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# Exploring The "Mojo" Of Presidential Awards For Excellence In Mathematics And Science Teaching (PAEMST) Recipients

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# EXPLORING THE "MOJO" OF PRESIDENTIAL AWARDS FOR EXCELLENCE IN MATHEMATICS AND SCIENCE TEACHING (PAEMST) RECIPIENTS

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ABSTRACT

The purpose of this dissertation was to determine how extraordinary science teachers develop their teaching mojo. The teachers investigated were recipients of the prestigious Presidential Award for Excellence in Math and Science Teaching (PAEMST). This investigation focuses specifically on science instruction. The method used for this investigation was individual and group interviews conducted with eight PAEMST recipients.

Five themes emerged from these interviews: 1. Science is a natural motivator for learning; 2. Students need to be scientifically literate citizens; 3. A critical "trigger event" propelled each of these teachers towards great science instruction; 4. Each sought out and engaged in ongoing, challenging professional development; 5. Despite isolation and inconsistent administrative support, all became and remain rock-solid advocates for science instruction.

Recommendations for district-level administration and principals to identify, support, and sustain exemplary science teachers include: 1. Embrace science as a natural motivator for learning; 2. Increase support for science instruction as related to science, technology, engineering and math (STEM) curricula and instruction; 3. Provide exceptional professional development in best practices in science curriculum and instruction for both teachers and administrators; 4. Make this professional development hands-on and rigorous; 5. When seeking to identify possible science teachers in your school or district, look for those individuals who have demonstrated a strong desire to extend themselves professionally.

ACKNOWLEDGEMENTS

I wish to acknowledge all of my professors at National Louis University; they have been outstanding. Most significantly, I wish to thank Dr. Norm Weston. When I applied for the doctoral program at NLU, I wanted to be pushed to my limit. I felt that I had been able to get through various programs, never truly being challenged. Dr. Weston changed that; he has made me a better teacher, a better leader, and a more thoughtful listener. He expanded my view of the world and the lens through which I view mutiple perspectives, especially in the world of education. It is all that I could have wished for and I am eternally grateful to him.

DEDICATION

To my wife Tiffany and children, Sara and Colin. The greatest blessings of my life.

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## Chapter One: Introduction

I hated science during elementary school, at least, when I was in school. When I was outside of school, my brothers and my friends and I spent hours and hours searching for insects and animals, fishing, hiking, collecting rocks and other artifacts, and reading *Outdoor Life, White Fang,* and *Mountain Man*. We climbed trees, built forts, and chased each other through wooded areas. As a family, we would spend our vacation each year in the Northwoods of Wisconsin. My five brothers and I would spend all of our daylight hours, fishing, searching for bears, deer, birds, turtles, anything that moved! We were surrounded by and engaged in an environment filled with science and natural wonders and we never wanted it to end.

My favorite part of each day during those vacations was watching the sunsets. The water of the lake we stayed on would become absolutely still. Like clockwork, a large flock of birds would fly to the west. In the morning, we had observed these very same birds flying east. We wondered why these birds didn't simply build their nests in the east and save themselves the trouble of flying back and forth each day. No matter, we appreciated their journey as we observed them during their daily flights. Our thoughts and actions were scientific in nature but this awe and wonder for our natural world, this scientific engagement, was nonexistent in our classrooms back home.

Looking back now, I recognize that for each of us there was a pure and natural connection with science. We were unencumbered by classroom parameters including textbooks, passionless instruction, and a lack of hands-on materials. We received a good education but when it came to science, I have no recollection of any significant

engagement or learning taking place. Why would a kid so inspired by science, engaged by nature, be so disconnected from science *only* while in the classroom?

Fifteen years after my last trip to Northern Wisconsin with my family, I became a fourth grade elementary school teacher. After teaching for a few years, I recognized that I *should* be a better science teacher. I felt competent teaching all other subject areas but I lacked something (mojo) when it came to science instruction. I decided I must improve my instructional skills. I began seeking and attending science-based professional development (PD) experiences. After gaining some confidence and ability, I applied for a two week workshop at NASA's Kennedy Space Center in Titusville, Florida. This PD experience was called NASA Educators' Workshop (NEW). This amazing opportunity changed my perceptions of science instruction, reconnected me with the science I had loved as a child, and inspired me to teach science more effectively. Simultaneously, I began to recognize that this subject area is underappreciated, undertaught, and lacked value in our national consciousness. Because of this, I was further motivated to continue on my journey to gain skill and knowledge. This dissertation is a product of these experiences and my growth as an elementary science educator.

In the years that followed my participation in NEW (1998), I continued to move forward and seek learning experiences. In 2007, I attended a science symposium at Chicago's Adler Planetarium. During this event, I saw an open panel discussion composed of leading representatives from Sun Microsystems, Boeing, NASA, and Northwestern University. The presenters expressed great concern regarding the path of our nation and the lack of students who might choose science, math, or engineering as a

major and a potential career. Although they indicated that the number of students in the US pursuing enginneering degrees was less than in China and India, more recent research by Duke Univerisity modified these claims (Gereffi, Ong, Rissing, Wadhwa, 2008). The number of students in other nations who were choosing science majors was (and is) increasing. In 2008, 31% of bachelor's degrees in the US were awarded in science and engineering compared to 61% in Japan and 51% in China (National Math and Science Initiative, 2014). These leaders stated that in order to remain globally competitive, the United States needed to increase the number of engineers and scientists.

I was blind-sided by this information. I was competely unaware that our country could potentially lose its lead in innovation; I think most of us take it for granted. After leaving this event, I wondered what, if anything, was being done to maintain our innovative edge. I began to question what efforts were being made to improve the ability of teachers to provide quality science instruction and to inspire learners. Were parents motivated and encouraged to guide their children towards science learning? Were university programs preparing elementary science teachers to teach most effectively? What were teachers doing to improve their instructional skills and background knowledge in science?

I reflected on these question for many weeks, and then months, and now it has been years. There has been so much to consider, but because I have been trying to become a great science teacher myself, one question remained foremost in my mind: How do great science teachers teach science and what motivates them to teach science so well? I felt that this might be the key to inspiring more students: exposure to quality

science instruction that could lead more kids to follow a scientific path that might help the US maintain its innovative leadership.

As I continued to explore issues related to science education, I discovered another troubling issue. Jackson (2007) stated that under-represented groups (women, Hispanics, Afro-Americans, and low-income families) are not preparing for careers in science and engineering in proportion to their numbers in our population and labor force. In other words, our shortage of scientists and engineers potentially could be eliminated if we were to educate all citizens more effectively. Why aren't we providing opportunities for each segment of our population? Jackson believes that one reason is that there are not enough role models both in teaching and in research. Is it also possible that these groups have been impacted more profoundly by the reduction of science instruction that has occurred at the elementary level due to No Child Left Behind Legislation (NCLB)? I believe that if *these* students had exceptional elementary science teachers, with *mojo*, these educators would vastly increase their opportunities for careers in science and engineering and also enhance their lives. This would enable the US to eliminate the shortage of scientists and engineers in our country and remain at the forefront of innovation.

My role as a mentor for candidates seeking National Board Certification in Illinois has also given me a unique perspective on elementary science teachers. I became a mentor after achieving National Board Certification in 2001. I then became involved with the Illinois Regional Support Network through which I guided cohorts and individual teachers during the National Board Certification portfolio process. I have had countless face-to-face interactions with elementary science teachers from throughout the

northern suburbs of Chicago. As I supported these teachers, I discovered that the majority struggled with the section of the National Board portfolio process that included science. I learned that few of these teachers were prepared to teach elementary science effectively! They lacked confidence, knowledge, and skill. I was shocked and disappointed by this. As I worked with these teachers, and saw this year after year, I had many questions: Why were such great teachers so unprepared? Why did they lack confidence? Was it the teacher or teacher preparation programs, the certification process, or the collective structure? This lack of skill was common to all the teachers I supported, and there were many.

What made all of this more enlightening was that the National Board Certification process itself requires teachers to complete a portfolio based on high and rigorous standards. The process continues to evolve but has always included portfolio entries connected to content and practice, professional development, community outreach, and a computerized assessment portion.

National Board Certification is a voluntary process and recognized to take an extraordinary amount of hours to complete (nbpts.org). I have found that teachers accepting this challenge tend to be individuals who want to go above and beyond. They are highly motivated, yet in my experience, the portfolio section on science remains *the* most challenging. This pattern has been consistent in the decade that I have provided support. Why would this be? Why aren't teachers, who are motivated, confident and competent, seemingly less skilled at science instruction compared to teaching other subject areas? Are observations and experiences about these teachers generalizable

beyond this group, throughout our state, region, nation, even our world? Are the majority of elementary science teachers unprepared to teach science? Are they unmotivated or intimidated, or do they lack support? What is the future of science education? How is this impacting students' ability to pursue science as a major and as a potential career?

Eventually, as my science teaching skills developed, I had the honor and privilege of being chosen a State Level Finalist for the Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) for elementary science instruction on four occasions (2006, 2008, 2010 and 2014) for the state of Illinois. The PAEMST application process mirrors the portfolio requirements for National Board Certification. After having experienced this application process and meeting many of the state level finalists and national recipients of this award, I have developed a profound respect for these educators and their desire and ability to teach science well. I believe that inspiring and motivating elementary science educators might be the key to developing a science-based society that encourages individuals to pursue science majors in college. Students can also grow to be science-minded citizens who can make sound personal decisions regarding personal health, advancing technologies, and their environment. In order to understand how the US could develop more elementary educators as competent in science instruction, I decided to focus my research on these award winning teachers.

As I thought about the exemplary teachers who had received this prestigious recognition, I tried to pinpoint what made them special, what made them exceptional. In the end, I felt that they possessed something unique, intrinsic. I felt that each of these talented teachers had mojo, defined by Goldsmith ( 2010) as "the postive spirit toward

what we are doing now that starts from the inside and radiates to the outside" (p. 5). After learning more about these educators through personal interactions and research, I recognized that Presidential Science Award winners possess mojo that *should* be replicated and cultivated by those teaching in our nation's classrooms. Our kids deserve exceptional science teachers. These are the models that school communities should strive to develop and place in each science class.

The good news is that mojo is not a zero sum game. Mojo is unlimited and those who want it should be able to get it if they try. Goldsmith (2010) goes on to say that, "mojo is also the moment when we do something that is purposeful, powerful, and positive and the rest of the world recognizes it" (p.4). These individuals, as PAEMST winners, have been recognized for their skill as exemplary elementary science instructors. They are doing something that *is* powerful and that can have a lasting impact on our nation. In this dissertation, I was able to determine what makes them tick.

As I analyzed these award winning teachers, the question was: where does mojo come from? If I do determine where it comes from, will educators be able to get science mojo when school communties want it? Can it be developed? Who will *insist* on the creation of exemplary science teachers and lead an inititative? The current trends in the improvement of science, technology, engineering and math (STEM) education presently focus on grades 6 –12. As I have pursued professional development experiencees for the previous two decades, I have found that experiences in grades K-5 are pitiful compared to upper grade levels. It appears that just as our system is failing to develop confident and competent science teachers at the elementary level, there is failure by educational

decision makers and other institutions to provide PD, in a manner that recognizes extreme need, that might help improve elementary science teachers' skill levels and confidence. I recently attended the NSTA 2015 National Convention in Chicago and numerous organizations that I spoke with had amazing and inspiring PD experiences (I will later refer to these as "triggers") but these were solely available to teachers in grades 6-12.

Goldsmith (2010) suggests that there are four vital ingredients that impact whether or not an individual has mojo; they are as follows:

1. Identity: Who do you think you are?
2. Achievement: What have you done lately?
3. Reputation: Who do other people think you are? What do others think you have done lately?
4. Acceptance: What can you change and what is beyond your control?

Of these ingredients, the PAEMST evaluation process has determined achievement and reputation for the award winning teachers. They have strong identities and care little for what others think of them. Acceptance has been the biggest challenge and also the most perplexing. The PAEMST process has been thoroughly analyzed and determined to be of exceptional quality. As I interviewed these teachers, I reflected on all of these ingredients (1-4) as I considered how their mojo activates and thrives.

Overall, my goal for this dissertation was to interview PAEMST elementary science award winning teachers with the intent of gaining insight into who they are and why they are motivated to teach science so well. Goldsmith (2009) also stated that mojo plays a vital role in our pursuit of hapiness and meaning because it is about achieving two

simple goals: “loving what you do and showing it” (p.5). I can say that each of the teachers I interviewed loved what they were doing. Can more teachers develop such a love for science instruction and gain the mojo needed to excel?

I believe the answer to these critical questions potentially could impact how schools, communities, universities, and governmental agencies approach, develop, and support science teachers and science instruction at the elementary level. The possession of mojo is worthy of being recognized, coveted, and replicated. Mojo can be encouraged and supported so that students receive the science education they deserve and from which they would benefit most, not only for themselves, but for the betterment of our country. A science-minded citizenry seems a necessity as our globally connected, innovative, science-based world moves forward.

**Statement of the Problem**

This investigation explores science teachers who possess mojo. Goldsmith had said that mojo is, “the moment when we do something that’s purposeful, powerful and positive and the rest of the world recognizes it” (p. 4*)*. Not only do the teachers featured in this investigation possess mojo, they have been recognized for their purposeful actions and rewarded for their efforts. Each of them has received the prestigious Presidential Awards for Excellence in Mathematics and Science Teaching. This award is presented to teachers for one of two categories, math or science. This report focuses on teachers who have been recognized for their efforts in science instruction at the elementary level.

In this dissertation, I determined how these award winnng teachers became exceptional school instructors, what motivates them, and where they get their *mojo*. How

can we nurture or create circumstances that allow other educators to develop mojo too? I will consider if mojo can possibly be recreated or developed with other teachers, in other classrooms and in other schools. Or, is this ability, this positive spirit, so intuitive, so innate, that it is an art form or skill set so unique that it can neither be fully created nor developed. If that is the case, educational leaders would then need to seek people of like minds and distinct abilities for our schools.

This topic, exemplary elementary science instruction, is critical for a number of reasons. The "Report to the President" (September, 2010) issued by the President's Council of Advisors on Science and Technology states, "The success of the United States in the 21st century–its wealth and welfare–will depend on the ideas and skills of its population" (p. v). In addition, this report states that, since the beginning of the 20th century, average per capita income in the United States has grown more than sevenfold, and science and technology account for more than half of this growth (p. v). The report also goes on:

> Despite our historical record of achievement, the United States now lags behind other nations in science, technology, engineering and math or STEM education at the elementary and secondary levels. International comparisons of our students' performance in science and mathematics consistently place the United States in the middle of the pack or lower. (p.v)

The report to the President also presents many ideas and specific recommendations related to the development of science instruction in the US. These include the following:

1. To improve STEM education, we must focus on preparation and inspiration.
2. The Federal Government has historically lacked a coherent strategy and sufficient leadership capacity for K-12 Education.
3. Standards: Support the current state-led movement for shared standards in Math and Science.
4. Teachers: Over the next decade, recruit and train 100,000 great STEM teachers who are able to prepare and inspire students. The most important factor in ensuring excellence is great STEM teachers, with both deep content knowledge in STEM subjects and mastery of the pedagogical skills required to teach these subjects well. The federal government should set a goal ensuring the recruitment, preparation, and induction support of at least 100,000 new STEM middle and high school teachers who have strong majors in STEM fields and strong, content-specific pedagogical preparation, by providing vigorous support for programs designed to produce such teachers.
5. Teachers: Recognize and reward the top 5 percent of the nation's STEM teachers by creating a STEM Master Teacher Corps. Attracting and retaining great STEM teachers requires recognizing and rewarding excellence.

The recommendations also includes the use of educational technology to drive innovation, student centered activities that create opportunities for inspiration through individual and group experiences outside the classroom, the creation of schools that are STEM focused (1,000), and strong and strategic national leadership (p. 12).

These goals and recommendations appear to create a series of actions that US educators can implement as they attempt to move forward to improve STEM education. While analyzing these recommendations, it is notable that they omit elementary teachers from part two. Recommendation (4) specifically focuses on middle and high school teachers. Yet, it has been noted by Griffith and Scharmann (2008) that:

> In order for students to be able to build on prior knowledge, they need an accumulation of developmentally appropriate knowledge and relevant experiences that must be nurtured over a number of years. This is why elementary school science programs are so important. (p. 43)

If this is so, shouldn't elementary science teachers be included in every aspect of the federal government's plan to improve science education?

Vasquez (Griffith and Scharmann, 2006, p.37) also indicated that, not since 1957, the year when the Soviet Union launched the Sputnik satellite, has the need to improve science education in America been as clear and as urgent as it is today.

Although I initially thought that the current quality of science instruction was damaged entirely by No Child Left Behind (NCLB) legislation, Lee and Houseal reported that instructional time in elementary science had been decreasing prior to its implementation (as cited in Griffith and Scharmann, 2006, p.36). NCLB simply exacerbated the problem. Despite the call for more and better science by seemingly every education and business leader, it appears that NCLB has had a negative impact. A survey of 164 elementary teachers (Griffith, G. & Scharmann, L., p. 4) indicated a 59.1% decrease in the amount of science instruction in their classrooms since NCLB was

implemented and a 71.8% decrease of 31 to 90 minutes of science instruction per week. As a result, 53.6% of K-6 educators surveyed spent 90 minutes or less per week on science instruction. What does this tell our students about how we value science education?

Part of the problem with NCLB is that it does not require accountability for science instruction; an accountability component would motivate administrators, communities, and elementary science teachers. Teachers would have to teach more science! Combine accountability with a well developed, government-supported program, community and corporate partnerships, and powerful professional development experiences, and our teachers might gain mojo. An accountability factor would also up the ante for universities and other agencies presently involved in the process of teacher preparation. Accountability would trickle down and encourage motivation throughout the system, or so I believe.

Perhaps these changes would alter the landscape of science education at the elementary level. Through the implementation of accountability (revised NCLB), improved teacher professional development, and exposure to unique learning experiences, teachers' instructional skills may grow. Please note that in 2015 both senate and congress voted to revised NCLB, let's hope that this updated bill, when it is developed, incorporates stronger commitment to science education including increased accountability.

**Rationale**

The teachers in this study are exemplary teachers of science. They have been nominated by peers, parents, or community members and have been recognized for their "purposeful action". As nominees, and after completing a rigorous application and selection process, they became recipients of the Presidential Award for Excellence in Math and Science Teaching. How do I know these teachers are exceptional?

When nominated for the PAEMST award, teachers are required to submit: a 45 minute videotaped lesson; an extensive analysis of this lesson reflecting on their practice (12 pages); three letters of recommendation; a resume detailing science leadership activities in their school, district, and community; as well as samples of student work or other artifacts from the particular lesson shared (video). There is a screening process to evaluate portfolios. A committee of science educators and former recipients select three to five state level finalists. These finalists' portfolios are then forwarded to Washington, DC and assessed by representatives from the National Science Foundation (NSF). These representatives include prominent mathematicians, scientists, mathematics/science educators, district level personnel and classroom teachers. The director of NSF submits the list of final candidates to the White House. From these state level finalists, one representative per state is chosen for the PAEMST Award for elementary science instruction at the national level (and one for math as well).

The purpose of this study is to explore how PAEMST national winners develop such exceptional mojo or skill that is extraordinary, innate, and intrinsically motivated. This information can be used by educators and community leaders to speculate about how the attainment of mojo could potentially impact future teacher development such as

teacher education at the university level, mentorship, curriculum, professional development, and school culture, *all* significant factors effecting teacher growth and development.

If none of the above factors are part of the mojo equation, what factors or characteristics, beyond the reach of traditional teacher developmental methods, contribute to the evolution of these great teachers? Should we be recruiting specific individuals who possess this unique science mojo so that our elementary students can receive the best science education possible?

I will investigate the factors that lead to the evolution of an exemplary elementary science teacher. Professional development experiences may be one of these but there is a catch. As I described previously, early in my career I recognized that my personal skill level as an elementary science teacher lacked mojo. I sought professional development programs to help me improve my skills. I discovered that there were many professional development experiences available that included opportunities to work with real scientists, to travel, and to experience authentic lab work. However, these opportunities were, more often than not, *limited to grades 6-12*. This is still the case today.

I wondered why experts, both in educational and scientific fields, chose to exclude elementary teachers. Based on my 20 years as an elementary science teacher, I can attest that young children have an innate connection with science learning. I felt then, and still feel strongly now, that connecting with children as early as possible helps them develop a solid science knowledge base and, perhaps more importantly, nurture their intrinisc motivation to learn. Maltese and Tai (2009), after interviewing 116 scientists and

graduate students, discovered that 65% of them developed an interest in science education before middle school. Focus should be shifted and expanded to younger grades!

Having an exceptional elementary school teacher potentially can have an impact on career choices. Baird and Penna (1992) reported that as students advance from primary to secondary school, they rapidly lose interest in science. Maltese and Tai (2009) indicated that students reporting an interest in science careers in eighth grade were three times more likely to obtain a college degree in a science field than those who did not show an interest. Osborne, Simon, and Collins (2003) stated that science teachers play a major role in student attitudes toward science and persistence toward science. It is essential to create elementary science teachers who provide mojo inspired experiences. Some experts recognize that this is true.

The Rising Above the Gathering Storm Committee's report, "Is America Falling Off the Flat Earth" (2007) stated that their committee's highest priority was a focus on K-12 education. It refers to the "10,000 Teachers Educating 10 Million Minds Scholarship Act" that suggested:

> We strengthen the skills of 250,000 current teachers by such actions as subsidizing the achievement of master's degrees and participation in workshops, and create a world-class math and science curriculum available for voluntary adoption by local school districts throughout the nation. (p.71)

How important are good science teachers? Collins, Osborne, and Simon (2003) concluded that the single most important change to improve the quality of science

education was the recruitment and retention of able, bright, enthusiastic teachers of science.

Regarding my own development, I had the good fortune of participating in a two week teacher workshop at NASA's Kennedy Space Center with 24 teachers from around the country. This experience was specifically tailored for elementary science teachers. What impact did it have on my instruction? It was a life changing experience. Not only did I return home with a large number of resources, but my interactions with astronauts, scientists, engineers, and the head of the NASA space program helped me to recognize and regain faith in the value of science and therefore of science education. It inspired me and rekindled mojo that had been dormant.

**Science-Less Society**

President Obama indicated in the Report to the President: Prepare and Inspire, (2010) that, "the problem is not just a lack of proficiency among American students; there is also a lack of interest in STEM fields among many students" (p. vi). Is part of the problem our culture? Our society?

In Rachel Carson's *Silent Spring,* E.B. White stated:

> I am pessimistic about the human race because it is too ingenious for its own good. Our approach to nature is to beat it into submission. We would stand a better chance of survival if we accomodated ourselves to this planet and viewed it appreciatively instead of skeptically and dictatorially. (p. 1)

I began to wonder, is America doomed? Our entire world? Has our country, our world, become compromised because of general science-less societies? Science-less

cultures? Have our schools become science-less? Is science dead or dying in our culture? Other cutures as well? In our schools? If so, who is to blame? Richard Louv (2008) stated as such:

> Parents, educators, other adults, institutions–the culture itself - may say one thing to children about nature's gifts, but so many of our actions and messages, especially the ones we cannot hear ourselves deliver, are different. And children hear them very well. (p.14)

Louv's comments focus on the amount of time children spend outside these days and their appreciation of nature. Kids simply don't explore our natural world as they once did, nor do they experience the benefits of playing outdoors as many of us did. The benefits of being outdoors include the development of imagination and improved physical health. How does this behavior impact science education in the US? Science education in other countries? Are other nations facing this challenge as well? Motivation of students? Science instruction as a whole?

In *John Dewey on Education,* Dewey stated (Archambault, 1964):

> Through the influence of the social environment each person becomes saturated with the customs, the beliefs, the purposes, skills, hopes and fears of the cultural group to which it belongs. The features of even his physical surroundings come to him through the eyes and ears of the community. Hills and plains, plants and animals, climate and the change of seasons are clothed with the memories of traditions, and characteristics, occupations and interests, of the society of which he is part. (p. 10)

As I consider the seemingly nature-less mindset most presently possess, I feel as if we live in dual or parallel worlds. These worlds, the Natural World and our present day Techno-Industrial World, are bound to one another yet one threatens the others' survival. Ironically, if our natural world falls, the Techno-Industrial world will fall as well. We depend on the Natural World whether we recognize it or not.

I would define the Natural World as nature; this would include: the sky; the air that life-forms breath; trees and animals; all living organisms and also non-living natural objects such as water, sand, soil and rocks. No matter where people live, or what they do, the Natural World is all around, yet, most people often choose to ignore it. In fact, this culture of ignorance, has led to a generation that seems to remain *unaware* of nature and, in turn, of science's importance. If we honestly assess our personal perceptions and actions and those about us, it easy to admit that we do not respect our natural world. Our actions: waste, refuse, habitat destruction, clearly reflects this dilemna.

Evidence suggests that children lack of interest in our natural world; from 1997 to 2003 there was a decline of 50 percent in the number of 9–12 year olds who spent time in activities such as hiking, walking, fishing, beach play, and gardening (Louv, 2008). Of course, those of us from previous generations also live and work and go about our business with little respect or apparent awareness of nature and its workings. What examples are we setting for our for own children and the children we teach? For many of us, as we go about our day-to-day lives, we become further disconnected from science and nature. Our busy lives limit our opportunities but, what values do we set regarding

science and science education and the ability to create these connections as parents, teachers, and educational leaders?

George Washington Carver's philosophy was that nature is a great teacher. Washington Carver (MacMurray, 1981) felt that nature:

> . . . provided an understanding and appreciation of natural phenomena and forces led to a clearer perception of all great truths. Nothing existed in a vacuum; everything was an integral part of the great whole. Therefore, when a student really understood a phenomenon, he could easily be led to understand all related phenomena. (p.97)

The Techno-Industrial World, as I call it, is our present human-made society and the tools and artifacts we have created. Technology is one of the components of our society and our Dual World. Techno-Industrial also would include human made objects such as streets, buildings, cars, trains, factories, refineries, dams and any and all objects that we have created.

Who might turn back the clock on our progress and choose to live in the past? Certainly not I. However, the world that humankind has created to support our standard of living and our cultural practices such as TV, media, music, video games, sports, and other interests has segregated us from the Natural World. It has pulled us away from our potential connection with nature and an appreciation for a scientific way of thought. It appears that nature is "background noise" for many of us.

Einstein stated (1977):

> A human being is a part of the whole, called by us 'Universe', a part limited in time and space. He experiences himself, his thoughts and feelings as something separated from the rest - a kind of optical delusion of his consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us. Our task must be to free ourselves from this prison by widening our circle of compassion to *embrace all living creatures and the whole of nature in its beauty*. Nobody is able to achieve this completely, but the striving for such achievement is in itself a part of the liberation and a foundation for inner security. (Quotations by Einstein)

**Children of Our Day**

On a typical day, a child can rise in the morning, eat breakfast while texting, play a game on his smart phone or catch a few videos on YouTube. He can then walk to the bus with headphones on while listening to music on his iPod or phone. The student can get on the bus and once again focus on his phones (games, texts, email) then arrive at school and through the course of the school day take part in classroom activities that migh**t** or might not incorporate experiences that connect kids to science. These experiences might include videos, pictures or readings about nature, hands-on science activities, pets or animals in the classroom, or exposure to other natural artifacts such as rocks, bones, leaves, or even chemistry. In our student's defense, Maltese and Tai (2010) wrote that students reported that the science they were taught in their classes was usually disconnected form the natural world they experienced on a daily basis. Furthermore, these feelings often resulted in students deciding not to continue their enrollment in

science classes. Of course, if students (teachers, parents, families) ignore the natural world all together during the course of their day, it would be difficult to create connections of any kind, regardless of the type of instruction.

As this child heads home with his head phones on and as he texts his friends, he might watch a video on his iPod or phone while failing to look out the window and observe, be fascinated with, or appreciate the world about him. As this child arrives at home, he might head to his room, rather than play outside, and then choose to play his PS-4, X-Box or other video game systems. He might watch TV after dinner and then wrap up with texting, homework, social media, and then fall asleep repeating this techno-cycle the following day. Please note, there are children in which it is unsafe to even consider playing outside, they have limited opportunity to connect with nature, even if they wished to.

These are examples of the life of a modern child, of an active participant in the Techno-Industrial Lane. Some simple adjustments to this scenario could produce a citizen who is far more conscious of the natural elements that surround him and lead to increased interest in science education.

For example, as this child rises for his day, his parents might model scientific discussion at breakfast. They could share experiences they had as children or focus on issues or topics in the news that effect their natural environment, health, weather, anything science related. As the child walks to the bus, his parents might insist that the student leave the iPod or smart phone behind (or off) so that they might become connected, in some way, with the natural world about them. At the very least, this child

may begin to recognize sights and sounds of the world such as: birds flying and singing; the variety of trees and plants; the weather and the interaction of the natural elements be they wind, rain, clouds or butterflies. The use of our senses is an essential part of processing and analyzing the environment; children need to refine these senses. This skill development does not have to take place in a classroom. I know this through my own personal, childhood experiences.

As the student rides to school on the bus, he may chat with a friend or catch up on some work but he might also look at the clouds and recognize the variety of shapes and sizes, observe the moon during daylight hours, or witness birds migrating. Simply recognizing these parts of his natural world might help create a connection that is lacking. He might create hypotheses regarding these observations. Why do some birds migrate while others do not? Why can we sometimes see the moon during the day? He might even share these thoughts with his friends and engage in a discussion that incorporates the practice of the scientific method.

As a social activity, science inevitably reflects social values and viewpoints (Ahlgren: Rutherford*, 1990*). The process of limiting technology, as it interferes with the ability to connect with nature, should be the norm. Students and children (and adults) need not commit themselves to full-fledged exploration of and expertise in our natural and science-based world. They should, however, recognize and appreciate its wonders and also think scientifically in each and every aspect of their personal world. Why is this important? Science, through the recognition of our natural world, produces citizens whose lives are enriched. This enrichment not only includes the recognition of the beauty

about us but the chance of connecting with science and developing potential scientific habits that enriches life experiences, including career choice. President Obama also indicated:

> Improving science education in math and science is about producing engineers and researchers and scientists and innovators who are going to transform our economy and our lives for the better. But its also about something more. It's about expanding opportunity for all Americans in a world where an education is the key to success. It's about an informed citizenry in an era where many of the problems we face as a nation are, at root, scientific problems. And it's about the power of science to not only unlock new discoveries, but to unlock in the minds of our young people a sense of promise, a sense that with some hard work -- with effort -- they have the potential to achieve extraordinary things. (Obama, 2009).

We are talking about career paths, life styles, and personal health and economic choices that have strong implications for each citizen's life. Science education that inspires our youth and, with quality instruction at the elementary level, can have an impact on the future progress of our nation. Friedman (2005) in *The World is Flat: A Brief History of the 21st Century* asks, "Are we investing in our future and preparing our children the way we need to for the race ahead?" Friedman believes we are not. Each of us should contemplate the very same question as we move forward as a nation in a new global landscape.

**Research Question**

My primary question is "How have elementary level PAEMST winning teachers developed exemplary mojo?"

Once I have determined how these teachers may have developed their skills, I will consider the following secondary research question: "To what extent can exceptional teachers be developed through the implementation of specific programs or learning experiences or should specific characteristics or traits be *sought* as teachers are hired or recruited?" All students should have science teachers with exemplary skills. How can educational leaders and school communities assure this for our children!?

In the end, my hope, my goal, is for all students to have teachers who have positive spirit toward what they are doing now that starts from the inside and radiates to the outside. I am certain that this could inspire more learners towards science, impact career choices and innovation, as well as produce citizens who may better care for themselves and live more productive and healthier, and potentially happier lives.

The implications are huge as students, citizens, and countries move forward in a new global landscape. I hope that this report will have some value in this regard and will benefit elementary science education for our children, our society, our country, and other nations, wherever better science instruction is needed.

# CHAPTER 2: LITERATURE REVIEW

## Introduction

As I considered the current status of science education in the US and the extent to which PAEMST science award recipients possess mojo, I realized it was critical to look back to where we had come from and to explore how we arrived where we are now.

It was fascinating to explore how science education evolved in this country. As with anything that changes over time, the path to the present is composed of actions impacted by a variety of variables and societal forces; they usually have been implemented with the best of intentions. This chapter provides information on the current status of elementary science education in America. The sections of this chapter includes History of U.S. Education, Culture of Quality Science Instruction, PAEMST Winners, and information related to my overall investigation.

I was able to find a limited amount of research about Presidential Award for Math and Science Teaching Excellence recipients and I analyzed this data as I considered their mojo development. Mojo lies at the core of this investigation. The research I found provided some insight into PAEMST winnners and how and why they are so skilled at teaching science as well as how their mojo evolved. I was able to use this information as a comparative measure for my own interviews.

## Where are We Now?

"There was more damage done to science education in this country than was ever thought possible because No Child Left Behind (legislation) did not talk about science," Jan Morrison, executive director of the Teaching Institute for Excellence in STEM

(Stainburn, 2011). Because of this, time spent on science instruction in the elementary classroom has dropped dramatically in this country. The Bayer Corporation Survey (May, 2004) indicated that, regardless of the region of the country or type of school, the majority of elementary teachers reported that they are three times more likely to teach English (95%) and math (93%) everyday than they are to teach science (35%). In addition, Rentner, et. al. (2006) stated that schools are providing "narrower curricula" because of NCLB:

> Seventy-one percent of the school districts surveyed reported that they have reduced elementary school district instructional time in at least one other subject to make time for reading and mathematics, the subjects on which students are evaluated by NCLB. In some case study districts, struggling students receive double periods of reading or math or both–sometimes missing certain subjects altogether. (p. 2)

These actions dampen the science mojo of any educator. If schools are not commited to or acountable for teaching science, why should teachers care? These facts regarding instructional time are significant for other reasons as well. Duschl, Schweingruber and Shouse *(*2010) stated the following reasons why we should give students a quality science education in our country:

> Science is a significant part of human culture and represents one of the pinnacles of human thinking capacity. Science provides a laboratory of common experience for development of language, logic, and problem-solving skills in the classroom. A democracy demands that its citizens make personal

> and community decisions about issues in which scientific information plays a fundamental role, and they therefore need knowledge of science as well as an understanding of scientific methodology. For some students, it will become a life-long vocation or avocation. The nation is dependent on the technical and scientific abilities of its citizens for its economic competitiveness and national needs. (p. 34)

Prior to NCLB's implementation, there were already many internal and external factors that caused a decrease in adequate elementary science education that impacted mojo negatively. Lee and Houseal (as cited in Griffith, 2003) detailed these factors in the following manner:

> The external factors include time, money, supplies, materials and equipment, classroom management, dealing with diverse learner and individual differences, and support from colleagues, administration, and the community. The internal factors include content preparation, self-confidence levels, anxiety, attitude, and professional identity toward teaching science. (p. 1)

These factors, combined with NCLB and its impact on instructional time, have provided the perfect storm that is stifling elementary science education from top to bottom. Despite this, PAEMST winners are teaching science successfully; their mojo is flourishing. This further validates the need to understand how they operate and how we might also develop more educators like them.

**History of Science Education in the US**

Dewey (1934) stated that "the educational end and the ultimate test of the value of what is learned is its use and application in carrying on and improving the common life of all (p. 100)." Although Dewey wrote this more than 80 years ago, it is equally relevant in any day and age. The needs of society began to reshape education; science curriculum began to be included as part of education. Great changes in society were occurring as the 20th century began, and progressed. By the end of the 19th century, a broad and practical education was essential for life in a world that was becoming increasingly dominated by science, technology, and industry. There were strong feelings regarding the need for educational reform. DeBoer (1991) indicated that the 20th century began with an educational system that had been inherited from the Middle Ages. Our system consisted, at the primary level, of reading, writing, and arithmetic, while at the upper levels it was dominated by the study of classical languages (p. 2). Counter to the science content argument was one suggested by classicists stating that the "true purpose of a liberal education was the development of one's intellectual faculties through the study of ancient classics, and the growth of personal pleasure that results from this study" (p. 3).

In 1828, the best known defense of classical education came from the faculty of Yale College. *The Yale Report* stated that a classical education "forms the most effectual discipline of the mental faculties and that every faculty of the mind is employed; not only the memory, judgment and reasoning powers, but taste and fancy are occupied and improved" (DeBoer, 1991). Science advocates countered that, "science study provides the best mental discipline, not classical studies". (p.4)

Mill suggested (cited in *History of Science*, 1991, p.8) :

> Science instruction provides us with a method for arriving at truth through observation, experimentation, and reasoning that has utility in everyday life. In fact, the process of arriving at the nature of things through observation, and judging the significance of those observations, is what separates one human intellect from another. The ability to weigh evidence, to determine what is relevant and what is not–these are the things that make for intellectual strength, and it is these things that science instruction can provide.

Both in Europe and in the US, numerous noted scientists of the 19th century joined the campaign to make science teaching part of the school curriculum. They included John Tyndall, Thomas Huxley, James Paget, Claude Bernard, Michael Faraday, Herbert Spencer, Justus Von Liebig, John Herschel, Charles Lyell, Joseph Hooker, and many others who wrote essays, gave lectures, and presented testimony before government commissions on the value of science education (DeBoer, p.8).

Leaders began to realize that citizens needed a general understanding of concepts that were applicable to new and developing technologies and 20$^{th}$ century general health practices. Edward Livingston Youmans, a mid 19th century textbook writer and science lecturer in the U.S. said:

> Science teaching should begin at the early ages when children's curiosity is freshest, and the perceptions keenest, and memory most impressible, before the maturity of the reflective powers, the opening mind should be led to the art

of noticing aspects, properties and simple relations of the surrounding objects of nature (as cited in *History of Science*, 1991, page 7).

Youman's ideas are echoed by more recent thinkers; Dr. Mark St. John (2007) indicated, while presenting to members of the House of Representatives, that elementary education sets the foundation for later science learning and that it also develops key intellectual skills, attitudes, and habits of the mind. St. John also thought that, although this domain was important, it was not in good shape. He said, "the teaching of elementary science in this country can fairly be described as weak, or even very weak." (p. 3)

In the early part of the 19th century, Dewey (as cited in *Why Science?*, 2008, p. 118) argued for the inclusion of science in high school curriculum. Dewey felt that schools needed to develop a scientific habit of mind. In 1910, Trefil also noted that the percentage of Americans who received high school diplomas was less than 10% and it wasn't until 1950 that the passing rate surpassed 50%. Up until that time, only an elite portion of the US population received a high school education.

By the start of World War II, however, science leaders felt that we had drifted away from solid science and overall instructional practices that were a necessary component of invention and innovation. World War II revealed that recruits and officer candidates scored lower than expected in basic literacy and quantitative reasoning skills (DeBoer, p. 128). The war became a catalyst for U.S. commitment to the principles of democracy and to universal education, as well as general education for all American youth (DeBoer, p. 129).

The national shock and outrage over Russia's launch of Sputnik on October 4th, 1957, provided renewed energy for the teaching of science. Curriculum projects of the 60s encouraged the development of scientific thought (DeBoer, p. 193) by putting students in the postiion of being a scientist. The student was expected to complete investigations as *scientists*. Diane Ravitch (as cited in *History of Ideas in Science Education*, 1983, p. 174) referred to the 1970s as the "new progressivism" as it was said that all students should be science literate so that they could respond effectively to issues such as hunger, overpopulation and energy shortages. The National Science Teachers Association (NSTA), in its position statement, School Science Education for the 70's (*History of Science*, 1991, p. 177) started with : "The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action."

The 50s and 60s saw the first federal involvement in science teacher education and curriculum through the National Science Foundation (NSF). The NSF curriculum (*Taking Science to School*, p. 12) focused on improving science teaching by "modernizing the content of science courses". In the 70s the National Science Foundation was challenged and, in the 1980s policy makers (*Taking Science to School*, 2007, p. 12) analyzed K-12 student achievement and progress and declared that our nation was at risk. During the 1990s, we saw standards based reforms leading to No Child Left Behind which, unfortunately, ignored science altogether.

Presently, as indicated by recent governmental reports, science education has reached a state of crisis. Many believe that we need to cultivate scientific learners as it is

feared that our worldwide leadership in science and innovation will dissolve in this new global economy. A report created by the Committee on Science Learning Kindergarten through 8th Grade (*Taking Science to School*, 2007) stated the following:

> Scientists have used the discovery of DNA to help map the human genome, can prevent diseases like polio and rheumatic fever, and have landed probes on Mars. Today the scientific knowledge to see and manipulate atoms is available, whereas 100 years ago people debated the existence of atomic matter. Major public policy issues, such as cloning, climate change, and alternative fuels, require scientifically informed citizenry as never before. (p. 11)

These ideas, educational preparedness impacting citizens of the US, correlate with similar efforts proposed at the turn of the 20th century when new technologies of no less relative importance were developing.

**Culture of Quality Science Instruction**

As we consider what quality science teaching is, it must be recognized that good science teaching requires consistency. The TIMSS 1999 Video Study (National Center for Education Statistics, 2006) revealed there are two major differences between the US and other countries. First, the higher-achieving countries have a consistent pattern of teaching science; the US pattern was characterized by a variety of approaches. Second, in the US, content played a less central role. Sometimes there was no content as lessons often focused on engagement of students in various activities. In China (Asia Society, 2006), textbooks, materials, teacher preparation, and professional development are all

aligned to national standards; there is also rigorous and ongoing preparation of science and math teachers.

In Japan, the educational system is highly centralized through the Ministry of Education, Science and Culture. This ministry controls texbooks, school accreditation, teacher's salaries, educational subsidies, and the course of study. There is national uniformity. At the primary level, there is an emphasis on observation and experimentation and the curriculum encourages the "awakening and strengthening of curiosity". Compared to their US counteparts, teachers in Japan are also also held in much higher esteem (*AAAS*, 1995).

Ahlgren and Rutherford (1990) recognized that educational institutions and their faculties should review the content and pedagogical standards for the preparation of elementary and secondary teachers and that these institutions should "implement changes in which future teachers prepare" (p. 227)". According to the *Bayer Facts of Science Education X* (May, 2004) only 61% of teachers felt that they were very qualified to teach science while 71% of all teachers surveyed indicated that they felt that they are "only somewhat, a little, or not at all science literate (p. 5)".

Sanders (2004) stated that only 1 in 10 teachers had participated in programs that gave them the opportunity to work directly with scientists and/or engineers on science curriculum or other professional development experiences. I have found, through personal experience, that many of these institutions are withholding these opportunites from the elementary teacher (K-5) and are offering them instead to middle and high school instructors (p.2).

**PAEMST Winning Teachers**

Presidential Awards for Excellence in Mathematics and Science Teaching recipients are recognized for their skill as exemplary instructors. Is this relevant in a time when science instruction at the elementary level is faltering? When minority students are not getting the quality instruction that they deserve and require? I think it is critical that we increase our knowledge of how these educators operate and develop so that we can understand how the US can create more of these outstanding science educators with strong mojo. If the amount of time for instruction remains low because of NCLB accountability and other factors, the experiences students have must be maximized. More and better prepared elementary science instructors may be the difference-makers for the future, for both students and citizens alike.

The criteria for selection of PAEMST recipients include subject matter competence, evidence of sustained professional development, an understanding of how children learn science, an ability to engage students in direct hands-on learning activities, and an ability to foster curiosity and generate excitement among students. Awardess provide examples of their innovative approaches to teaching, as well as their leadership abilities and experiences.

Raphael and Weiss (1996), in their exploration of PAEMST winners, indicated that Presidential Awardees are much more educated than national counterparts, 79% of elementary awardees, compared to only 52% nationally, meet or exceeded NSTA recommendations for coursework in life science, earth science, physical science, and science education. They also found that the most significant difference between

PAEMST recipients and national peers was in the amount of in-service education (professional development). This report also indicates that 8 out of 10 Presidential Awardees in the previous three years had spent more than 35 hours completing professional development learning experiences. Presidential Awardees' views are more strongly aligned with current reform notions than are the views of science and mathematics teachers nationally. At both the elementary and secondary levels, Presidential Awardees were more likely than their national peers to agree that virtually all students can learn to think scientifically and mathematically and that laboratory-based science classes are more effective than non-laboratory-based classes (p.19).

A critical fact discovered by Raphael and Weiss was that science awardees were more likely than their national peers to emphasize increasing interest in science, developing problem-solving/inquiry skills, learning to explain science ideas, and learning to evaluate arguments based on scientific evidence (p. 25). These are the skills we wish students and citizens to possess regardless of the career paths they choose!

What makes PAEMST winners such great teachers? Raphael and Weiss (1996) also found differences in levels of involvement (for PAEMST recipients as compared with peers nationally) in professional activities. These differences were enormous. Presidential Awardees were more likely to be active professionally, whether serving on school or district committees, attending state or national teacher association meetings, or teaching in-service workshops for their colleagues. The process of selecting Presidential Awardees is effective in recognizing teachers whose backgrounds, beliefs, teaching

styles, and professional involvement are consistent with the recommendations of professional associations and state and national standards (p. 34).

The question is: How do we get all educators who are responsible for teaching science, no matter at what teaching level, to be as highly motivated and as well-prepared as PAEMST teachers? How do we encourage mojo which may be instrinsically fueled? Isn't this what our students deserve? Isn't this what our country needs?

Further evidence of the importance of good (science) teachers include a study of student performance in Texas which found that a teacher's ability was the single most influential determinant, outside of home and family circumstances, of student success (Ferguson, 1991). Students who have a good teacher for three years in a row showed a significant increase in percentile rank on state testing, regardless of socioeconomic status (Sanders and River, 1996). Can we afford not to improve science teaching? In 2004 Sanders stated:

> America's competitive edge in the global economy, the strength and versatility of ts labor force, its capacity to nourish research and innovation all are increasingly dependent on an education system capable of producing a steady supply of young people well prepared in science and mathematics. But all along the pipeline–from the quality of science and math instructon in the early grades, to the performance of our high school seniors on international tests, to the content and rigor of teacher-education programs in our colleges and univeristites–there are troubling weaknesses, gaps and disconnects (p. 1).

All in all, my research determined that it begins with elementary science teachers. Hudson and Skamp (1993) stated that to achieve the Science for All Goal a focus on science needs to commence at the elementary level. Bybee (as cited in Hudson and Skamp, p. 2, 1993) also said that, "the decisive component in reforming science education is the classroom teacher". *Science for All Americans* (1990) also indicated that only teachers can provide insights that emerge from intensive, direct experience in the classroom itself (p. 212). If teachers are not convinced of the merit of proposed changes, they are unlikely to implement them energetically. Finally, if teachers do not fully understand what is called for or have not been sufficiently well prepared to introduce new content and ways of teaching, measures will fail.

A research report similar to mine was prepared by Foster (1996) in which he interviewed six PAEMST recipients who attempted to describe what is going on in the lives and practices of excellent elementary science teachers (p. 5). This qualitative investigation determined that all of the PAEMST awardees had taught for 12 or more years. The number of years taught ranged from 12–33 years at the time the interviews were conducted. Foster determined that there were a number of key areas that emerged through the course of her investigation including: 1. significant historical events, 2. mentorships, collaboration and networks, 3. characteristics of exemplary elementary teachers, 4. preservice preparation experience, 5. inservice experience, teaching, learning and science instruction, and 6. perceived barriers to the teaching of science.

I found it interesting that this research report presented information regarding the evolution of mojo for these awardees. One candidate admitted that she did not set out to

teach. Another said that she wanted to teach because she had been exposed to such bad teaching when she were a child. A third shared a personal elementary science classroom activity in which she completed a hands-on experience, planting of a bean seed, and the observation/recording of data regarding how it grew into a plant. As with me, an awardee mentioned how they had more memories of informal learning experiences outside of school rather than of structured school experiences within the classroom.

This report also indicated that the awardees had mentors who were often instrumental in guiding, nurturing and supporting natural enthusiasm and interest these teachers already demonstrated. In several cases, mentors were responsible for the continued education and growth of the awardees who pursued advanced degrees and leadership positions (p. 34).

Foster's research (1996) correlated with Weiss and Raphael's research; Foster found that the awardees provided examples of informal and formal collaboratives they found to be professionally enriching and critical to their successful practices. These collaboratives included a wide variety of people including custodians, cafeteria workers, the teacher next door, national organizations, and univeristy partnerships.

All six of these awardees mentioned how much they enjoyed science, not just teaching science, but also learning about the true nature of science, "Science is something that I have always loved", one stated. " I like science, I enjoy it and I don't feel threatened by it. It's okay if you don't know something." Each of the awardees felt that their work was critical to the improvement of our society, just as I later found out from Illinois and Wisconsin PAEMST awardees.

Regarding pre-service preparation, their recollections were "unsubstantial or unavailable". Remarks included "not much was required" and "some of the courses were pretty squirrely". One said, "I didn't have any preparation for teaching science, I did for reading". Another awardee struggled to remember anything of relevance from her college science methods course. I also struggle recalling anything of relevance from my college science methods course either!

All agreed that their graduate level courses were "more meaningful and stimulating". Professional development experiences, however, were "intensive, long term, relevant to the teaching of science content, and in many cases, out in the field".

Their thoughts on children and their capacity for learning science correlates with Weiss and Raphael (1996). One stated, "I respect their abilities and try to look at what I do in a holistic way, that I am preparing kids who are going to be leaders in this world". Another said, "All children are gifted. All children have some gift. And we can reach all children regardless of race, capability, and background through science".

Foster's report had a final summary that cited one important commonality that had surfaced:

> Not a single awardee set out to teach science. All six awardees became science teachers by chance. Science just happened to be the subject each began to cultivate while teaching sometime during their practice in his or her self-contained classroom. Through the pursuit of advanced degrees, participation in programs run by the National Science Foundation, American Association for the Advancement of Science, and university-sponsored institutes, as well as

interactions with other teachers, their successful science teaching careers were born. (p. 69)

Each of these teachers may have experienced a powerful *trigger event* that uplifted, inspired, and changed the way they thought about science instruction: A National Science Foundation event, an honor's institute for science teachers sponsored by a university, an intensive summer science curriculum development experience while traveling to universities nationwide, a trip to Washington, DC to work with a group of astronomers and university professors on a potential science curriculum, additional work with university researchers, including a summer institute, and also curricular work.

I couldn't help thinking about my own experience at NASA when I spent two inspiring weeks being exposed to highly motivating science practices and knowledge. It uplifted and motivated me. All of the engineers and scientists appreciated us for being teachers. Everyone loved science and couldn't wait to share their knowledge. It absolutely changed the way I felt about science and science instruction forever.

**Investigation**

My investigation is a qualitative report on how PAEMST winners evolve into great science teachers. *Science for All Americans* (1990) on its final page, states details for reform that are necessary to "recognize and award innovation". These PAEMST winners are innovative. For these winners (Vaden-Kierman, Michie, Fechtling 1994), the effects of receiving this award was positive on a personal, professional, and public level. They report increased respect for teachers and the teaching profession and a renewed sense of validation for their effort and also motivation to continue as teachers.

Shouldn't all teachers feel this way? Validated? Motivated? Ultimately, I hope the information I present will have an impact on the process of preparing elementary science teachers. Whether through my efforts or the efforts of others that read this, I hope that all science teachers develop and possess science mojo and that our students are the beneficiaries of this quality instruction. Whether they choose to become scientists, engineers, or citizens who can make informed decisions regarding health, technology, and other science related issues, all Americans deserve to have a solid science education, from start to finish, as they progress through our educational system.

## Chapter Three: Methodology

### Introduction

The purpose of this dissertation was to determine how exceptional elementary science teachers evolve, how they develop mojo, so that we, as a nation, can nurture and develop teachers of similar quality. Why are we concerned about developing high quality science instructors? First, 42% of all elementary school science teachers reported (St. John, 2007) that they did not feel prepared to teach science well. Second, this same report states that time spent on science instruction has decreased by up to one half since 2000. This is despite recognition that America is rapidly losing its competitive edge to steadily progressing economies, primarily in the developing world, a world populated by substantial numbers of highly motivated, increasingly well-educated, low-paid workers (Friedman, 2007, p. 4).

Besides economic implications, there are other compelling reasons to teach science well. Ahlgren and Rutherford (1990) stated that:

> Scientific habits of mind can help people in every walk of life to deal sensibly with problems that often involve evidence, quantitative considerations, logical argument, and uncertainty. It provides us with the ability to think critically and independently (p. xiv).

The development of a scientific way of thinking would certainly benefit the lives of all Americans, peoples of all nations, and allow them to live more healthy and productive lives, regardless of their career choices.

**Research Question**

My research question was: How have PAEMST winning science teachers at the elementary level developed exemplary mojo? Within this context, I determined exactly what inspired these individuals and what continues to motivate them.

I interviewed PAEMST winners who have been teaching for various lengths of time; some are now retired. Each of these individuals, to this day, maintains a commitment to exemplary science instruction whether in the classroom or through the continued guidance of other educators. I couldn't help but think of athletes who perform for the love of the game. High achieving athletes often receive awards. The awards themselves are never the goal; the satisfaction of completing the journey or achieving something internally satisfying is what makes them tick, what gives them their mojo. These teachers care about kids and their profession and, although they are not paid like pro athletes, they are equally motivated to do something significant. They possess mojo of exceptional quality.

As I studied these great teachers, I wonder if it is possible for educational institutions to develop great science educators who possess mojo. Can mojo be created, nurtered, or developed? Ahlgren and Rutherford (1990) stated:

> That although teachers are central to reform, they need allies. Teachers alone cannot change the textbooks, install more sensible testing policies than are now in place, create administrative support systems, get the public to understand where reform is headed and what it takes time to get there, and raise the funds necessary to pay for reform. (p. 213)

It goes on to say the teachers need academic colleagues: scholars who are experts on relevant subject matter, child development, learning, and the educational potential of modern technologies. In order to develop more of these teachers, teachers with mojo, we need help from any and all stakeholders in a given community.

There is no way science instruction can improve through teachers alone. It must be a community effort. Perhaps the results of this investigation can help propel a community in this direction, towards a *culture* of positive science instruction, so that they can develop and/or recruit teachers with a high mojo factor and provide them with resources, administrative support, and policies that make quality science teaching a priority.

**Methodology**

The research methodology for this dissertation is qualitative. It consisted of interviews, as Malinowski (as cited in Brenner, 2006) stated, intended to "grasp the native's point of view, to realize his vision of his world". I conducted interviews with PAEMST recipients, in this regard the "natives".

I chose to interview these candidates for two reasons Stake (2010) indicated as potential purposes for qualitative research: Obtain unique information or interpretations held by the person interviewed and to find out about a "thing" that the researchers were unable to observe themselves. In this case, that would be mojo. Stake also suggests using open-ended questions so that the interviewees can comment or tell stories. These stories give the interviewees an opportunity to present from their own, unique perspectives on how they came to be.

PAEMST winners *are* unique. One elementary teacher (grades K–5) has been chosen every other year for the state of Illinois since 1990 so there are only 16 elementary teachers from grades K-6 who have achieved this award. Limited research has been conducted on these skilled teachers. Mojo cannot be observed. It is difficult to ascertain what motivates any individual without probing their thoughts and thought processes. An interview is the best means for discovering this information.

This exploration has been open-ended, as Brenner (2006) states, giving interviewees the space to express meaning in his or her own words and give direction to the interview process (p. 357). These interviews helped me, and potentially others, to better understand PAEMST awardees and, as Brenner states, "how they make meaning of their own lives, experiences, and cognitive processes" (p. 357).

This qualitative research was inductive in nature. It desribed themes that emerged from data during the analytical process (Brenner, 2006, p. 360). Brenner stated that the inductive approach of grounded theory focuses on the process of generating theory rather than a particular theoretical content (cited in Patton, 2002, p. 125). I interpreted the data presented through the interview process and established how mojo evolved for each individual.

**Participants and History of PAEMST**

The particpants in this study are all teachers or former teachers who have achieved the Presidential Awards for Excellence in Mathematics and Science Teaching from 1993–2010. This award is divided into two categories, one for science and one for

math. These teachers received the award for science. The awards are presented every other year, on a alternating basis, for grades K-6 and grades 7-12.

The PAEMST award requires the completion of an extensive application packet including a video lesson, three letters of recommendation, student work samples, a 15 page analysis of the videotaped lesson and a detailed resume that lists contributions made to science education. Three to five state level finalists are chosen from the initial group of applicants. The application portfolios from these state-level finalists are forwarded to Washington, D.C. The National Science Foundation administers the selection process; it selects one math and one science teacher for each state. Later in the year, the award winners attend a week-long awards ceremony in Washington, DC which is highlighted with a reception at the White House and a personal meeting with the President. PAEMST recipients spend the week meeting with various government and education leaders, as well as with leading scientists. They also have the opportunity to network amongst themselves and have an impact on science education decision-making at the government level.

In 1983, this award was established for secondary teachers; in 1988 the program was amended to include elementary teachers. Elementary teachers were not formarlly recognized until 1990. That the award orginally excluded elementary teachers is further evidence that governmental agencies failed to recognize the opportunity to impact science at the earliest stages of learning. Seven years were lost, an entire generation of students who would have been positively impacted by 100 teachers (math and science) nationwide per year, 700 teachers total, mutiplied by hundreds of students, perhaps

thousands. Research has shown the positive results of receiving this award. Who can quantify the impact this award might have had on that generation? I struggle to understanding why elementary teachers were excluded during that time period.

**Research Design**

The design of this research project was simple: one-on-one interviews with five PAEMST elementary science recipients followed by a focus group conversation with three additional PAEMST winners from Wisconsin. I presented the questions listed in Appendix A. The interview was a conversation, the goal of which was to better understanding the intrinsic nature of these individuals and how they developed such strong mojo specifically related to science instruction. Why do they teach science so well? What energizes them to teach science in an extraordinary fashion?

For these interviews, awardees were given questions (see Appendix A) prior to our face-to-face meeting. Stake (2010) suggested that if there was an expectation that one or several interviewees would produce quotable materials, then the interview should be tailored to what is special about that person (p. 95). He also suggested that it is sometimes better to ask an open question, allowing the interviewees to comment or tell stories (p. 95). Therefore, the general nature of the questions are open-ended, allowing the PAEMST teachers to share their individual stories. I wanted the PAEMST recipients to speak freely so I could get a clearer understanding of who they were and how they developed mojo. These discussions were quite amazing and I looked forward to each discussion with a great deal of enthusiasm. I continue to reflect on them to this day.

**Data Collection**

After interviewing five candidates, I identified themes that revealed themselves through analysis of each participant's thoughts. I then shared these themes with a focus group of PAEMST winners (three teachers) from Wisconsin and asked them to share their ideas, perceptions, and experiences. Are there connections related to these themes? I facilitated a discussion of these ideas. This provided extensive dialogue and coverage as to how mojo was developed amongst all of these talented educators and served to further validate my findings.

This was my hope, to hear the stories, the evolution of these exemplary teachers. I had hoped to determine their mojo or the magic that makes them great teachers. Will there be commonalities? Can their development possibly be replicated? What are the themes amongst this group that connect to motivation? The determination of the *specific* characteristics of their development is what I hoped to identify. I sought to clarify and validate the manner in which these teachers became great so that this process can be shared, duplicated, and refined - ultimately, so that our children may receive the best elementary science education possible. I believe that I achieved this goal.

**Limitations**

The small number of PAEMST winners available within the state of Illinois limited the number of individuals that I was able to find and interview. There are sixteen candidates who have received the award for elementary education since 1990. They were an extremely difficult bunch to track down. Ironically, for some of these recipients, opportunties presented themselves after the awardees were honored that pulled them

away from the school and classroom in which they had been teaching. This complicated my ability to locate them.

All of these awardees are leaders and their influence resonated beyond the walls of their schools, districts, and communities, so it was not that surprising that they moved on into other positions in an attempt to spread mojo with and for others. For many of the these candidates, my attempts to locate them led to dead-ends; I was unable to track them down.

## Chapter Four: Findings

### Introduction

After conducting interviews with eight Presidential Award for Excellence in Science National awardees, I delineated five themes.

1. Science is a natural motivator for learning.
2. Students must become scientifically literate citizens.
3. A "trigger" event propelled each of these teachers towards science.
4. All have engaged in ongoing, challenging professional development.
5. While experiencing isolation and inconsistent administrative support, all have remained rock-solid advocates for science instruction.

### Theme One: Science is a Natural Motivator for Learning

As I recognized at the very start of *my* teaching career, PAEMST awardees likewise observed that most children were inspired and motivated by science. These teachers used science as a learning *hook* and a means to generate enthusiasm towards learning beyond science, in other content areas. When Ellen was asked how she judged success in her classroom, she said:

> One of the ways I judge success is by looking at the enthusiasm of the students for science. I look at the work that they do and just how they love science and looking at their enthusiasm for *all* different things that we do. Kids often come back and tell me, 'I remember when we made that ocean in the classroom that was my favorite thing!' ' I remember when we did the camp-in and got rid of all of the

desks and got sleeping bags!' Such positive experiences for children serve to create positive feelings about school in general.

Ellen seems to have created (she recently retired) a positive culture for learning and students are eager to be in her room before the year even begins! What a wonderful feeling that must be for her students and their families. Shouldn't all kids feel such eager anticipation for learning? It seems that Ellen has established a reputation for excellence that is recognized by classmates, siblings and parents. Such respected status seems to be the norm amongst all of the PAEMST recipients.

Lena embraces science as a catalyst for all learning and in her classroom often tries to link science, literacy, and real life. She tries to extend positive feelings about learning beyond science; she shared these thoughts:

> I wanted to make it science; I wanted the kids to have experiences, to try to make connections between real life and reading it in a book so I tried everything I could and I really liked it (science) and that was my thing. Regarding kids being pulled from class for reading interventions, I try really hard subtly, and not so subtly, to get them to, I've argued for it some (using science to help teach reading), that you can teach reading and teach them about simple machines and do it at the same time and let them get their hands on things.

Lena uses science as a natural learning motivator to teach and reinforce reading skills. This may be especially powerful with students who are struggling readers. Linking science with real life problems is a natural means of creating connections for kids.

Nancy had similar feelings and explained it this way:

> I found that the thing that really intrigued kids was problem-solving and, of course, science lends itself wonderfully to problem solving so I really wanted kids to think and to take what they knew and apply it. That's how I personally got into it by saying to the kids, 'There isn't a right answer, we're going to try this, it may work and it may not work. We're going to learn from whatever happens and if you have questions or ideas let's branch out and do it with what you are interested in.

Nancy recognized that there was a natural connection between real life experiences and science and that she would take advantage of these connections to engage children. This could help them learn more effectively.

When Sharon was asked what the administration could do to nurture the growth and development of both science and science teachers, she too believed that students' natural interest in science could be used to teach reading and math skills as well as problem solving. Sharon shared the following ideas:

> I think they should definitely recognize that science is a viable tool for teaching reading and math and language and with the big push we read and write and do math all of the time (NCLB). And I think it's even better that way because it's being integrated into something so that kids can see the different perspectives. Very few principals have a science background; they should be provided with more training. They need to realize that it (science) provides critical thinking

skills, you know the problem solving skills. Kids aren't just, hopefully, reading a book and getting answers but they're talking to each other and they're developing others skills that are necessary in life.

Sharon's thoughts touched on school culture and expectations of administrators. Although Catherine did not mention administrators, she had similar thoughts regarding science and how it could and should be used to motivate learners:

I don't see myself as a science teacher because that's not my background, that's not my training. But I see myself as a teacher working with children and that's what I do. Science is one vehicle to help children learn, it's an important one.

Catherine will use anything she can to help her kids to remain engaged, even an area with which she does not necessarily feel comfortable (science!). She recognizes science as a natural means for her to engage learners.

Lena seemed to feel more naturally inclined to teach science. When asked what makes her successful at her work, she said:

I think what makes me successful is that I'm the biggest kid in the room. I'm still as curious as they are and I want to learn more and I try to roll with the punches so to speak, roll with the kids, whatever they're interested in at the moment, trying to get that as a part of my science class will pull that in, whatever is going on in the world. Even in reading…. pulling in what is important to them.

Regardless of each of these teachers' perspectives, they all desire to connect with students' interests, to make real world connections, and they indicate that they are cognizant of what matters to students. Each wants to know what will motivate them

rather than blindly force-feeding content. They will provide required content but do so in a manner that learners embrace.

Lena expressed this honestly and expressed as much specifically in these thoughts:

> You have to find out what kids are interested in and then they'll learn better. You know if you just read out of a boring textbook all of the time or if you just call something reading all of the time, there are kids who struggle with reading. If they think it's reading they are going to give up before they try. If they are trying to build a robot and they have to read some directions to build that robot, they might be more interested in reading! It might make them like school better. It might make them want to come to school if they know they are going to go to science for an experiment that day or if they are going to learn something, do something, rather than just read out of the book.

Lena again demonstrates the use of students' self-motivation, intrinsically developed, as a critical component to successful learning. If kids care, they'll try that much harder. Making real world connections and using hands-on activities further build on students' internal motivation. Nancy shared these thoughts regarding the use of new experiences incorporating these principles of learning:

> Having something we can really explore together was really fun for me. Putting equipment in kids' hands who had never tried anything before was, you could see their excitement and energy! It was fun.

Nancy also mentioned that there were programs she created that students approached her about even before they were in her class. They were brimming with excitement about an upcoming activity with her. She also mentioned, "I had a lot of parents walk in and say, 'I understand you like science and my child likes science and I think we'll be a good match'. That was a reputation that I had."

These teachers have reputations in their communities that their classrooms are special places for learning. Students and parents recognize this. One can only imagine the impact this has on students' attitudes and the parents' expectations as they enter these rooms. On the other hand, parents and children who are not in these rooms may be disappointed and that is a problem in and of itself. Good science should be across the board.

How does student engagement impact mojo? I know that I feel successful when my students are engaged and motivated. It is incredibly rewarding and motivating for me to create and develop similar experiences. It provides fuel that I believe intrinsically motivates *me* and these award winning teachers feel the same way. It is a cycle of reward. In *Hero's Journey: How Educators can Transform Schools and Improve Learning,* Brown and Moffet (1999) wrote:

> True Learning comes from a fusion of head, heart and body. The knowledge and understanding that become a true part of ourselves are always the result of experiential learning in which we are intellectually connected, emotionally engaged, and physically involved. The heroic school and school system are

places in which the joy and chaos of exploration and inquiry are dominant and always present. (p. 31)

The PAEMST winners seem to recognize this innately and they appear to encourage a classroom environment that entices and embraces students' "heads, hearts, and bodies". Theirs is a classroom culture of success in which both students and teacher seem to have a reciprocal reward system grounded on exemplary science instruction and science based interactions.

At the award week in Washington, DC, 2010, one PAEMST recipient shared experiences which further emphasized the impact a good science teacher can have on students. Mel shared:

> We talked with the first woman to walk in space. We went to NASA and talked to the engineers and the scientists there. We went to the EPA and talked to them and all of them, *all* of them, wanted to tell us about their 3rd grade science teacher or their 8th grade science teacher and it wasn't about what they learned about science, astronomy, physics, whatever. It was about getting them *excited*!

These were examples of how teachers' actions can resonate for years and years.

When discussing her classroom, Wendy also felt it was the by-product of the inspired learning that science provided which motivated her kids in all content areas:

> It was that good teaching, good science teaching and activities that excited leaners about learning. But coming back with your students and other teachers, it's not about the stuff you are teaching, it's about *how* you are teaching and getting kids excited.

This is a critical idea: *how* you teach. These teachers inspired their students through their natural enthusiasm. I personally felt their charisma when I spoke with them. The PAEMST awardees were a force to be reckoned with and the recognition that they have a successful means of reaching kids and achieving success seems to make them more confident and energized. Mary added her thoughts on motivating students, "And you can learn to connect, that excitement, with other kids because you build a community of learners." Mary introduces the emotional element of her teaching and how important community is. This was explored further in Foster's research (1996) on PAEMST recipients in Texas. This study provided further focus on students' emotional connection to positive learning:

> I respect students' abilities and try to look at what I do in a holistic way. I am preparing kids who are going to be leaders in this world. One of the most important things in elementary school is self-esteem and love of learning. I want my students not just to be science students, but to be a student, to be somebody that enjoys learning. (p.54)

These teachers recognize that this is not just about science but also their students as learners. All of the teachers I interviewed and those in the Foster study group were/are student-centered teachers. A teacher in the Foster group made this powerful statement:

> All kids are gifted. All children have some gift. And we can reach all children regardless of race, capability and background through science. (p. 5)

Personally, I think this is the optimal mindset for all educators. The ultimate mojo. All kids possess strengths and unrecognized talents and I have often found that

science has been a doorway to release these talents. I have taught students who struggled at reading but excelled at implementing the scientific method as they led their science team in the completion of a lab activity. I have had students who have barely spoken in class bring me artifacts (feathers, rocks) they found in their yard. They can't wait to tell me about animals they have seen. Science combined with students'natural curiosity opens doorways for learners. Science can change students' experiences and perceptions in ways that can be life changing.

I know most kids love to read about animals, volcanoes, space, oceans, almost all things connected with nature and science. They often choose to read or watch shows on these topics on their own. I have witnessed this throughout my 21 years of teaching. This innate curiosity has not changed over the years despite technological advances, specifically video gaming and other tech diversionary devices.

The teachers I interviewed provided endless examples of how science motivated their students. It was inspiring and vindicating to hear. But most importantly it revealed a valuable asset for all elementary teachers. These nationally recognized teachers have already discovered this magic elixir, science. This elixir, this hook, is free of charge for all teachers. Anyone can use it as a tool to motivate leaners.

**Theme Two – Students Must Become Scientifically Literate Citizens**

Trefil (2008) defines *scientific literacy* as "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" (p. 28). He described how a person who is not

equipped with the matrix of knowledge we call scientific literacy will be "excluded from large areas of debate, and simply will not be able to make his or her voice heard" (p. 35).

The PAEMST winners I interviewed had similar thoughts about the needs and rights of students as citizens to possess scientific knowledge and skill. Regarding scientific literacy, Catherine shared the following:

> Well, I don't see myself as a science teacher because that's not my background, that's not my training. But I see myself as a teacher, working with children. That's what I do. Science is one vehicle to help children learn, it's important. I see myself more as preparing students to be citizens in a democracy and science is one of those things that they are going to need to know, not only just for background knowledge and content but in order to make decisions as they become citizens, to make informed decisions in a democracy. So I see myself as preparing people for citizenship and that includes having science experiences and background that includes being mathematically literate. It includes understanding about the common good, and you can bring a lot of understanding about the common good in science lessons.

Clearly Catherine has powerful feelings and a clear sense about her responsibility as a science teacher. Not only is it a natural motivator but it is a necessity, a right as a citizen, for all kids to possess.

Referring to an administrator's statement that, because of Adequate Yearly Progress (AYP), teachers should not worry about science, Lena had strong feelings related to students being scientifically literate:

> I'm like what?! What do you mean don't worry about it?! Don't you have a doctor that takes care of you? Don't you have a dentist that takes care of your teeth? You need a mechanic to fix your car. You know we need those people. We need scientists! I think sometimes people forget that a doctor is a scientist. A person working on a car is an engineer. You know that you don't have to be working as a chemical engineer to be a scientist, I mean everybody somewhat is a scientist, so I was like you have to find what kids are interested in and then they'll learn better.

The PAEMST winners recognized that science is part of the fabric of all of our lives and that recognition of this element begins during the earliest stages of development. Nancy shared how early we begin to explore:

> One professor said to me that (science) education starts in the high chair, when the kid drops something and it goes to the ground they're going to want to know why that happened and then they let go of a balloon and it goes up and all of a sudden their theory, you know, is blown. If a child in the high chair is already questioning their world, we somehow kill that someplace between then and when they get to high school.

When I asked Nancy what being a science teacher meant to her personally, her ideas further supported the beliefs of the other PAEMST winners, that science resonates beyond the classroom:

> It means trying to inspire kids to learn more about their environment, and about science in general. I want them to learn about scientists; not just science but what

do people do who are scientists because they are very different than our perception of them. And I want them to think about careers in science. Especially girls, what could you do that was really cool in science because they don't think of science careers as there are so many possibilities.

These teachers recognized that science empowers kids. Kids are unaware of the potential value of science in their futures. They are innately drawn to science but certainly don't understand the implication of this interest, that it can empower them for life if nourished and developed.

Sharon responded: "Nurture the growth and development of both science and science teachers." When I asked her what administration can do, she also added:

> They [administration] need to realize that it [science] provides those critical thinking skills, you know, the problem solving skills. Kids aren't just, hopefully, reading a book and getting answers but they [kids] are talking to each other. They're developing other skills that are necessary in life in addition to what they're reading just science content period. It would be nice but, like you said, very few principals have a science background.

I brought this theme, empowered citizens, to the Wisconsin teachers who I interviewed together. The following dialogue is evidence of their explicit thoughts on the importance of scientific literacy and its potential lifelong impact:

> Mary: You learn to think.
>
> Margie: Responding to life crises in an organized way without becoming hysterical.

Mary: Having questions and then answering those questions based on evidence and so they learn to think now, why do I think that because, you can feel that way but okay where is that coming from so at least okay if I'm going to say this I have evidence to back that up. And if I don't have evidence to back that up, I'm going to do something to figure out how I'm going to get that evidence to back it up.

Mel: It's empirical, asking why do you think that, not just what do you know, but why do you think that. There are more questions that can ever be answered. Scientists ask more questions than they can answer and that's all right.

Mary: It's never done.

Marge: Think about critical questions. Should I get in that car with that drunk guy? I mean, what are the consequences of that? I mean those are the social questions that kids need to be able to ask themselves, in every situation in school.

Mel: And as they get older, they learn this pattern.

Mary: Who should I marry? What should I eat? Where should I go? What should I do? Who am I as a person? It takes a lot of pressure off of people, if you don't have to be, you think you to have to be smart. Every answer is different for every person.

Mel: It's not about having all of the answers and understanding everything, that's the misconception.

Mary: Its really giving kids the power to make choices about their life.

Margie: The power to make choices.

What does this have to do with mojo? I interpret these thoughts and beliefs as a calling or a feeling of responsibility that transcends the classroom environment. These teachers truly believe that if students embrace science and if they cultivate students' interest in science, they can help them have better, safer, more enriched lives - what an incredibly powerful motivator, mojo generator, if you will.

All of the teachers from this research report felt that their work was critical to the improvement of our society and Mel stated the following:

> I have a lot of passion about taking care of the world and taking care of each other and maybe it comes from my politics and all that; but, you can't be a teacher and not have real strong convictions about what your are doing; because if you really believe in your heart that what you are doing is the right thing and that you are doing it with meaning and purpose, then you are going to be good at it and so that's what I think drives me.

These teachers recognized that science is part of our daily lives and that as they look to the future developing skills in science and becoming science literate, is essential to citizenship, good health, and important decision-making through the course of their students' lives.

**Theme Three – A "trigger" Event Propelled These Teachers' Focus Towards Science**

The teachers in this study were asked if they had always intended to teach science. They all said no. For some, administrators recognized something about them and either encouraged them to teach science or required them to attend a PD experience that changed their perceptions of science. While others, on their own, discovered PD experiences, pushed themselves to participate, and then they gained confidence and a commitment to science instruction. Their experiences seemed to lead them to recognize that science instruction at the elementary level could be a game-changer. Elly shared her history:

> I didn't necessarily like science in school because they didn't have any good teachers that really excited me about science. I went to college at the University of Illinois and I can't tell you one thing I learned about science education, not one thing.

She then experienced what I refer to as a "trigger" event that changed her perceptions of science instruction forever:

> My love of science came as a young teacher. I got a Ranger Rick magazine in my classroom. Because it was about nature and I loved nature, I always felt this connection about nature. I saw an advertisement about something called the Conversation Summit. I decided to pay the money to go and that's when science became ignited for me. That made me really focus on science.

Nellie shared the history leading up to the start of her teaching career and then the trigger event that altered the trajectory of her teaching forever:

I didn't start out to be a teacher at all. I started out as a math major. My mother did not think it was a good choice. She steered me towards elementary education. I was substitute teaching. They begged me to come teach and I finally agreed. We met as a team with the principal and I and the other teacher were asked what we wanted to teach and we both said reading and math. The principal looked at me and said, 'You complained about the science program before, so you will teach science'. I said, 'You don't understand. I'm the one who skipped science in high school and every time they dissected in college. I hate science! So that is when it started. She started sending me to workshops, then it took me two years, and I was hooked. And one of the first things I wanted to do as soon as I taught my five years was go to NASA's NEW program. I went to every workshop and convention. Anything I could do to build my skills. I think I was as intrigued as the kids were.

Nellie's story is a wonderful telling of her transformation and the impact quality science PD combined with science-centered administrative commitment and leadership can have on the development of an outstanding science teacher. She needed a little nudge and it worked. This administrator sensed that Nellie had mojo, it just needed a spark.

Catherine never intended on teaching science she shared these thoughts:

I was a social science major. That was my love. I loved world history and politics. I saw that all the history teachers were male and coaches so I switched to elementary education. I took every social studies course there was offered in college, even geography of China. I took one science course,

Astronomy. Finally, I got into my 15th year of teaching and I was in a new school. The principal wanted us to go to some science workshops. I said, 'All right, I'll go.' They were very exciting, two great presenters, they were like you know, getting us all excited and I got excited of the science and I said, I could do this. This was 15 years into my career.

Catherine was yet another teacher who was encouraged by her administrator. Each was astute enough to choose the right person and the right learning experiences.

Lena shared that she had come to her school to apply for a pre-school position and then she experienced an incredible turn of events that changed her life:

The principal said come into my office. He said, you'd make a great 5th grade teacher. I really think you would. And he said it's a full time position and I'm like okay, you think I can do it then I can do it. And here I am starting my 24th year. But what really sparked my science nature was a refinery nearby that sponsored a workshop called Teaching with Toys. I fell in science all over again.

This followed a similar pattern: sound judgment by an administrator combined with solid PD.

Sharon also never intended to teach science. She wanted to teach, no doubt about that, but she was hooked in a slightly different manner:

Well I always knew that I wanted to be a teacher. I always really, and I thought, I mean from the time I was a little kid that I was going to be an elementary education teacher. I was going to teach second grade. So, I never really thought specifically science because of that but when I got into the

elementary education program, I was horrible. I was so bad. I couldn't control the kids. I think I barely passed. But then luckily I heard about, in our special ed. class, I heard about deaf education. I'm like small classes, sign language, that's cool so I got into it and I had a fabulous mentor. So, that hands-on element falls in with sign and it allows me to be creative. It allows me to be active in hands-on. And I think that, you know, what I really like. And that was channeled into working with the kids getting them motivated and energized.

Although not technically through PD, Sharon found a niche that matched her personal skill set and beliefs and led her to great science instruction. Her experiences actually made me think of how kids become engaged when taking part in hands-on experiences. It seemed to hook Sharon as well.

Not one of the Wisconsin teachers I interviewed was originally hired as a science teacher. Margie was a general education teacher who taught kindergarten. She did not become a kindergarten science specialist but she recognized that science is a hook for learning and she used that as a foundation for her teaching.

Mary: If you believe in the learning model for kids, you work on the weaknesses. And it (science) was a weakness because in kindergarten it was all about learning to read, That's all we did was read, read, read.

Mel: I went back to school for teaching, teaching is a second career. Primary teachers, who are incredible people, that's not their love (science); it's more the technical subject. They're there. They're there about learning and they're about kids. We need more, high school

teachers don't have to care about, I mean here is the information and if you get it, good, if you don't well, that's your problem.

Margie: I was piloting and I got 15 credits to learn how to teach hands-on science and hands-on math. They were going to put that as a specialist like you, and I was like, I want to do that, so I got that all and then I got hired as a science lab teacher and I was like, wow, I get to do hands-on science all day!

Foster's (1996) research presented similar accounts: teachers who never intended to teach science but became hooked by a trigger event:

> Not a single awardee set out to teach science. All awardees became science teachers by chance. Science just happened to be the subject each began to cultivate while teaching sometime during their practice in his or her self-contained classroom. Through the pursuit of advanced degrees, participation in National Science Foundation, American Association for the Advancement of Science, and university-sponsored institutes, and interaction with teachers, their successful science teaching careers were born.

The trigger event is a powerful common thread for administrators and schools to think about as they seek to create science educators with powerful mojo and a capacity for outstanding instruction. Choosing the right people and providing exceptional PD experiences have changed not only the way these teachers instruct but what they believe to be most important for students. These experiences have changed the way these teachers think. After trigger events, they never taught the same way again.

**Theme Four: Ongoing History of Professional Development.**

All of the interviewees with whom I spoke participated in a continual string of PD. It was never ending for them, their norm, the only way they felt they could teach effectively. Lena shared:

> I am constantly trying to improve myself and to learn new things. When I applied for the PAEMST award and I had my National Board I was like, okay, now what am I going to do? I'm always looking for a challenge. That led me to the PAEMST process; I wanted to challenge myself to do something new. Now that I've won the award, I'm like, now what am I going to do? I constantly want to be learning, I constantly want to be challenged, doing something.

Lena is hungry to learn and to continue growing despite her accomplishments. Certainly this passion radiated throughout her classroom and beyond, to other teachers. As students witnessed her desire to learn and improve, she became a role model. Teachers and administrators in her building also became aware of her teaching and learning and sought to emulate them. It certainly puts pressure on others to achieve.

Elizabeth's professional development experiences are extraordinary. She also sets an exceptional example for her students and colleagues. She said,

> I led summer hikes to the Rocky Mountains, Mount Hood, and I've been to Yellowstone and Kiawah. Good science teachers must be role models. A good

science teacher shows the kids that we are all scientists and that I'm a scientist and how they are scientists as well. We must encourage them to believe that. Never stop learning and looking at ways to learn.

She travels to Finland each summer to work with teachers there. She has been to Antarctica on multiple occasions and has presented around the world regarding her experiences there.

Catherine has participated in PD experiences throughout her career, including one run by the Smithsonian Institute. Early on, she received a two-year grant; she stated, "This was really the beginning for me. These workshops were the beginning of my journey that perpetuated me."

Through her PAEMST experiences, Catherine was given opportunities to attend additional PD, but often she had to push the district hard to allow her to go. She also used her PAEMST winnings ($7,500 at that time) to fund herself and additional educators to attend quality PD programs. They would not have attended otherwise; they were without financial support from administration.

Catherine's PD experiences were unique in that she wrote multiple grants for large sums of money that allowed a multitude of teachers within her district to attend PD in science as well. Her efforts were extraordinary, unique for this group, and apparently far-reaching. These efforts also took place long before present STEM initiatives. The pedagogy of her district's learning is inquiry based. Led by her efforts, they were far ahead of their time. Now retired, she still provides PD for other educators and mentors multiple teachers in various districts. Catherine stated:

You have to see the bigger picture and I think that's what I can offer to teachers because I see that there is always a bigger picture. And as far as being successful at my work, I think it's because I remain focused, I'm persistent, I never give up and I'm continually reflective. I think maybe, I've taught 2, maybe 3 lessons, which would now be in 44 years, that I've been satisfied with.

Sharon attended a fellowship in Japan. She also stated that in the summer she keeps going. She shared:

I go out and continue to learn, have experiences. I think having those experiences and then bringing them back into the classroom is really important. It provides the students primary resources that they can use and it just makes them more authentic, I encourage my kids when I go out and do something and I come back and tell them, you can go out and do this too! I attend the NSTA conferences, I attended a workshop in Wyoming and I've done fellowships. I did a course through Eastern on geology and we went to the Black Hills and Yellowstone.

Once Nellie was committed (strongly encouraged) to teaching science, she said she went to every workshop possible.

The Chemistry Institute of Education in Madison, and Teaching Science with Kids, anything I could do to build my skills, I wanted to be sure I was teaching them fact. I think I was as intrigued as the kids were.

One of the first things she wanted to do as soon as she taught five years was to attend NASA's NEW program. She applied for this two week intensive hands-on

workshop at the Glenn Research Centers as soon as she could and after that she was hooked.

The NEW workshop was also what hooked me (J. O'Malley). The respect they showed for the elementary teachers in our group was extraordinary. The scientists and engineers shared how grateful they were for the elementary teachers they had as children. Many shared that it was because of these teachers that they had chosen to become scientists and engineers. This further validated science for me and deepened my commitment to science instruction. It was *my* trigger event.

The Wisconsin teachers' experiences were also inspiring: trips to Russia in which a teaching partnership was formed, National Board Certification, peer reviews for *Children and Science,* experiences in Milwaukee that emphasized hands-on science and math, and a program called Picture Perfect Science. In addition, because of their PAEMST awards, they are now involved in committee work, piloting and a multitude of PD experiences. Each also exhibited tremendous awareness of resources available to improve their instructional practice. Wendy stated, "Its crazy. We teach at conferences and meetings galore, crazy, crazy, crazy."

These teachers were of similar quality to those cited by Foster (1996): One became involved in NSF sponsored institutes; one spent several intensive summers at universities throughout the country working with teachers developing national science curriculum models; another traveled to Washington, DC, with a group of astronomers and university professors; one of the teachers developed technology-enhanced science classrooms with university researchers. Catherine, after twenty-five years of classroom

teaching, attended an intensive university sponsored summer institute in which she learned new strategies for teaching science. All of these teachers recognized the importance of their own continuous growth in science teaching. They actively sought ways to "sharpen their saws" (Foster, 1996).

It is evident that these professionals continually challenged themselves to become better at what they do. This was consistent amongst all of the teachers I interviewed and the participants in the Foster (1996) study as well. Two things stood out as I analyzed these facts: 1. None of these teachers were required to participate in these experiences and 2. The depth and quality of the experiences were extraordinary. They included worldwide travel and partnerships with educators from other nations, outdoor experiences that required time, challenges, funding and even risk-taking. They realize that they, like their students, needed to experience true hands-on, inquiry-based learning experiences. These were authentic adventures that were truly above and beyond the norm.

Having recently traveled to Kenya, Glacier National Park, the Black Hills, Grand Tetons, and Custard State Park (summer of 2014), I can say with absolute certainty that my experiences allowed me to teach at a level that was unmatched as I shared primary experiences that no websites, videos or other potential resource could possibly provide for myself and my students.

**Theme Five – Despite Isolation and Inconsistent Administrative Support, Each Teacher has Remained a Rock-Solid Advocate for Science Instruction**

Many of the PAEMST recipients felt isolated from colleagues, administration, and sometimes from the community. I attributed this isolation to two factors.

1. An interest and focus in an area of instruction in which many elementary teachers lack knowledge; interest and confidence to teach, thereby creating a disconnect from some colleagues.
2. An overall lack of commitment to science education by school districts and a lack of support, recognition, and validation of skill by administrators.

These teachers would not allow isolation, poor support, or lack of recognition form community members deter them from their mission of providing an outstanding science education for their students. I was inspired by their conviction because it had nothing to do with them and everything to do with their students' best interests.

As an example of their ability to connect with colleagues, Catherine stated that, when she attended the PAEMST award ceremony in DC, it occurred to her that the people, the other award recipients, were all teachers with whom she could talk. She said, "We could really have professional, intellectual conversations. And that part, right there, I realized I had been missing."

Regarding administrative support, after she first won her award, she asked to take a team of teachers to a special science program at the Smithsonian Institute. It was very reasonably priced ($400) but the superintendent would not support the expenditure. Fortunately, she was able to use her PAEMST award money to fund the trip for the team of teachers. In addition, she attempted to show the school board members the benefits of hands-on science learning and instruction by demonstrating activities at board meetings. Catherine also personally secured hundreds of thousands of dollars to promote science

education throughout her large school district. She also shared that, in 2002, "principals began lowering their expectations (for science)". She stated:

> No matter what they throw at me, I find a way around it. To do the right thing, to teach it the way it is supposed to be taught, no matter what, there is always a way to do what you know is right for kids and teaching. That's what I believe.

Catherine's school board did not recognize that she had received her PAEMST award for one year. This award is considered the highest honor an elementary science teacher in this country can achieve.

I asked Catherine, "But have you ever had to push back and strongly advocate?" She responded, "Every minute of every day. Whatever it is, you have to keep fighting, in a positive way of course".

I shared with Sharon that I thought, at my school, in my present position as science specialist, it seems that there was more interest in science, more respect. I asked if she sensed that in her school community. She replied, "Not so much here because people, it's looked down on, nobody cares about science around here. I should probably close my door".

Sharon also shared how an outdoor education trip that, for many years she had taken students, was cancelled with no explanation. Later, a new superintendent was hired; she wrote her a letter explaining that this valuable trip had been cut. The new superintendent reinstated the field trip. At present, she has moved to new school within the district and the trip no longer takes place where she previously taught.

Other teachers who have seen Sharon teach have called her class "controlled chaos". This is something I have also heard about my classroom. Her classroom is active, engaging and she trusts her kids. She has created a culture in which students move, collaborate, and are active.

I asked Sharon about the school community response to her award and any recognition that may have taken place. She replied:

> No, not really. I didn't get any (recognition). I had my one friend, who is across the hall from me, she gave me balloons that said congratulations and nobody else said anything, including administration. There was no recognition ceremony; the superintendent didn't say a word.

I responded that this was shocking and she said, "Yeah, it's a shame but, oh well."

I wondered what this same administration thought about science instruction in general. I aked her about her principal's perceptions on how science should be taught: she said:

> I think that she just expects teachers to just give them a book, read a chapter and answer the work sheet so science is going to go way down hill now.
>
> They've cut science in half. I think elementary, maybe two days a week, if even.

Nancy felt that teachers needed to be heard. In her experience, teachers were not given the opportunity to share their thoughts on science education. PAEMST changed that for her as she found a voice alongside fellow awardees:

> When I attended the PAEMST festivities in DC I loved that the teachers were asked their opinions about science education. They always ask the administrators,

they always ask the school board but they never ask the teachers' opinions. So to be able to go and talk to the secretary of education and they were taking notes on what you said to senators, you know, you feel they were actually listening to you, it was just unreal. We felt for the first time someone really cared about what went on in the classroom.

I stated that she had been empowered by the experience and Nancy reiterated:

> It just isn't fair; there is now talk about pushing for more science but you never really talk to the teachers. All the administrators talk about it but they never really push their teachers to teach science.

Nancy did receive positive affirmation from her administration but she said, "It wasn't for my glory, it was in order to help kids".

After Nancy won the award, she felt that she could convince other schools how important she thought science was. She was empowered. At some of these schools, principals said that due to AYP related to NCLB, no science would be taught; Nancy was able to influence these school communities. She shared:

> We were fighting it every step of the way on how you can sneak it (science) in, how you call it reading and still teach science and all of those kinds of things so I think it was a battle.

I had asked her if, prior to this, she had ever needed to push back or advocate with administration and she said:

> They would come in my room and ask why are you spending so much time on science. My math and reading scores were good so I told them I'm sorry but I

feel that it's more important. I got some grief. I had one principal in particular who was not supportive.

When I asked her what happened, she said that parents went to the school board in support of her efforts and the superintendent told the principal to leave her alone. The superintendent responded, "She's doing what is right for our kids". This was evidence that some administrators did recognize and appreciate the skill level of these teachers, perhaps, more importantly, they valued what was best for kids.

Elizabeth talked about the need to find other science teachers with whom to talk:

Because, as you know, it's not something a lot of elementary teachers necessarily enjoy talking about and that's been not a problem but an issue. There are not a lot of people in my building who I can sit down and talk science with; you try to find those people. I can never be satisfied with just knowing what I know. Keep going, always keep going. Administrative support? The curriculum director butted heads with me over everything. She wasn't interested in science. She was in charge of everything, overall curriculum. In fact, they changed the curriculum and she made sure that energy was not a part of my grade level anymore.

This was further validation of the isolation these teachers experienced, diconnections with staff combined with lack of administrative support. I probed further, "Are they supportive now?":

My current principal didn't even come to say goodbye when I left (out of country teaching experience), never once communicated, never said hello when I

got back. I've had to fight tooth and nail for things that made me a better teacher. There is no reason for others to get excited about science because nobody is saying, 'hey, we value science'. I like to do things that excite children and yet, we're boring them to death because everybody has to conform and we're not allowed to. I'm waiting for them to say you can't do the special unit because it's not the same as everybody else, and you need to do the same as everybody else. I find that to be very frustrating and wrong. I think life is not about every teacher being the same.

The conversation turned here and she spoke from the heart. I believe this is where her true passion emanates from:

I love science so much and I just want to do more science and it's not about trying to outshine anybody. I couldn't give a rip, you know. If someone wants to do some cool language arts things because that's their thing, yeah, awesome. I'm supporting you; I'm your cheerleader. I'm not going to look down on them because they want to do more. I'd actually like to learn from them.

I asked Lena what being a science teacher meant to her personally. She also spoke with great conviction, her motivation was clearly beyond classroom "responsibilities" and federal or state edicts:

I fight so hard to keep science in the curriculum in our building. It is really hard, because of, like I said, with RtI and it sounds like I don't like RtI and I know it has benefits, especially with the younger grades. I just feel like we've thrown the

baby out with the bathwater. We focus so much on one thing that these kids, they need to be well rounded, they need to have, you know, so I don't know, I just fight (for science).

Regarding a special award ceremony at a board meeting, she told me that the baseball team who had won sectionals was also at the event. When her name was announced she heard cheering and turned around and the entire baseball team was giving her a standing ovation. She had taught many of these boys and she said this meant more to her than shaking the hand of the president. "That's where you find your successes; the kids let you know." Lena shared on her motivation to become a PAEMST awardee:

> One of the reasons that I applied for the award was so that I could talk to some people in power about science, getting it back in the classroom and about sharing how rural schools are functioning and all those things which I was able to do. I made an appointment and I was able to talk to a senator. I'm constantly fighting for science at my school. Some kids are pulled 2 or 3 times a week for Response to Intervention (RtI) initiative and those kids miss a lot of science and social studies so I really try subtly, and not so subtly, to get them to, I've argued for it some, you know, meetings we have. I say you can teach them reading and let them get their hands- qon things! I've told student teachers that they need to let their kids get their hands dirty, to be in our lab. An admin of ours said, I can't remember the exact words, but something to the effect that, 'science doesn't count towards AYP, don't worry about it'.

Lena constantly appeared to be fighting against a mindset that discouraged science instruction; she believes that science should be used as a catalyst for those kids who struggle at school. She took this battle on her own and she is fearless in her pursuit of science education in her school/district. Lena's response when her principal stated that science didn't matter:

> I'm like what!!! What do you mean don't worry about it? Don't you have a doctor that takes care of you? A dentist? We need scientists and everyone is should be somewhat of a scientist. You have to find, you have to find what kids are interested in and they they'll learn better.

Lena's response is an excellent example of the strong feelings she possessed for science and its implications on citizenship and education.

I asked Catherine about mojo, here is how she interpreted mojo:

> I think a lot of this [mojo] has to do with surrounding you with people who love what they are doing in a positive way. I love science; I eventually was hired as a lab teacher and I was so excited to teach science all day! Nobody else wanted it [the position], nobody else wanted to teach science.

Catherine felt that good mojo was a lot about attitude. Surround yourselves with teachers of a similar mindset and you are more likely to create a culture of positive teaching and learning.

A dialogue with three of the Wisconsin teachers follows that further validates the passion with which they teach, one even sharing her concerns about the legacy she would leave behind:

Mary: The key to being a good teacher is not knowing everything; it is creating an environment that gives kids freedom to make some choices, to make some mistakes. What are you going to do next? How can I help you?

Mel: I would mention that few elementary teachers who like science because it is messy.

Margie: It take a lot of time, set-up. However, I think that mojo comes from the fact that you build a network, you know the more you talk about it.

Mel: The community starts to talk about it.

Mary: The more that people that you talk with, people you find, like-minded sciencey people, you get into those conversations, you develop support.

Margie: I just don't want to retire and die without passing on what I've learned to somebody, passing on the torch. The reason I got into science was because I wanted to get better at something and I wasn't so good at science. But I still have people who believe that you can't do science if you don't know how to read. I heard somebody say that this year. You have to learn how to read first. They've been doing science since they were little when they put their finger in their mouth. What does this taste like?

Mary: I never thought I was any better than any other teacher. But then you win [PAEMST] and you go [D.C.] and you see wow these people are amazing and you're like, oh my God, there is so much out there I can do.

Margie: We are people who want to give something, maybe it's like the political essence, why people are politicians: they want to serve. There are always some people who are in it for the money or something but you feel like you want to give back or something. So that is mojo. Is that mojo?

Mel: I also think that, with the elementary teachers, is someone getting them over the hurdle, thinking, 'yes, this is going to be a little messy'. Let's change the paradigm.

Mary: The thing is they're very rule followers.

Margie: I've never been a rule follower!

Mary: I've never been a rule follower! (laughter)

This was another trait shared by the PAEMST winners: they tended to be rule benders, a bit rebellious, and willing to take chances if they felt it was best for kids. This dialogue exemplifies all of the themes explored in this section; conviction, isolation, and inconsistent administrative support. This is clearly a group of passionate teachers who recognize that there are issues in science education. These teachers observed that *all* elementary educators need to step up and take some accountability for science instruction. They needed to be courageous and overcome discomfort and gain some mojo. These teachers also displayed a sense of humility, they were strongly committed to science education but recognized that they needed to remain reflective. This dialogue continued but then turned towards the "nuts and bolts" of teaching, professional

development. Next, they ventured into professional development and administrative support, a reoccurring theme for these PAEMST awardees:

Mary: You have to get some training and PD. Our district is good about letting us get some of that, if you don't get training to be better at your craft, I don't think you can improve. It's a must.

Margie: Yeah, you can go there or yeah, you know, and they give you things but just the regular, everyday support is a little touchy. I like to go to conferences but I have to beg, borrow and steal to get to conferences.

Mel: The district cut back on that.

Mary: It's like for training, they're going to give us days to go in there as long as the company is willing to pay for that and get their names (the school or principal) out there. Very PR conscientious these days (administrators). Math and reading right now is huge! And science, it's critical thinking, if there's critical thinking (this can stimulate math and reading) but she says math and reading are most important. No! I disagree with you!

Margie: Well, what are you going to read? READ SCIENCE!

Mel: One of the things you said, talking about creating mojo, at the school I was at, I had to supplement with the Habits of Mind. And it's a well established educational background and some of the administration were like, 'we don't need that, we're not going to have teachers that do that'.

Katzka identified 16 of them and he broke them into four different categories, things that lead to good scientific thinking.

Mary: Thinking about your own thinking.

Mel: Thinking about your own thinking, metacognition, questioning, posing problems, thinking and communicating with clarity and precision, striving for accuracy, responding with wonderment and awe.

The importance of PD experiences to the development of PAEMST winners with mojo, has proven to be most critical. All of the districts in which they reside commit to PD sparsely: they do not support experiences that may produce the mojo needed for teachers to excel and for students to prosper.

As I compared the circumstances of the Illinois PAEMST group I interviewed, the Wisconsin teachers (focus group) were in a unique situation. They had each other to whom they could reach out for support; they understood one another and were committed to the same philosophy. All the other PAEMST recipients I interviewed were the sole winners in their districts. They were alone in their belief in and commitment to science education. This is not to imply that only teachers who win this award are extraordinary and that collegiality cannot occur without the presence of a PAEMST recipient but, it appeared that of the five individual interviews I conducted, all of these individuals were on their own. I believe that this reflects the culture of the districts in which no effort has been made to establish cohorts or groups of science educators who can support and collaborate with one another. Through my work as a National Board mentor, I have witnessed first hand the lack of confidence elementary teachers possess regarding science

instruction. Of course this connects to quality science instruction and accountability. Mary said this regarding elementary teacher accountability:

> Elementary teachers say things like they're so worried and I go, you know, I tell them you've got to change that word worried to *wonder*. Instead of saying you're worried about something, say you wonder what is going to happens if this happens . . . you wonder. Someone came in the other day and said, 'I'm so worried'(regarding science instruction). I said, why don't you change it to 'wonder what will happen'. That's all it is. It's more of an acceptance of, if are worrying something bad is going to happen. Einstein said if a messy desk is the sign of a cluttered mind, what's the sign of a clean desk?

Foster's (1996) research paper regarding support indicated that many of the six PAEMST winners of that state had strong mentors. Not one of the Illinois or Wisconsin teachers mentioned mentorship of any kind. Foster's paper stated that administrators and supervisors played a critical role in the support and mentorship of these outstanding science teachers. One noted that if you are in a progressive school district with administrators and supervisors who are futuristic in their thinking and supportive of their staff members, then they start to mentor you. A second PAEMST winner stated that her science effort was enhanced by her administrator's strong background in science.

The positive support of these teachers by their administrators was so significant, when compared to the lack of support Illinois and Wisconsin science teachers received, that I must emphasize it.

> One teacher stated: My administrator provided me with a leadership position as a department chair and then allowed me to order all the science equipment and also to assist teachers with the science equipment. Then, when I had the idea . . . to have the students teach the whole school about astronomy, he supported my science initiatives.

Why did not one Illinois or Wisconsin teacher note any significant support by their administrators? Has the culture of science education changed so dramatically? Foster's data was gathered in 1994, is this type of encouragment no longer offered? Earlier research I uncovered regarding six PAEMST winners from Texas in the 1990s was most fascinating; these awardees received extraordinary recognition by administration and their school communities. The Texas study was pre-NCLB so could it have been because science instruction was more relevant then? After all, schools were not forced to focus on reading and math as they are now. Then I wondered if it was the culture of the states involved, Texas as opposed to Illinois and Wisconsin? I also considered that the new model for education, a corporate model, may have created a less relationship-oriented environment. I will say that things have changed. Teachers seem more stressed and divisions between admin and teachers more fractured. Could this be the reason that teachers were not recognized? I also considered that administrators might be fearful of creating division amongst staff for recognizing one teacher's skill set over another's? I considered multiple scenarios but none seem to make complete sense to me. I can only conclude that these incidents were isolated to these particular districts. A few were honored and given some form of recognition but, in my mind, it would seem most

appropriate to recognize such high achievement and celebrate, as well as *use,* such leaders to their school communities' advantage.

Despite this, these PAEMST recipients from Illinois and Wisconsin roll on. They remain undaunted in their commitment to their students. Their mojo is pure. Tin, Hean & Lang (1996) wrote:

> Highly motivated teachers take care to provide an environment conducive for students' academic progress. The resultant positive response from the recipients in turn serves as a motivator; in that it satisfies the teachers' higher motivational needs like self-esteem. Satisfiers lead to job satisfaction. The motivated teacher proceeds to perform beyond the minimum level of work requirement. Such a cyclic perspective serves as a framework in the understanding of teachers' motivation (p. 4).

I think that as much as the kids were "rewarded" by these great instructors, the teachers were also rewarded and motivated by their students. Science and nature in the classroom create a self-perpetuating system, an environment or culture of success. Why else would these teachers press on despite so many obstacles? They are an incredible group of teachers, one and all.

## Chapter Five – Conclusion

### Discussion of Findings

My primary research question was, "How have elementary level PAEMST winning science teachers developed exemplary mojo?" Why is this question significant? If we can better understand how to develop science teachers of excellent quality, we can embrace and implement a process to produce more. Schools and districts could make decisions leading to more exceptional science teachers and our elementary students would get the best science education possible.

Why mojo? Inspired does not begin to describe my desire to better understand how these teachers developed. In fact, I have been obsessed with what motivates great science instructors. In my 20 years of teaching at the elementary level (K-5), I have crossed paths with few who were exceptional at science instruction. I reflected on this for many years and attempted to quantify what made this minority group of teachers evolve; as I met more of these individuals, many of them PAEMST awardees, I tried to quantify their uniqueness. I realized it would be challenging to describe something that appeared to be innate, abstract, and intrinsic. How could something unobservable be explored and defined? Could it be simplified and translated so that it gains public and administrative understanding and attention? After much reflection, I determined that *mojo* was an engaging phrase that provided a creative, descriptive way to describe highly motivated science instructors.

I have always liked the word mojo. It is a word that people use sparingly, and yet, it is understood to define unique qualities: "My mojo is off" and "That kid sure has

mojo!" are terms often used in sports. As I attempted to find a word that might define PAEMST awardees, I discovered an online definition that aligned with my perceptions of what mojo meant to me: "A power that may seem magical and that allows someone to be very effective, successful." After reading this definition (www.merriam-webster.com), I decided to use mojo to describe the unique qualities of PAEMST awardees. Later, I was led to a variation of the definition for mojo written by Goldsmith (2009), "The moment when someone does something purposeful, powerful and positive and the rest of the world knows and recognizes it (p. 8)". Combined, these definitions served to define PAEMST awardees as I perceive them.

Although my research report focused on PAEMST recipients, I do recognize that there are many unheralded elementary science teachers. I am certain that they don't teach for recognition. Even if they did, they were unlikely to gain any. This idea was validated by the treatment of the PAEMST winners themselves. Even after receiving recognition by the White House, their accomplishments were often ignored by the administration, colleagues, and even their communities.

What makes these teachers relevant? Nationwide, schools are scrambling to implement STEM initiatives at the elementary level. Are teachers prepared? The National Researh Council (NRC) stated that adequate STEM instruction remains the exception in US schools that are "typically facilitated by extraordinary teachers who overcome a variety of challenges that stand between vision and reality" (p. 19).

As this research investigation determined, the creation of great science teachers is not as complicated as one might think. Truly, it is about people, interactions between

teachers and kids, and exceptional professional development. Administrators must choose the right people and give them the opportunity to experience PD that is extraordinary. Combined with recognition that science is a means to motivate learners, you have a winning combination. I identified five themes that contributed to the success, conviction, and mojo development of the PAEMST winning teachers I had the privilege of interviewing.

These five themes include:

1. Recognition that science is a natural motivator for learning;
2. All students must become scientifically literate citizens;
3. A PD trigger event fueled each teacher's focus towards science;
4. Continued participation in rigorous professional development; and
5. Despite isolation and inconsistent administrative support, each teacher has remained rock-solid advocates for science instruction.

These five themes coalesced to forge mojo for these teachers. Each of these teachers followed a unique path but none initially sought to teach science. In fact, some were terrified at the very though of teaching science. It also must be noted that for many of these teachers, administrators *chose* them to teach science despite their initial misgivings. The administrators sensed that these teachers had the potential to develop mojo, or that they possessed mojo already and it just needed to be refined.

Regardless of how they were initially steered towards science, they all grew to love what they were teaching. The sequence generally progressed in this manner:

1. They were either chosen by an administrator specifically or were required to teach science as part of the general curriculum.
2. They participated in numerous professional development experiences that they were either required or encouraged to take, or they reflected and recognized their need to grow and improve. For almost all, one specific PD experience triggered a passion in science that had been dormant or non-existent.
3. Over time, all of the teachers recognized that their student are engaged by science, especially hands-on science, and they used it as a hook for all subject areas. Their classrooms were built around science and everybody, parents, teachers, administrators, and often board members knew that this was how they achieved success in their rooms with science as a hook. Most importantly, kids knew it and they were excited to be a part of these classrooms.

As these teachers journeyed forward, they presented their students with comprehensive science instruction. Science experiences were further enhanced, as these teachers literally traveled the world and integrated these experiences for their learners. Kids not only benefited from this first hand knowledge, but these teachers inspired them.

In addition to inspirational teaching and recognition that science motivates, these teachers know that, as citizens, kids will benefit by being scientifically literate. The PAEMST awardees are passionate about scientific literacy. It seemed that this passion evolved while these teachers gained knowledge and confidence as science instructors. It was not evident when they first started teaching.

What was most alarming about my discussions with these devoted educators was the inconsistent support from administration. Most received little, if any, recognition for an award that some consider the highest national honor an elementary science teacher can receive. I struggled to understand why because these teachers constantly went above and beyond. They spent summers traveling to unique and engaging places to improve their knowledge set: they consistently participated in professional development experiences, often on their own and at their own expense, and they provided extensive and engaging activities for students. Yet many of the administrators failed to provide any recognition. Perplexing.

**Implications**

From the very start of this investigation, my goal was to solve the mystery of mojo so that this mindset could be embraced. I believe that it can. Would school districts be able to create an army of PAEMST winners? Certainly, that is not the intent. Could school districts create science (STEM) teachers who are confident, aware of the value of science education for careers, science literacy and it's value as a "hook" for learners? I believe that this can be accomplished.

Please also note that, when I first began this investigation, the word STEM was just beginning to percolate. Now, it is boiling. I consider that the science educators I focus on be thought of as STEM teachers and the process, developing great ones, follow a similar trajectory to these PAEMST winners.

**Stem Assimilation**

As schools (administration) begin to integrate STEM into existing curriculum, including increased and improved science instruction, they should choose carefully as they consider who might specialize in these areas. As indicated by this research, the individual need not be someone who prefers to teach science. In fact, none of these teachers *did* prefer to teach science and only one had classes other than Methods of Science Teaching while in college. The question is, how would administrators choose? I do know that all of the awardees were relationship oriented; all had an innate curiosity for learning and a positive energy that was contagious. I think teachers need this type of energy to teach science and STEM effectively. Since my interviews, I don't think I have ever taught science more passionately and energetically. I have sought new knowledge beyond what I knew before these interviews. I found the attitudes of the teachers contagious.

**Who Might Lead?**

Administration must consider the above factors as they seek educators who are self-motivated and constantly seeking to improve their instructional skill-set. Something that stood out in all of these teachers' comments was that they all considered the PAEMST award (and National Board, etc.) just a part of their journey. They all shared that they were looking for what was up "next". For these teachers, even for the teachers who were retired, the path remained incomplete. Admin must find educators who are intrinsically motivated to perfect their skills.

**Professional Development**

Some schools may be taking a different approach to STEM and they are attempting to mobilize all teachers to acquire a STEM skill-set; they must analyze these themes and suggestions and determine which elements may lead to an across-the-board improvement in science teaching. Under those circumstances, high quality professional development may be the answer to creating a STEM or science based culture of learning and teachers that are well trained. These teachers also have to challenge themselves to reflect on their perceptions of science education and personal skill-set and devote themselves to remaining cognizant of students' interests.

As I reflect on students' interest in science, I firmly believe (as do the PAEMST teachers I interviewed) that teachers need to embrace this and flow with students' interests. I have viewed many elementary teachers (and administrators) who are squeamish when it came to certain elements of science but, for mojo like teachers, they need to alter that mindset. Some of the PAEMST winners admitted freely how they were intimidated by elements of science. I think this is where professional development of the highest quality can play the biggest part in developing mojo. The professional development these individuals need must be hands-on, engaging, and it must force teachers beyond their comfort zones.

Even though I have not received the PAEMST award and currently remain a four time state level finalist, I did share that my personal "trigger" event was a two-week program at NASA's Kennedy Space Center. I will never forget how nervous I was! As I

I arrived early and stepped into the lobby of the building where we first met as a team. I sat in the lobby and waited. One of the other participating teachers (there were 25 from around the country) sat down, we introduced ourselves, and we started to chat. I stated that I did not know what to expect. He said that he had heard that this workshop was a life-changing experience. I was skeptical. Life changing? Little did I know. When I left NASA, my interest in science and desire to teach science was reborn. As it turned out, it *was* a life-changing experience, I reflect on it to this very day.

In my experience, when schools and districts do have science professional development it is often provided by representatives from textbook publishers. These reps visit and use a "lecture" format on the variety of resources to which they now will have access: online sites, simple labs/materials, and resources in their textbooks. I'm sure some may provide limited hands-on experiences but none, that I have been a part of, push teachers to become true scientists, explorers, engineers, collaborators, inventors or engage them out in the field to do real science. Experiences are needed that *change* an individual's perception of science and that may *trigger* a passion for science that alters their perspective of this subject area and raise their mojo factor. Why can't these companies improve the quality of the PD they provide? I think this is something science leaders, school communities, and government institutions can change by requiring higher standards from these companies and these and other presenters.

Of course, these experiences and professional development triggers might be offered to a team or group of teachers, depending on the structure of the school for STEM. Administrators, who I also believe should be participating, can use these as a

barometer to identify individuals who might be developing mojo more strongly than others. These mojo filled educators can become teacher leaders who can guide, coach, and encourage others as they embrace STEM learning. Mojo coaches.

**Promote Interest in Science**

When considering how administrators, districts, and school communities might integrate students' passion for science, I truly believe that, although this must be a factor for true mojo, a culture of science respect should, at the very least, be become part of ALL school cultures. Often I have found that this is not the case. Science is feared. Teachers are intimidated, and instead of facing this obstacle, they shy away form it. This becomes the culture, as teachers descend towards science aversion rather than challenging each other to achieve skill in this area.

Each of the awardees has used science as a hook for student engagement in all subject areas. They have proven, I have personally proven, that it can be an effective lure for students to become more engaged in subject areas such as reading and writing. Since this is the case, science should be embraced by all educators, whether a teacher of science (STEM) or not. The final portion of my research may be the most significant in terms of the potential for impacting the most students.

**Recommendations for School Districts**

After analyzing these themes, I integrated them with my own personal experiences as a science specialist, PAEMST finalist, National Boad Certified teacher, STEM leader and 20-year classroom teacher, to create suggestions for school districts so they can create skilled elementary science instructors.

1. Embrace science as a natural motivator for all subject areas. Despite a lack of comfort or interest in science, educators must recognize that kids possess science mojo, that it is innate, and that they should use this to their advantage, to hook kids on learning. Whether teachers like it or not, they must let science "in".
2. Inform all teachers about the value of STEM education. All students should be scientifically literate. Teachers should be too. Many teachers are unclear about the value of STEM and the impact it can have on our students in terms of their career choices, personal health, and citizenship. Just as we share learning objectives with our students, teachers would benefit by recognizing the reasons and value of STEM education and why it is or should be at the forefront of education at this time.
3. Promote, seek, and provide exceptional professional development experiences for both teachers and administrators. This is a must for many of our teachers but why not for administrators, too? Regardless, it is not necessary to convert all science teachers into PASTS recipients that are flush with mojo. At the very least, teachers should be confident and comfortable teaching science effectively.
4. Make professional development ongoing, rigorous, hands-on, and scientifically stimulating. Next Generation Science Standards (NGSS) focus on performance based assessment and the use of inquiry based, hands-on experiences. Why should teacher professional development be any different?

5. Choose individuals who have exhibited a strong desire to extend themselves professionally. Since none of the PAEMST recipients interviewed had originally chosen to teach science, handpicking individuals who present mojo-like characteristics may be the best means of developing skilled science instructors and/or leaders. Although this does not correlate with a specific theme, it was a path that many of the interviewees followed.
6. Support, collaborate with, and acknowledge the skill levels and abilities of science teachers who possess mojo. Consider them assets in a time when school district communities are scrambling to incorporate STEM learning and, for many states, NGSS.

**Final Thoughts**

My journey to conduct this research truly was a 20 year project. My initial recognition that I taught science poorly, the realization that my colleagues taught just as poorly, and my work mentoring National Board candidates with failures in the areas of science, all planted the seeds of curiosity as to why science was floundering in elementary science classrooms.

Further reflection led me back in time, to my youth, and the love I had for science but the lack of stimulation I experienced in school. A reconnection with the science I loved as a child was rekindled at NASA's Kennedy Space Center after participating in their NEW workshop and I moved forward, teaching science at an appropriate level with further growth to come.

As my skill level developed and I received recognition as a state level finalist for the PAEMST award, I was privileged to connect with other state level finalists and national award recipients. I recognized that there was something special about these teachers and yet, I could not pinpoint what this quality was.

After starting my doctoral program, and as I considered topics to explore, this topic, extraordinary science instruction coupled with extraordinary science failure, was foremost in my mind. Why and how do these individuals teach science so well? Why are so many teaching science so poorly, with such little confidence? How can I focus on what is being done "right" rather than on shortcomings in our system?

This combination of factors led to recognizing mojo and the desire to locate the mojo factor in each of these great teachers. Once I was able to locate and qualify mojo through five themes, I could share this process so kids can benefit. This was, ultimately, the goal of this endeavor: to help kids flourish in a system that they can understand, that inspires them, and that correlates with their innate curiosities regarding science and the wonders of our natural world.

Why have we turned our back on science? Why have we taken a subject area that can be easily integrated into reading, writing, or math and avoided it as if taboo? Teachers, as my PAEMST recipients all recognized, must use science as a hook. Is it a hook for all kids? Certainly not, but to deny students' interest in animals, space, rocks, insects, soil, birds, trees, the very wonders of the universe, certainly seems foolish. This is especially true if we are doing so because of our lack of preparation or discomfort in

that area. Educators and educational leaders removed a tool, a very effective tool, from teachers' toolboxes: science. We must bring it back, and with a vengeance!

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# APPENDIX A

## Interview Questions

1. Tell me a little about yourself. How did you end up being a science teacher? Was this something you always knew that you wanted to be?
2. What does being a science teacher mean to you personally? Professionally? What makes you successful at your work? How do you judge your success?
3. What do others think or say about you as a teacher? What is your reputation among fellow teachers, colleagues, and peers?
4. What is it like to be a PAEMST winner? Has there been any downside? If so, how so? And how have you dealt with it?
5. Do you feel professionally supported in your school and district? Have you ever had to push back and strongly advocate for something you thought was right?
6. What can administration do to support and nurture the growth and development of both science and science teachers?
7. Is there anything else I should know?

APPENDIX B
Informed Consent - Interviews

You are being asked to participate in a research study conducted by James O'Malley, a doctoral student at National -Louis University located in Chicago, Illinois.

I understand that this study is entitled An Exploration into the Mojo of Presidential Science Award Winning Elementary Teachers and the Potential Implications on Future Elementary Science Teacher Development. The purpose of this study is to determine what motivates and inspires recipients of the Presidential Award for Excellence in Math and Science Teaching (science recipients). These teachers' intrinsic motivation or mojo is defined within the context of this paper as the positive spirit toward what we are doing now that starts from the inside and radiates to the outside. Furthermore, mojo includes the moment when we do something that's purposeful, powerful and positive **and** the rest of the world recognizes it. By conducting interviews with multiple PAEMST award winners this study will determine how mojo might be formed. Once this is accomplished, the researcher will consider how this development (mojo) can be replicate by other teachers, through administrative leadership or by any other means that an educational institution strives to prepare and develop quality teachers.

With your consent, you will be interviewed for about one hour with a possible second, follow-up focus group discussion. You will receive a copy of your transcribed interview at which time you may clarify information.

Your participation is voluntary and you may discontinue your participation at any time without penalty. Your identity will be kept confidential by the researcher and will not be attached to the data. Only the researcher will have access to all transcripts, digital recordings, and field notes from the interview(s). Your participation in this study does not involve any physical or emotional risk to you beyond that of everyday life. While you are likely to not have any direct benefit from being in this research study, your taking part in this study may contribute to our better understanding of quality teacher development.

While the results of this study may be published or otherwise reported to scientific bodies, your identity will in no way be revealed.

In the event you have questions or require additional information you may contact the researcher:

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If you have any concerns or questions before or during participation that you feel have not been addressed by the researcher, you may contact the chair of NLU's Institutional Research Review Board:

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