.00%** 0
Scientists earn a lot of money.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Scientists should generally have access to all specimens.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
I consider myself to be scientifically literate.	**0.00%** 0	**1.27%** 1	**3.80%** 3	**35.44%** 28	**59.49%** 47
Scientists usually make bad teachers.	**20.25%** 16	**45.57%** 36	**27.85%** 22	**6.33%** 5	**0.00%** 0
You can only call yourself a "scientist" if you do professional scientific research as a job.	**37.97%** 30	**44.30%** 35	**12.66%** 10	**5.06%** 4	**0.00%** 0
Scientists do a good job of exploring diverse perspectives.	**0.00%** 0	**11.39%** 9	**37.97%** 30	**41.77%** 33	**8.86%** 7
Scientists need to take responsibility for teaching science to the public.	**0.00%** 0	**6.33%** 5	**15.19%** 12	**48.10%** 38	**30.38%** 24
Money strongly influences what scientists do.	**1.27%** 1	**5.06%** 4	**11.39%** 9	**58.23%** 46	**24.05%** 19
Scientists cannot be religious.	**60.26%** 47	**33.33%** 26	**3.85%** 3	**1.28%** 1	**1.28%** 1
Historically, discoveries in science did more harm than good.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
I would like to work in a laboratory.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
If science reveals something socially controversial, we should avoid it.	**73.42%** 58	**25.32%** 20	**1.27%** 1	**0.00%** 0	**0.00%** 0

Some cultures cannot do science.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Thinking like a scientist is something people can learn.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
Thinking like a scientist is innate - a person is either born with it or not.	**45.57%** 36	**49.37%** 39	**1.27%** 1	**1.27%** 1	**2.53%** 2
Science is objective, so it does not matter who is doing it - the answers would be the same.	**15.19%** 12	**32.91%** 26	**10.13%** 8	**31.65%** 25	**10.13%** 8
Some cultures are better at science than others.	**18.99%** 15	**37.97%** 30	**21.52%** 17	**20.25%** 16	**1.27%** 1
Men and women are equally good at science.	**0.00%** 0	**1.27%** 1	**0.00%** 0	**22.78%** 18	**75.95%** 60
A teacher inspired me to like science.	**1.27%** **1**	**13.92%** **11**	**10.13%** **8**	**39.24%** **31**	**35.44%** **28**
A teacher discouraged me from liking science.	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**
Science helps to make life better for humanity.	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**
I chose to teach science because I think it is the most important school subject.	**6.33%** **5**	**21.52%** **17**	**22.78%** **18**	**35.44%** **28**	**13.92%** **11**
I think many of my students could excel in science careers.	**0.00%** **0**	**2.53%** **2**	**2.53%** **2**	**51.90%** **41**	**43.04%** **34**
I consider myself to be a scientist.	**0.00%** **0**	**8.86%** **7**	**2.53%** **2**	**45.57%** **36**	**43.04%** **34**
When I form an opinion, scientific evidence is the most important factor.	**0.00%** **0**	**3.80%** **3**	**5.06%** **4**	**55.70%** **44**	**35.44%** **28**
It takes too many years of education to become a professional scientist.	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**
I understand the scientific peer review process.	**0.00%** **0**	**2.53%** **2**	**5.06%** **4**	**43.04%** **34**	**49.37%** **39**
I trust scientists.	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**
Scientific knowledge is the closest thing we have to the truth.	**2.53%** **2**	**8.86%** **7**	**21.52%** **17**	**41.77%** **33**	**25.32%** **20**
I encourage all my students to pursue science careers equally.	**0.00%** **0**	**9.09%** **7**	**6.49%** **5**	**50.65%** **39**	**33.77%** **26**
I am too extroverted to be a scientist.	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**	**0.00%** **0**

Agreement Data: OKLAHOMA Respondents (n=47)

	Strongly Disagree (1)	Disagree (2)	Neutral/Not Sure (3)	Agree (4)	Strongly Agree (5)
Science and technology endeavors should be publicly funded.	**0.00%** 0	**3.39%** 2	**32.20%** 19	**37.29%** 22	**27.12%** 16
Technology endeavors should be publicly funded.	**0.00%** 0	**0.00%** 0	**23.08%** 3	**46.15%** 6	**30.77%** 4
I would prefer to do experiments than to read about them.	**0.00%** 0	**3.33%** 2	**5.00%** 3	**46.67%** 28	**45.00%** 27
Modern scientific discoveries are doing more harm than good.	**38.46%** 5	**30.77%** 4	**23.08%** 3	**7.69%** 1	**0.00%** 0
I would like to be given a science book or piece of scientific equipment as a gift.	**3.45%** 2	**15.52%** 9	**10.34%** 6	**41.38%** 24	**29.31%** 17
Americans do more important science than professionals from other countries.	**10.17%** 6	**27.12%** 16	**55.93%** 33	**5.08%** 3	**1.69%** 1
Scientists earn a lot of money.	**0.00%** 0	**46.15%** 6	**46.15%** 6	**7.69%** 1	**0.00%** 0
Scientists should generally have access to all specimens.	**0.00%** 0	**15.38%** 2	**30.77%** 4	**46.15%** 6	**7.69%** 1
I consider myself to be scientifically literate.	**13.56%** 8	**18.64%** 11	**22.03%** 13	**38.98%** 23	**6.78%** 4
Scientists usually make bad teachers.	**32.76%** 19	**51.72%** 30	**13.79%** 8	**1.72%** 1	**0.00%** 0
You can only call yourself a "scientist" if you do professional scientific research as a job.	**23.73%** 14	**59.32%** 35	**15.25%** 9	**1.69%** 1	**0.00%** 0
Scientists do a good job of exploring diverse perspectives.	**0.00%** 0	**3.39%** 2	**37.29%** 22	**49.15%** 29	**10.17%** 6
Scientists need to take responsibility for teaching science to the public.	**3.45%** 2	**13.79%** 8	**36.21%** 21	**37.93%** 22	**8.62%** 5
Money strongly influences what scientists do.	**0.00%** 0	**17.24%** 10	**24.14%** 14	**43.10%** 25	**15.52%** 9
Scientists cannot be religious.	**48.28%** 28	**43.10%** 25	**3.45%** 2	**5.17%** 3	**0.00%** 0
Historically, discoveries in science did more harm than good.	**30.77%** 4	**53.85%** 7	**15.38%** 2	**0.00%** 0	**0.00%** 0
I would like to work in a laboratory.	**0.00%** 0	**23.08%** 3	**15.38%** 2	**46.15%** 6	**15.38%** 2
If science reveals something socially controversial, we should avoid it.	**35.09%** 20	**54.39%** 31	**8.77%** 5	**1.75%** 1	**0.00%** 0

Some cultures cannot do science.	**46.15%** 6	**38.46%** 5	**15.38%** 2	**0.00%** 0	**0.00%** 0
Thinking like a scientist is something people can learn.	**0.00%** 0	**0.00%** 0	**7.69%** 1	**38.46%** 5	**53.85%** 7
Thinking like a scientist is innate - a person is either born with it or not.	**24.14%** 14	**65.52%** 38	**8.62%** 5	**1.72%** 1	**0.00%** 0
Science is objective, so it does not matter who is doing it - the answers would be the same.	**6.78%** 4	**54.24%** 32	**16.95%** 10	**22.03%** 13	**0.00%** 0
Some cultures are better at science than others.	**15.52%** 9	**31.03%** 18	**32.76%** 19	**20.69%** 12	**0.00%** 0
Men and women are equally good at science.	**1.69%** 1	**3.39%** 2	**6.78%** 4	**52.54%** 31	**35.59%** 21
A teacher inspired me to like science.	**5.17%** 3	**10.34%** 6	**10.34%** 6	**37.93%** 22	**36.21%** 21
A teacher discouraged me from liking science.	**46.15%** 6	**46.15%** 6	**0.00%** 0	**7.69%** 1	**0.00%** 0
Science helps to make life better for humanity.	**0.00%** 0	**0.00%** 0	**15.38%** 2	**46.15%** 6	**38.46%** 5
I chose to teach science because I think it is the most important school subject.	**1.72%** 1	**36.21%** 21	**27.59%** 16	**22.41%** 13	**12.07%** 7
I think many of my students could excel in science careers.	**1.69%** 1	**3.39%** 2	**23.73%** 14	**47.46%** 28	**23.73%** 14
I consider myself to be a scientist.	**11.86%** 7	**22.03%** 13	**18.64%** 11	**37.29%** 22	**10.17%** 6
When I form an opinion, scientific evidence is the most important factor.	**1.69%** 1	**18.64%** 11	**35.59%** 21	**32.20%** 19	**11.86%** 7
It takes too many years of education to become a professional scientist.	**7.69%** 1	**69.23%** 9	**15.38%** 2	**0.00%** 0	**7.69%** 1
I understand the scientific peer review process.	**3.45%** 2	**15.52%** 9	**39.66%** 23	**25.86%** 15	**15.52%** 9
I trust scientists.	**0.00%** 0	**7.69%** 1	**30.77%** 4	**53.85%** 7	**7.69%** 1
Scientific knowledge is the closest thing we have to the truth.	**5.08%** 3	**18.64%** 11	**32.20%** 19	**30.51%** 18	**13.56%** 8
I encourage all my students to pursue science careers equally.	**1.69%** 1	**5.08%** 3	**23.73%** 14	**55.93%** 33	**13.56%** 8
I am too extroverted to be a scientist.	**23.08%** 3	**76.92%** 10	**0.00%** 0	**0.00%** 0	**0.00%** 0

Emotion Data: All Respondents (n=152)

	Excited, Happy, Positive	Frustrated, uncomfortable, overwhelmed, annoyed	Neutral or Calm	Anxious	This has happened to me
You are demonstrating a new science experiment procedure for your students.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
A student asks you a science question to which you do not know the answer.	**81.01%** 64	**3.80%** 3	**34.18%** 27	**7.59%** 6	**86.08%** 68
A student asks you how to pursue a career in science.	**97.47%** 77	**0.00%** 0	**10.13%** 8	**1.27%** 1	**74.68%** 59
You are speaking with parents who disapprove of the science curriculum.	**6.41%** 5	**23.08%** 18	**58.97%** 46	**33.33%** 26	**55.13%** 43
During a unit on geology, a student insists that crystals, rocks, and fossils can hold certain powers or energy.	**8.86%** 7	**12.66%** 10	**79.75%** 63	**2.53%** 2	**26.58%** 21
A new science article comes out that does not agree with what you have previously taught your students about a subject.	**51.90%** 41	**3.80%** 3	**44.30%** 35	**11.39%** 9	**58.23%** 46
A student asks what you think about anthropogenic climate change.	**67.09%** 53	**3.80%** 3	**41.77%** 33	**10.13%** 8	**62.03%** 49
You are teaching a newly developed science unit.	**73.42%** 58	**13.92%** 11	**13.92%** 11	**31.65%** 25	**74.68%** 59
A student questions your religious beliefs.	**12.66%** 10	**5.06%** 4	**79.75%** 63	**6.33%** 5	**69.62%** 55
You are training a preservice teacher on laboratory safety.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
A student says that scientists are atheists.	**8.86%** 7	**11.39%** 9	**82.28%** 65	**3.80%** 3	**54.43%** 43
A colleague asks your opinion on a recent science story in the news.	**82.28%** 65	**1.27%** 1	**26.58%** 21	**2.53%** 2	**67.09%** 53
You are visiting a museum with friends and they ask a science-related question to which you do not know the answer.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
You have taken your class on a trip to the museum and a student asks a science-related question to which you do not know the answer.	**75.95%** 60	**0.00%** 0	**36.71%** 29	**2.53%** 2	**41.77%** 33
An administrator or colleague discourages you from saying the word "evolution".	**5.13%** 4	**69.23%** 54	**23.08%** 18	**16.67%** 13	**17.95%** 14

You disagree with something in your students' science textbook.	**20.25%** 16	**21.52%** 17	**54.43%** 43	**11.39%** 9	**51.90%** 41
A student asks you a History of Science-related question.	**83.54%** 66	**0.00%** 0	**25.32%** 20	**0.00%** 0	**63.29%** 50
Another science teacher at your school tells you they don't believe in evolution.	**7.79%** 6	**57.14%** 44	**37.66%** 29	**22.08%** 17	**31.17%** 24
A student tells you they don't believe in evolution.	**11.69%** 9	**16.88%** 13	**74.03%** 57	**10.39%** 8	**71.43%** 55
You are asked to briefly explain the Nature of Science to your students.	**79.75%** 63	**2.53%** 2	**25.32%** 20	**3.80%** 3	**59.49%** 47

Emotion Data: NATIONAL Respondents (n=92)

	Excited, Happy, Positive	**Frustrated, uncomfortable, overwhelmed, annoyed**	**Neutral or Calm**	**Anxious**	**This has happened to me**
You are demonstrating a new science experiment procedure for your students.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
A student asks you a science question to which you do not know the answer.	**81.01%** 64	**3.80%** 3	**34.18%** 27	**7.59%** 6	**86.08%** 68
A student asks you how to pursue a career in science.	**97.47%** 77	**0.00%** 0	**10.13%** 8	**1.27%** 1	**74.68%** 59
You are speaking with parents who disapprove of the science curriculum.	**6.41%** 5	**23.08%** 18	**58.97%** 46	**33.33%** 26	**55.13%** 43
During a unit on geology, a student insists that crystals, rocks, and fossils can hold certain powers or energy.	**8.86%** 7	**12.66%** 10	**79.75%** 63	**2.53%** 2	**26.58%** 21
A new science article comes out that does not agree with what you have previously taught your students about a subject.	**51.90%** 41	**3.80%** 3	**44.30%** 35	**11.39%** 9	**58.23%** 46
A student asks what you think about anthropogenic climate change.	**67.09%** 53	**3.80%** 3	**41.77%** 33	**10.13%** 8	**62.03%** 49
You are teaching a newly developed science unit.	**73.42%** 58	**13.92%** 11	**13.92%** 11	**31.65%** 25	**74.68%** 59
A student questions your religious beliefs.	**12.66%** 10	**5.06%** 4	**79.75%** 63	**6.33%** 5	**69.62%** 55
You are training a preservice teacher on laboratory safety.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
A student says that scientists are atheists.	**8.86%** 7	**11.39%** 9	**82.28%** 65	**3.80%** 3	**54.43%** 43

A colleague asks your opinion on a recent science story in the news.	**82.28%** 65	**1.27%** 1	**26.58%** 21	**2.53%** 2	**67.09%** 53
You are visiting a museum with friends and they ask a science-related question to which you do not know the answer.	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0	**0.00%** 0
You have taken your class on a trip to the museum and a student asks a science-related question to which you do not know the answer.	**75.95%** 60	**0.00%** 0	**36.71%** 29	**2.53%** 2	**41.77%** 33
An administrator or colleague discourages you from saying the word "evolution".	**5.13%** 4	**69.23%** 54	**23.08%** 18	**16.67%** 13	**17.95%** 14
You disagree with something in your students' science textbook.	**20.25%** 16	**21.52%** 17	**54.43%** 43	**11.39%** 9	**51.90%** 41
A student asks you a History of Science-related question.	**83.54%** 66	**0.00%** 0	**25.32%** 20	**0.00%** 0	**63.29%** 50
Another science teacher at your school tells you they don't believe in evolution.	**7.79%** 6	**57.14%** 44	**37.66%** 29	**22.08%** 17	**31.17%** 24
A student tells you they don't believe in evolution.	**11.69%** 9	**16.88%** 13	**74.03%** 57	**10.39%** 8	**71.43%** 55
You are asked to briefly explain the Nature of Science to your students.	**79.75%** 63	**2.53%** 2	**25.32%** 20	**3.80%** 3	**59.49%** 47

Emotion Data: OKLAHOMA Respondents (n=47)

	Excited, Happy, Positive	Frustrated, uncomfortable, overwhelmed, annoyed	Neutral or Calm	Anxious	This has happened to me
You are demonstrating a new science experiment procedure for your students.	**130.77%** 17	**23.08%** 3	**15.38%** 2	**38.46%** 5	**53.85%** 7
A student asks you a science question to which you do not know the answer.	**38.33%** 23	**16.67%** 10	**48.33%** 29	**10.00%** 6	**61.67%** 37
A student asks you how to pursue a career in science.	**83.05%** 49	**3.39%** 2	**28.81%** 17	**5.08%** 3	**28.81%** 17
You are speaking with parents who disapprove of the science curriculum.	**1.69%** 1	**54.24%** 32	**49.15%** 29	**16.95%** 10	**13.56%** 8
During a unit on geology, a student insists that crystals, rocks, and fossils can hold certain powers or energy.	**1.67%** 1	**28.33%** 17	**73.33%** 44	**6.67%** 4	**11.67%** 7
A new science article comes out that does not agree with what you have previously taught your students about a subject.	**18.64%** 11	**16.95%** 10	**69.49%** 41	**10.17%** 6	**16.95%** 10

A student asks what you think about anthropogenic climate change.	**25.00%** 15	**23.33%** 14	**58.33%** 35	**5.00%** 3	**20.00%** 12
You are teaching a newly developed science unit.	**56.67%** 34	**25.00%** 15	**26.67%** 16	**36.67%** 22	**36.67%** 22
A student questions your religious beliefs.	**13.56%** 8	**23.73%** 14	**77.97%** 46	**5.08%** 3	**40.68%** 24
You are training a preservice teacher on laboratory safety.	**23.08%** 3	**7.69%** 1	**46.15%** 6	**38.46%** 5	**15.38%** 2
A student says that scientists are atheists.	**0.00%** 0	**40.68%** 24	**64.41%** 38	**3.39%** 2	**18.64%** 11
A colleague asks your opinion on a recent science story in the news.	**46.55%** 27	**5.17%** 3	**55.17%** 32	**3.45%** 2	**29.31%** 17
You are visiting a museum with friends and they ask a science-related question to which you do not know the answer.	**25.00%** 3	**25.00%** 3	**83.33%** 10	**16.67%** 2	**25.00%** 3
You have taken your class on a trip to the museum and a student asks a science-related question to which you do not know the answer.	**31.58%** 18	**14.04%** 8	**64.91%** 37	**5.26%** 3	**28.07%** 16
An administrator or colleague discourages you from saying the word "evolution".	**8.62%** 5	**55.17%** 32	**41.38%** 24	**10.34%** 6	**8.62%** 5

Correlation Data

		A	B	C	D	E
A. Science and technology endeavors should be publicly funded.	Pearson Correlation	1	-.050	.496	-.126	.494
	Sig. (2-tailed)		.558	.000	.145	.000
	N	137	137	135	136	136
B. I would prefer to do experiments than to read about them.	Pearson Correlation	-.050	1	.263	.207	-.004
	Sig. (2-tailed)	.558		.002	.015	.967
	N	137	138	136	137	137
C. I would like to be given a science book or piece of scientific equipment as a gift.	Pearson Correlation	.496	.263	1	-.103	.576

	Sig. (2-tailed)	.000	.002		.233	.000
	N	135	136	136	136	136
D. Americans do more important science than professionals from other countries.	Pearson Correlation	-.126	.207	-.103	1	-.177
	Sig. (2-tailed)	.145	.015	.233		.038
	N	136	137	136	138	138
E. I consider myself to be scientifically literate.	Pearson Correlation	.494	-.004	.576	-.177	1
	Sig. (2-tailed)	.000	.967	.000	.038	
	N	136	137	136	138	138
F. Scientists usually make bad teachers.	Pearson Correlation	.002	-.093	-.022	.038	.029
	Sig. (2-tailed)	.982	.279	.801	.656	.740
	N	135	136	135	137	137
G. You can only call yourself a "scientist" if you do professional scientific research as a job.	Pearson Correlation	-.129	-.035	-.191	-.109	-.117
	Sig. (2-tailed)	.134	.683	.026	.201	.171
	N	136	137	136	138	138
H. Scientists do a good job of exploring diverse perspectives.	Pearson Correlation	.144	-.057	.020	.123	-.047
	Sig. (2-tailed)	.094	.510	.815	.149	.588
	N	136	137	136	138	138
I. Scientists need to take responsibility for teaching science to the public.	Pearson Correlation	.155	-.148	.187	-.060	.231
	Sig. (2-tailed)	.072	.086	.030	.487	.006
	N	135	136	135	137	137
J. Money strongly influences what scientists do.	Pearson Correlation	.053	.017	.247	-.262	.186

	Sig. (2-tailed)	.542	.848	.004	.002	.029
	N	135	136	135	137	137
K. Scientists cannot be religious.	Pearson Correlation	-.148	-.047	-.135	.071	-.113
	Sig. (2-tailed)	.089	.588	.119	.411	.191
	N	134	135	134	136	136
L. If science reveals something socially controversial, we should avoid it.	Pearson Correlation	-.529	.063	-.224	.197	-.375
	Sig. (2-tailed)	.000	.468	.009	.022	.000
	N	134	135	134	136	136
M. Thinking like a scientist is innate - a person is either born with it or not.	Pearson Correlation	-.291	.129	-.243	.090	-.272
	Sig. (2-tailed)	.001	.134	.005	.296	.001
	N	135	136	134	136	136
N. Science is objective, so it does not matter who is doing it - the answers would be the same.	Pearson Correlation	-.010	-.020	.018	-.039	.228
	Sig. (2-tailed)	.912	.817	.836	.651	.007
	N	136	137	135	137	137
O. Some cultures are better at science than others.	Pearson Correlation	-.126	-.135	.026	.114	-.164
	Sig. (2-tailed)	.144	.117	.765	.188	.056
	N	135	136	134	136	136
P. Men and women are equally good at science.	Pearson Correlation	.371	-.026	.324	-.152	.431
	Sig. (2-tailed)	.000	.765	.000	.077	.000
	N	136	137	135	137	137
Q. A teacher inspired me to like science.	Pearson Correlation	.178	.160	.278	-.012	.234
	Sig. (2-tailed)	.039	.062	.001	.885	.006
	N	135	136	134	136	136

R. I chose to teach science because I think it is the most important school subject.	Pearson Correlation	.076	.117	.208	.120	.117
	Sig. (2-tailed)	.382	.175	.016	.163	.177
	N	135	136	134	136	136
S. I think many of my students could excel in science careers.	Pearson Correlation	.256	.199	.351	.113	.343
	Sig. (2-tailed)	.003	.020	.000	.188	.000
	N	136	137	135	137	137
T. I consider myself to be a scientist.	Pearson Correlation	.397	.145	.527	-.001	.660
	Sig. (2-tailed)	.000	.090	.000	.989	.000
	N	136	137	135	137	137
U. When I form an opinion, scientific evidence is the most important factor.	Pearson Correlation	.393	.076	.524	-.070	.501
	Sig. (2-tailed)	.000	.376	.000	.419	.000
	N	136	137	135	137	137
V. I understand the scientific peer review process.	Pearson Correlation	.428	-.093	.456	-.116	.634
	Sig. (2-tailed)	.000	.281	.000	.179	.000
	N	135	136	134	136	136
W. Scientific knowledge is the closest thing we have to the truth.	Pearson Correlation	.337	-.013	.364	-.140	.349
	Sig. (2-tailed) N	.000	.883	.000	.103 137	.000
		136	137	135		137
X. I encourage all my students to	Pearson	.157	.235	.305	-.027	.237
pursue science careers equally.	Correlation					
	Sig. (2-tailed)	.071	.006	.000	.753	.006
	N	134	135	133	135	135

F	G	H	I	J	K	L	M	N
.002	-.129	.144	.155	.05 3	-.148	-.529	-.291	-.010

.982	.134	.094	.072	.542	.089	.000	.00	.912
						1		
135	136	136	135	135	134	134	135	136
-.093	-.035	-.057	-.148	.017	-.047	.063	.129	-.020
.279	.683	.510	.086	.848	.588	.468	.134	.817
136	137	137	136	136	135	135	136	137
-.022	-.191	.020	.187	.247	-.135	-.224	-.243	.018
.801	.026	.815	.030	.004	.119	.009	.005	.836
135	136	136	135	135	134	134	134	135
.038	-.109	.123	-.060	-.262	.071	.197	.090	-.039
.656	.201	.149	.487	.002	.411	.022	.296	.651
137	138	138	137	137	136	136	136	137
.029	-.117	-.047	.231	.186	-.113	-.375	-.272	.228
.740	.171	.588	.006	.029	.191	.000	.001	.007
137	138	138	137	137	136	136	136	137
1	.150	-.328	.104	-.068	.163	.135	-.143	.032
	.080	.000	.228	.432	.059	.118	.098	.712
137	137	137	136	136	135	135	135	136
.150	1	.005	-.174	-.191	.057	.051	.031	-.054
.080		.958	.042	.025	.513	.555	.716	.532
137	138	138	137	137	136	136	136	137
-.328	.005	1	.092	-.088	.005	-.115	-.049	.147
.000	.958		.284	.306	.954	.183	.572	.086
137	138	138	137	137	136	136	136	137
.104	-.174	.092	1	.233	-.138	-.168	.041	.124
.228	.042	.284		.006	.109	.051	.638	.152
136	137	137	137	137	136	136	135	136
-.068	-.191	-.088	.233	1	-.099	-.098	.046	.050
.432	.025	.306	.006		.252	.255	.596	.561
136	137	137	137	137	136	136	135	136
.163	.057	.005	-.138	-.099	1	.230	.124	.089
.059	.513	.954	.109			.007	.154	.304

135	136	136	136	.252 136	136	135	134	135

.135	.051	-.115	-.168	-.098	.230	1	.244	-.088
.118	.555	.183	.051	.255	.007		.004	.308
135	136	136	136	136	135	136	135	136
-.143	.031	-.049	.041	.046	.124	.244	1	.035
.098	.716	.572	.638	.596	.154	.004		.684
135	136	136	135	135	134	135	137	137
.032	-.054	.147	.124	.050	.089	-.088	.035	1
.712	.532	.086	.152	.561	.304	.308	.684	
136	137	137	136	136	135	136	137	138
.084	.102	-.020	.038	.001	.185	.167	-.052	.038
.334	.236	.813	.662	.993	.033	.053	.550	.657
135	136	136	135	135	134	135	136	137
-.141	-.159	.110	.231	.014	-.249	-.539	-.235	.119
.103	.064	.202	.007	.876	.004	.000	.006	.163
136	137	137	136	136	135	136	137	138
-.136	-.096	.192	.072	-.042	-.092	-.116	-.097	.030
.117	.266	.025	.408	.626	.290	.182	.260	.729
135	136	136	135	135	134	135	136	137
-.044	-.148	.161	.166	.166	-.016	-.054	.159	.136
.611	.085	.061	.054	.054	.852	.534	.065	.113
135	136	136	135	135	134	135	136	137
-.083	-.275	.079	.085	.125	-.179	-.237	-.123	-.012
.336	.001	.362	.327	.148	.038	.006	.151	.887
136	137	137	136	136	135	136	137	138
.086	-.361	-.089	.295	.165	-.106	-.218	-.078	.238
.318	.000	.299	.000	.055	.219	.011	.363	.005
136	137	137	136	136	135	136	137	138

.022	-.061	.111	.284	.102	-.017	-.313	-.233	.164
.801	.478	.195	.001	.236	.846	.000	.006	.054
136	137	137	136	136	135	136	137	138
.097	-.092	-.046	.321	.193	-.194	-.342	-.266	.179
.263	.287	.599	.000	.025	.025	.000	.002	.037
135	136	136	135	135	134	135	136	137
-.030	-.082	.152	.284	.137	-.048	-.273	-.088	.164
.732	.340	.076	.001	.112	.577	.001	.307	.055
136	137	137	136	136	135	136	137	138
-.006	-.197	.199	.258	.212	-.067	-.112	.016	.265
.949	.022	.021	.003	.014	.444	.197	.857	.002
134	135	135	134	134	133	134	135	136

Correlation Data, Condensed

Correlations

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Science_and_technology_endeavors_should_be_publicly_funded.	Pearson Correlation	1	-.058	.541	-.207	.512	-.022	-.192	.146	.247	.147	-.222	-.594	-.262	.058	-.153	.443	.248	.142	.307	.462	.494	.546	.429	.238
	Sig. (2-tailed)		.550	.000	.032	.000	.821	.046	.131	.010	.132	.022	.000	.006	.552	.114	.000	.009	.144	.001	.000	.000	.000	.000	.013
	N	109	109	108	108	108	108	108	108	107	107	106	107	108	109	108	109	109	108	109	109	109	108	109	108
I_would_prefer_to_do_experiments_than_to_read_about_them.	Pearson Correlation	-.058	1	.243	.137	.040	-.022	-.029	-.102	-.130	.055	-.038	.020	.127	-.002	-.212	.015	.178	.136	.200	.182	.142	-.059	-.042	.314
	Sig. (2-tailed)	.550		.011	.158	.679	.822	.770	.296	.183	.575	.699	.839	.190	.986	.027	.878	.065	.162	.037	.058	.141	.543	.663	.001
	N	109	109	108	108	108	108	108	108	107	107	106	107	108	109	108	109	109	108	109	109	109	108	109	108
I_would_like_to_be_given_a_science_book_or_piece_of_scientific_equipment_as_a_gift	Pearson Correlation	.541	.243	1	-.203	.649	.002	-.208	-.034	.203	.272	-.154	-.250	-.250	.065	.000	.355	.286	.191	.327	.554	.580	.524	.401	.332
	Sig. (2-tailed)	.000	.011		.036	.000	.985	.030	.728	.036	.005	.114	.010	.010	.507	.997	.000	.003	.049	.001	.000	.000	.000	.000	.000
	N	108	108	108	108	108	108	108	108	107	107	106	107	107	108	107	108	108	107	108	108	108	107	108	107
Americans_do_more_important_science_than_professionals_from_other_countries	Pearson Correlation	-.207	.137	-.203	1	-.261	.039	-.129	.086	.018	-.161	.046	.200	.165	-.022	.052	-.166	-.011	.077	.032	-.053	-.114	-.198	-.283	-.103
	Sig. (2-tailed)	.032	.158	.036		.006	.689	.182	.376	.857	.096	.637	.038	.088	.820	.593	.084	.912	.427	.744	.586	.239	.040	.003	.291
	N	108	108	108	109	109	109	109	109	108	108	107	108	108	109	108	109	109	108	109	109	109	108	109	108
I_consider_myself_to_be_scientifically_literate.	Pearson Correlation	.512	.040	.649	-.261	1	.037	-.106	-.024	.293	.259	-.149	-.339	-.238	.263	-.137	.422	.299	.138	.344	.703	.530	.679	.401	.255
	Sig. (2-tailed)	.000	.679	.000	.006		.699	.271	.806	.002	.007	.127	.000	.013	.006	.158	.000	.002	.154	.000	.000	.000	.000	.000	.008
	N	108	108	108	109	109	109	109	109	108	108	107	108	108	109	108	109	109	108	109	109	109	108	109	108
Scientists_usually_make_bad_teachers.	Pearson Correlation	-.022	-.022	.002	.039	.037	1	.098	-.365	.048	-.033	.184	.154	-.114	.052	.111	-.176	-.112	-.025	-.138	.072	.005	.051	.030	-.047
	Sig. (2-tailed)	.821	.822	.985	.689	.699		.310	.000	.621	.735	.058	.111	.240	.591	.252	.067	.248	.801	.151	.457	.961	.598	.753	.628
	N	108	108	108	109	109	109	109	109	108	108	107	108	108	109	108	109	109	108	109	109	109	108	109	108
You_can_only_call_yourself_a_"scientist"_if_you_do_professional_scientific_research_as_a_job	Pearson Correlation	-.192	-.029	-.208	-.129	-.106	.098	1	-.062	-.195	-.174	-.014	.014	.093	-.045	.028	-.136	-.119	-.140	-.282	-.386	-.082	-.111	-.136	-.230
	Sig. (2-tailed)	.046	.770	.030	.182	.271	.310		.520	.043	.072	.888	.886	.339	.643	.776	.158	.216	.148	.003	.000	.399	.252	.158	.017
	N	108	108	108	109	109	109	109	109	108	108	107	108	108	109	108	109	109	108	109	109	109	108	109	108
Scientists_do_a_good_job_of_exploring_diverse_perspectives.	Pearson Correlation	.146	-.102	-.034	.086	-.024	-.365	-.062	1	.160	-.056	-.108	-.215	-.055	.143	-.085	.178	.201	.142	.132	-.084	.099	-.016	.105	.213
	Sig. (2-tailed)	.131	.296	.728	.376	.806	.000	.520		.099	.565	.267	.026	.571	.139	.383	.064	.036	.142	.171	.388	.307	.872	.278	.027
	N	108	108	108	109	109	109	109	109	108	108	107	108	108	109	108	109	109	108	109	109	109	108	109	108
Scientists_need_to_take_responsibility_for_teaching_science_to_the_public.	Pearson Correlation	.247	-.130	.203	.018	.293	.048	-.195	.160	1	.147	-.028	-.219	.041	.155	.083	.210	.094	.202	.054	.302	.329	.307	.339	.228
	Sig. (2-tailed)	.010	.183	.036	.857	.002	.621	.043	.099		.130	.773	.023	.672	.109	.397	.029	.331	.037	.577	.001	.001	.001	.000	.018
	N	107	107	107	108	108	108	108	108	108	108	107	108	107	108	107	108	108	107	108	108	108	107	108	107
Money_strongly_influences_what_scientists_do.	Pearson Correlation	.147	.055	.272	-.161	.259	-.033	-.174	-.056	.147	1	-.008	-.129	-.062	.059	.075	.020	-.081	.214	.168	.176	.162	.235	.202	.233
	Sig. (2-tailed)	.132	.575	.005	.096	.007	.735	.072	.565	.130		.933	.185	.525	.544	.442	.839	.402	.027	.081	.069	.094	.015	.036	.016
	N	107	107	107	108	108	108	108	108	108	108	107	108	107	108	107	108	108	107	108	108	108	107	108	107
Scientists_cannot_be_religious.	Pearson Correlation	-.222	-.038	-.154	.046	-.149	.184	-.014	-.108	-.028	-.008	1	.226	.164	.071	.211	-.251	-.088	-.006	-.163	-.090	-.048	-.229	-.039	-.038
	Sig. (2-tailed)	.022	.699	.114	.637	.127	.058	.888	.267	.773	.933		.019	.093	.469	.030	.009	.365	.955	.093	.355	.623	.018	.692	.703
	N	106	106	106	107	107	107	107	107	107	107	107	107	106	107	106	107	107	106	107	107	107	106	107	106
If_science_reveals_something_socially_controversial,_we_should_avoid_it.	Pearson Correlation	-.594	.020	-.250	.200	-.339	.154	.014	-.215	-.219	-.129	.226	1	.214	-.108	.185	-.548	-.168	-.099	-.277	-.239	-.325	-.379	-.323	-.145
	Sig. (2-tailed)	.000	.839	.010	.038	.000	.111	.886	.026	.023	.185	.019		.027	.265	.056	.000	.081	.308	.004	.013	.001	.000	.001	.137
	N	107	107	107	108	108	108	108	108	108	108	107	108	107	108	107	108	108	107	108	108	108	107	108	107
Thinking_like_a_scientist_is_innate_-_a_person_is_either_born_with_it_or_not	Pearson Correlation	-.262	.127	-.250	.165	-.238	-.114	.093	-.055	.041	-.062	.164	.214	1	-.014	-.033	-.195	-.092	.216	-.106	-.029	-.194	-.256	-.045	.007
	Sig. (2-tailed)	.006	.190	.010	.088	.013	.240	.339	.571	.672	.525	.093	.027		.883	.732	.042	.339	.025	.274	.764	.043	.007	.640	.940
	N	108	108	107	108	108	108	108	108	107	107	106	107	109	109	108	109	109	108	109	109	109	108	109	108
Science_is_objective,_so_it_does_not_matter_who_is_doing_it_-_the_answers_would_be_the_s	Pearson Correlation	.058	-.002	.065	-.022	.263	.052	-.045	.143	.155	.059	.071	-.108	-.014	1	.061	.146	.118	.110	.045	.298	.181	.230	.185	.277
	Sig. (2-tailed)	.552	.986	.507	.820	.006	.591	.643	.139	.109	.544	.469	.265	.883		.525	.128	.219	.256	.644	.002	.058	.016	.053	.004
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
Some_cultures_are_better_at_science_than_others.	Pearson Correlation	-.153	-.212	.000	.052	-.137	.111	.028	-.085	.083	.075	.211	.185	-.033	.061	1	-.215	-.038	-.089	-.233	-.039	.136	-.085	.053	-.111
	Sig. (2-tailed)	.114	.027	.997	.593	.158	.252	.776	.383	.397	.442	.030	.056	.732	.525		.025	.698	.359	.015	.688	.159	.382	.581	.253
	N	108	108	107	108	108	108	108	108	107	107	106	107	108	109	109	109	109	108	109	109	109	109	109	108
Men_and_women_are_equally_good_at_science.	Pearson Correlation	.443	.015	.355	-.166	.422	-.176	-.136	.178	.210	.020	-.251	-.548	-.195	.146	-.215	1	.167	.233	.379	.330	.327	.397	.272	.174
	Sig. (2-tailed)	.000	.878	.000	.084	.000	.067	.158	.064	.029	.839	.009	.000	.042	.128	.025		.081	.015	.000	.000	.000	.000	.004	.070
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
A_teacher_inspired_me_to_like_science.	Pearson Correlation	.248	.178	.286	-.011	.299	-.112	-.119	.201	.094	-.081	-.088	-.168	-.092	.118	-.038	.167	1	.320	.208	.240	.356	.272	.173	.104
	Sig. (2-tailed)	.009	.065	.003	.912	.002	.248	.216	.036	.331	.402	.365	.081	.339	.219	.698	.081		.001	.029	.012	.000	.004	.070	.280
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
I_chose_to_teach_science_because_I_think_it_is_the_most_important_school_subject	Pearson Correlation	.142	.136	.191	.077	.138	-.025	-.140	.142	.202	.214	-.006	-.099	.216	.110	-.089	.233	.320	1	.248	.293	.252	.048	.185	.198
	Sig. (2-tailed)	.144	.162	.049	.427	.154	.801	.148	.142	.037	.027	.955	.308	.025	.256	.359	.015	.001		.009	.002	.008	.618	.054	.040
	N	108	108	107	108	108	108	108	108	107	107	106	107	108	109	108	109	109	109	109	109	109	108	109	108
I_think_many_of_my_students_could_excel_in_science_careers.	Pearson Correlation	.307	.200	.327	.032	.344	-.138	-.282	.132	.054	.168	-.163	-.277	-.106	.045	-.233	.379	.208	.248	1	.375	.260	.223	.183	.547
	Sig. (2-tailed)	.001	.037	.001	.744	.000	.151	.003	.171	.577	.081	.093	.004	.274	.644	.015	.000	.029	.009		.000	.006	.020	.056	.000
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
I_consider_myself_to_be_a_scientist.	Pearson Correlation	.462	.182	.554	-.053	.703	.072	-.386	-.084	.302	.176	-.090	-.239	-.029	.298	-.039	.330	.240	.293	.375	1	.477	.489	.370	.285
	Sig. (2-tailed)	.000	.058	.000	.586	.000	.457	.000	.388	.001	.069	.355	.013	.764	.002	.688	.000	.012	.002	.000		.000	.000	.000	.003
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
When_I_form_an_opinion,_scientific_evidence_is_the_most_important_factor.	Pearson Correlation	.494	.142	.580	-.114	.530	.005	-.082	.099	.329	.162	-.048	-.325	-.194	.181	.136	.327	.356	.252	.260	.477	1	.538	.457	.245
	Sig. (2-tailed)	.000	.141	.000	.239	.000	.961	.399	.307	.001	.094	.623	.001	.043	.058	.159	.000	.000	.008	.006	.000		.000	.000	.010
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
I_understand_the_scientific_peer_review_process.	Pearson Correlation	.546	-.059	.524	-.198	.679	.051	-.111	-.016	.307	.235	-.229	-.379	-.256	.230	-.085	.397	.272	.048	.223	.489	.538	1	.425	.274
	Sig. (2-tailed)	.000	.543	.000	.040	.000	.598	.252	.872	.001	.015	.018	.000	.007	.016	.382	.000	.004	.618	.020	.000	.000		.000	.004
	N	108	108	107	108	108	108	108	108	107	107	106	107	108	109	109	109	109	108	109	109	109	109	109	108
Scientific_knowledge_is_the_closest_thing_we_have_to_the_truth.	Pearson Correlation	.429	-.042	.401	-.283	.401	.030	-.136	.105	.339	.202	-.039	-.323	-.045	.185	.053	.272	.173	.185	.183	.370	.457	.425	1	.214
	Sig. (2-tailed)	.000	.663	.000	.003	.000	.753	.158	.278	.000	.036	.692	.001	.640	.053	.581	.004	.070	.054	.056	.000	.000	.000		.025
	N	109	109	108	109	109	109	109	109	108	108	107	108	109	110	109	110	110	109	110	110	110	109	110	109
I_encourage_all_my_students_to_pursue_science_careers_equally.	Pearson Correlation	.238	.314	.332	-.103	.255	-.047	-.230	.213	.228	.233	-.038	-.145	.007	.277	-.111	.174	.104	.198	.547	.285	.245	.274	.214	1
	Sig. (2-tailed)	.013	.001	.000	.291	.008	.628	.017	.027	.018	.016	.703	.137	.940	.004	.253	.070	.280	.040	.000	.003	.010	.004	.025	
	N	108	108	107	108	108	108	108	108	107	107	106	107	108	109	108	109	109	108	109	109	109	108	109	109

Positive Significant Correlations

Positive Correlations

- A. Science and technology endeavors should be publicly funded.
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - M. Thinking like a scientist is innate - a person is either born with it or not. (+)
  - P. Men and women are equally good at science. (+)
  - S. I think many of my students could excel in science careers. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
- B. I would prefer to do experiments than to read about them.
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - D. Americans do more important science than professionals from other countries. (+)
  - S. I think many of my students could excel in science careers. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- C. I would like to be given a science book or piece of scientific equipment as a gift.
  - Science and technology endeavors should be publicly funded. (+)
  - I would prefer to do experiments than to read about them. (+)
  - E. I consider myself to be scientifically literate. (+)
  - I. Scientists need to take responsibility for teaching science to the public. (+)
  - J. Money strongly influences what scientists do. (+)
  - P. Men and women are equally good at science. (+)
- D. Americans do more important science than professionals from other countries.
  - B. I would prefer to do experiments than to read about them. (+)
  - L. If science reveals something socially controversial, we should avoid it. (+)
- E. I consider myself to be scientifically literate.
  - A. Science and technology endeavors should be publicly funded. (+)
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - I. Scientists need to take responsibility for teaching science to the public.(+)
  - J. Money strongly influences what scientists do. (+)
  - N. Science is objective, so it does not matter who is doing it - the answers would be the same. (+)
  - P. Men and women are equally good at science. (+)
  - S. I think many of my students could excel in science careers. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- F. Scientists usually make bad teachers.
  - K. Scientists cannot be religious. (+)
- H. Scientists do a good job of exploring diverse perspectives.
  - Q. A teacher inspired me to like science. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- I. Scientists need to take responsibility for teaching science to the public.
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - J. Money strongly influences what scientists do.(+)
  - P. Men and women are equally good at science. (+)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
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  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- K. Scientists cannot be religious.
  - F. Scientists usually make bad teachers. (+)
  - L. If science reveals something socially controversial, we should avoid it. (+)
  - O. Some cultures are better at science than others. (+)
- L. If science reveals something socially controversial, we should avoid it.
  - D. Americans do more important science than professionals from other countries. (+)
  - K. Scientists cannot be religious. (+)
  - M. Thinking like a scientist is innate - a person is either born with it or not. (+)
  - O. Some cultures are better at science than others. (+)
- M. Thinking like a scientist is innate - a person is either born with it or not.
  - L. If science reveals something socially controversial, we should avoid it. (+)
- N. Science is objective, so it does not matter who is doing it - the answers would be the same.
  - E. I consider myself to be scientifically literate. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor.(+)
  - V. I understand the scientific peer review process. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- O. Some cultures are better at science than others.
  - K. Scientists cannot be religious. (+)
  - L. If science reveals something socially controversial, we should avoid it. (+)
- P. Men and women are equally good at science.
  - A .Science and technology endeavors should be publicly funded. (+)
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - I. Scientists need to take responsibility for teaching science to the public. (+)
  - K. Scientists cannot be religious. (-)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - S. I think many of my students could excel in science careers (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- Q. A teacher inspired me to like science.
  - A. Science and technology endeavors should be publicly funded. (+)
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - H. Scientists do a good job of exploring diverse perspectives. (+)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - S. I think many of my students could excel in science careers. (+)
  - T. I consider myself to be a scientist. (+)
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- R. I chose to teach science because I think it is the most important school subject.
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  - I. Scientists need to take responsibility for teaching science to the public. (+)
  - J. Money strongly influences what scientists do. (+)
  - P. Men and women are equally good at science. (+)
  - Q. A teacher inspired me to like science. (+)
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  - E. I consider myself to be scientifically literate (+)
  - P. Men and women are equally good at science. (+)
  - Q. A teacher inspired me to like science. (+)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- T. I consider myself to be a scientist.
  - A. Science and technology endeavors should be publicly funded. (+)
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - I. Scientists need to take responsibility for teaching science to the public (+)
  - J. Money strongly influences what scientists do. (+)
  - N. Science is objective, so it does not matter who is doing it - the answers would be the same. (+)
  - P. Men and women are equally good at science. (+)
  - Q. A teacher inspired me to like science. (+)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - S. I think many of my students could excel in science careers. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- U. When I form an opinion, scientific evidence is the most important factor.
  - A. Science and technology endeavors should be publicly funded. (+)
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  - I. Scientists need to take responsibility for teaching science to the public. (+)
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  - V. I understand the scientific peer review process.(+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
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  - E. I consider myself to be scientifically literate. (+)
  - I. Scientists need to take responsibility for teaching science to the public (+)
  - J. Money strongly influences what scientists do. (+)
  - N. Science is objective, so it does not matter who is doing it - the answers would be the same.(+)
  - P. Men and women are equally good at science. (+)
  - Q. A teacher inspired me to like science. (+)
  - S. I think many of my students could excel in science careers. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- W. Scientific knowledge is the closest thing we have to the truth.
  - A. Science and technology endeavors should be publicly funded. (+)
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - I. Scientists need to take responsibility for teaching science to the public (+)
  - L. If science reveals something socially controversial, we should avoid it. (-)
  - N. Science is objective, so it does not matter who is doing it - the answers would be the same. (+)
  - P. Men and women are equally good at science. (+)
  - Q. A teacher inspired me to like science. (+)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - X. I encourage all my students to pursue science careers equally. (+)
- X. I encourage all my students to pursue science careers equally.
  - B. I would prefer to do experiments than to read about them. (+)
  - C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
  - E. I consider myself to be scientifically literate. (+)
  - G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)
  - H. Scientists do a good job of exploring diverse perspectives. (+)
  - I. Scientists need to take responsibility for teaching science to the public. (+)
  - J. Money strongly influences what scientists do. (+)
  - N. Science is objective, so it does not matter who is doing it - the answers would be the same. (+)
  - P. Men and women are equally good at science. (+)
  - R. I chose to teach science because I think it is the most important school subject. (+)
  - S. I think many of my students could excel in science careers. (+)
  - T. I consider myself to be a scientist. (+)
  - U. When I form an opinion, scientific evidence is the most important factor. (+)
  - V. I understand the scientific peer review process. (+)
  - W. Scientific knowledge is the closest thing we have to the truth. (+)

Negative and Unexpected Significant Correlations

Negative Correlations

A. Science and technology endeavors should be publicly funded.
- L. If science reveals something socially controversial, we should avoid it. (-)

C. I would like to be given a science book or piece of scientific equipment as a gift.
- G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)
- L. If science reveals something socially controversial, we should avoid it. (-)
- M. Thinking like a scientist is innate - a person is either born with it or not. (-)

D. Americans do more important science than professionals from other countries.
- E. I consider myself to be scientifically literate. (-)
- J. Money strongly influences what scientists do. (-)

E. I consider myself to be scientifically literate.
- D. Americans do more important science than professionals from other countries. (-)
- L. If science reveals something socially controversial, we should avoid it. (-)
- M. Thinking like a scientist is innate - a person is either born with it or not. (-)
- O. Some cultures are better at science than others. (-)

F. Scientists usually make bad teachers.
- H. Scientists do a good job of exploring diverse perspectives. (-)

G. You can only call yourself a "scientist" if you do professional scientific research as a job.
- C. I would like to be given a science book or piece of scientific equipment as a gift. (-)
- I. Scientists need to take responsibility for teaching science to the public. (-)
- J. Money strongly influences what scientists do. (-)

H. Scientists do a good job of exploring diverse perspectives.
- F. Scientists usually make bad teachers. (-)

I. Scientists need to take responsibility for teaching science to the public.
- G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)
- L. If science reveals something socially controversial, we should avoid it. (-)

J. Money strongly influences what scientists do.
- D. Americans do more important science than professionals from other countries. (-)
- G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)

L. If science reveals something socially controversial, we should avoid it.
- A. Science and technology endeavors should be publicly funded. (-)
- C. I would like to be given a science book or piece of scientific equipment as a gift. (-)
- E. I consider myself to be scientifically literate. (-)
- I. Scientists need to take responsibility for teaching science to the public (-)
- P. Men and women are equally good at science. (-)
- S. I think many of my students could excel in science careers. (-)
- T. I consider myself to be a scientist. (-)
- U. When I form an opinion, scientific evidence is the most important factor. (-)
- V. I understand the scientific peer review process. (-)
- W. Scientific knowledge is the closest thing we have to the truth. (-)

M. Thinking like a scientist is innate - a person is either born with it or not.
- A. Science and technology endeavors should be publicly funded. (-)
- C. I would like to be given a science book or piece of scientific equipment as a gift. (-)
- E. I consider myself to be scientifically literate. (-)
- P. Men and women are equally good at science. (-)
- U. When I form an opinion, scientific evidence is the most important factor. (-)
- V. I understand the scientific peer review process. (-)

O. Some cultures are better at science than others.
- E. I consider myself to be scientifically literate. (-)
- P. Men and women are equally good at science. (-)
- S. I think many of my students could excel in science careers. (-)

P. Men and women are equally good at science.
- K. Scientists cannot be religious. (-)
- L. If science reveals something socially controversial, we should avoid it. (-)
- M. Thinking like a scientist is innate - a person is either born with it or not. (-)
- O. Some cultures are better at science than others. (-)

S. I think many of my students could excel in science careers.
- G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)
- K. Scientists cannot be religious. (-)
- L. If science reveals something socially controversial, we should avoid it.(-)
- O. Some cultures are better at science than others. (-)

T. I consider myself to be a scientist.
- G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)
- L. If science reveals something socially controversial, we should avoid it. (-)

U. When I form an opinion, scientific evidence is the most important factor.
- L. If science reveals something socially controversial, we should avoid it. (-)
- M. Thinking like a scientist is innate - a person is either born with it or not. (-)

V. I understand the scientific peer review process.
- K. Scientists cannot be religious. (-)
- L. If science reveals something socially controversial, we should avoid it. (-)
- M. Thinking like a scientist is innate - a person is either born with it or not. (-)

W. Scientific knowledge is the closest thing we have to the truth.
- L. If science reveals something socially controversial, we should avoid it. (-)

X. I encourage all my students to pursue science careers equally.
- G. You can only call yourself a "scientist" if you do professional scientific research as a job. (-)

Unexpected Correlations

D. Americans do more important science than professionals from other countries.
- B. I would prefer to do experiments than to read about them. (+)
- L. If science reveals something socially controversial, we should avoid it. (+)

F. Scientists usually make bad teachers.
- K. Scientists cannot be religious. (+)

J. Money strongly influences what scientists do.
- C. I would like to be given a science book or piece of scientific equipment as a gift. (+)
- E. I consider myself to be scientifically literate. (+)
- I. Scientists need to take responsibility for teaching science to the public. (+)
- R. I chose to teach science because I think it is the most important school subject. (+)
- T. I consider myself to be a scientist. (+)
- V. I understand the scientific peer review process.(+)
- W. Scientific knowledge is the closest thing we have to the truth. (+)
- X. I encourage all my students to pursue science careers equally. (+)

K. Scientists cannot be religious.
- F. Scientists usually make bad teachers. (+)
- L. If science reveals something socially controversial, we should avoid it. (+)
- O. Some cultures are better at science than others. (+)

L. If science reveals something socially controversial, we should avoid it.
- D. Americans do more important science than professionals from other countries. (+)
- K. Scientists cannot be religious. (+)
- M. Thinking like a scientist is innate - a person is either born with it or not. (+)
- O. Some cultures are better at science than others. (+)

M. Thinking like a scientist is innate - a person is either born with it or not.
- L. If science reveals something socially controversial, we should avoid it. (+)

O. Some cultures are better at science than others.
- K. Scientists cannot be religious. (+)
- L. If science reveals something socially controversial, we should avoid it. (+)