

S L O W D O W N: HOW SLOWING DOWN SCIENCE INSTRUCTION
FOSTERS CREATIVITY IN THE ELEMENTARY
CLASSROOM

by

Abigail J. Helberg Moffitt

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ABSTRACT

In much the same way that the slow food movement gained momentum years ago to promote connection to our food systems, so has the slow school movement gained in popularity admonishing schools and educators to slow down and help students explore and inquire more fully. In this study, a local Montessori school that fits the slow school model, is studied to see how their slower, more intentional pace helps elementary children be creative in science education.

INTRODUCTION AND BACKGROUND

In Aesop's classic tale of *The Tortoise and the Hare*, a slow and steady moving tortoise defies the odds and beats the fast-moving hare at a race. Plentiful interpretations abound as to how this paradox happens, but I have always preferred the "slow and steady" wins the race explanation. I suppose I relate more to the tortoise in his methodical, slow, and steady nature and in turn feel so pleased to learn that he wins the race against a fast and cunning hare. I have reflected on this story frequently the last few years, especially during my time in the MSSE program where I have been challenged to understand my philosophy of science education and why I feel strongly about it. In science education, as with the tortoise and the hare, it is not how much, and how quickly we can learn material, but what we learn along the way. Invaluable skills in science arise when we slow down the process. Skills like observation, inquiry, critical thinking, even creativity can proliferate in science education. And the best place to start this process of slower science education is in the elementary classroom.

As the daughter of a French chef, I became interested in the slow food movement years ago, as I witnessed the lack of connection we had to our food systems, our kitchens, and our tables. So, imagine my intrigue, when I came across a movement of slowing down education. As an educator, and a mother, the Slow Schools movement spoke my language. A movement encouraging schools to slow down to a pace where children could explore and inquire about things that they didn't understand or subjects they wanted to investigate more. Schools should have more time and space for critical thinking, inquiry, and reflection, especially in science education, where teaching children

how to think beyond facts and memorization can set them up for the future. Maurice Holt, a former professor of education at the University of Colorado, and a proponent of the Slow Schools' movement, explains it beautifully,

Stuffing information into children as fast as possible is as nourishing as wolfing down a Big Mac. Much better to study at a gentle pace, taking time to explore subjects deeply, to make connections, to learn how to think rather than how to pass exams. If eating slow excites the palate, learning slow can broaden and invigorate the mind. (Honore, 2004, p. 254)

It is vital to guide children using their curious nature, particularly in science education. They need to be allowed to ask the “how” and “why” and be encouraged to investigate. Learning science should be an exciting endeavor of discovery. These traits are nurtured in a slower-paced classroom where children don't feel rushed from one activity or lesson to the next. When children are given the time to explore, create, and investigate at their own pace, it sets up a foundation of inquisitive thinking that is essential for innovative thought and has lifelong implications on learning.

Surely there are schools doing something to combat the pace of our rushed American schools. Particularly in the arena of science education where the pace needs to be slowed down to allow the space and time for higher level thinking skills to develop. What are these schools doing? What methods have they adopted? How do they foster a slower, more intentional pace with their students? What do these schools and classrooms look and feel like? What language and teaching methods are used to support higher level thinking and project completion at the children's pace? Are children more innately inquisitive and creative when the pace is slowed down? I wanted to delve into these questions, and then narrow down my research to elementary science education and find

schools that were approaching science education slowly, and emphasizing connection and higher level thinking skills.

Through some initial research and observations, I have learned of schools that are either slow-paced in their methodology, or are actively implementing curriculum to slow down the pace of their teaching and learning. Additionally, I have seen a growing movement of advocacy to slow the pace of school down, and let children learn more naturally.

The STEM, Science, Technology, Engineering and Mathematics, movement in our country has placed a fresh emphasis on the importance of the sciences in education, and rightfully so, but my research lies at what schools are doing to prompt more creativity for students in the sciences. It is my thought, that students, especially in the elementary classroom, need science to be slow-paced to give them time to think deeply, creatively, and critically.

In my search for applicable resources, I frequently came across articles written about Finland and the educational reform it took in the late seventies. While not conclusive, it is interesting to note their method of education is contrary to the fast-paced, testing heavy schools we are accustomed to. They spend less time in school, start later, don't test until middle school, have more breaks, and are widely accepted as some of the most successful schools in the world. Finland consistently scores high on their international assessments, retains their highly-qualified teachers, and has a much lower dropout rate than our country.

The Program for International Student Assessment, PISA, is an international evaluation system that is performed every three years on fifteen year olds across the world. They are tested in science, mathematics, reading, collaborative problem solving and financial literacy. In 2015, science literacy was the main subject area to be tested and 28 million children were assessed in 72 countries. Finland scored in the top four of all participating countries (OECD, 2016).

Perhaps most fascinating for me, has been the Montessori Method. I knew very little of this form of education until we decided to enroll our son at the local Montessori school and have seen him thrive in the slow, and methodical manner they use to guide students into self-directed learning. The Montessori Method and schools were designed by Maria Montessori, the first female physician in Italy, who started her schools initially for students with disabilities and limitations in 1906. Her method is recognized for allowing children free choice of materials, uninterrupted time to work, and freedom of movement, within limits. Her principal goal was to allow students independence, which she felt developed autonomy, self-direction, and deeper learning.

The Montessori Method is unique in that it calls children to learn mainly through what they call “personal works.” This is time taken in the morning to work uninterrupted for a minimum of a two-hour block. Students chose an activity to work on independently or collaboratively. Teachers guide students rather than lecture students. Children learn to be self-directed and motivated to learn about any subject with hundreds of lessons and materials. Montessori students also engage in what they call, “grand lessons,” or known more commonly, as group lessons. These are times where the curriculum is much more

traditional in the sense that all the students are learning a lesson or concept from the teacher together. The difference in the Montessori Method as compared to more traditional schools, is that even within this model of group lessons, students are given freedom. This freedom allows children to explore the content of the group lesson with follow up activities and “works.” For example, a group lesson was given on the topic of pollinators, which was prompted by a field trip to a local farm. Some students wanted to research why pollinator numbers have decreased, especially the honey bee and Monarch butterfly. This prompted a small group project researching this decline and students making a poster of pollinators in our area, and plants that they preferred.

Students in Montessori schools have an abundance of resources to use for learning. These special Montessori materials provide hundreds of lessons, in all subjects, that are neatly arranged at the children’s level. See Appendix A.

Montessori classrooms have a few similar characteristics including, multi-age classrooms, special educational materials, student led/chosen work in long time blocks, no grades or formal tests, and group and individual work with academics and other special social group work.

Going a step further, I wanted to investigate a slower-paced school environment and explain how it helped make a more conducive learning environment for creativity in science. My speculation was that a slower-paced science education would foster more higher level thinking skills, especially creativity, a skill not always encouraged in science education. Since I was already involved as a parent and volunteer at our local Montessori

School, I decided this would be the place to conduct my research. Swannanoa Valley Montessori School, SVMS, is our local Montessori school in the Swannanoa Valley.

SVMS is in Black Mountain, North Carolina. Black Mountain is a small town outside of Asheville, in the Swannanoa valley of Western North Carolina. There are twenty students in the lower elementary class, 1st- 3rd, with two main teachers, and quite a few other teachers for extra-curricular subjects. Black Mountain has a predominantly Caucasian, middle class population. Since the Swannanoa Valley Montessori School is private, it is financially out of reach for many families. However, scholarships and financial aid are given to many families, including some on complete or partial scholarships.

This year, the lower elementary class, is a younger, more immature group. The class is full of energy that is sometimes hard to manage. The students generally have good attitudes, and are excited to learn and please.

Five students show signs and symptoms of developmental limitations that have affected their abilities in school. While specific diagnoses are kept confidential, it is generally assumed that these students need extra time, and help with school work, and are not in the average range cognitively. The teachers make sure plenty of accommodations are available for these students. This is important to note, as creative thinking is an abstract concept, and for students with delays, it is difficult and sometimes impossible to think in the traditional creative way, of having a unique idea.

I have been actively involved in SVMS for three years. This year, I taught science on Monday and Friday afternoons. These science lessons were ‘grand lessons’ where we learn as a group. In the fall, we learned about freshwater and took field trips to investigate lentic and lotic bodies of water and search for invertebrates, indicative of clean water, including raising a tank of rainbow trout eggs that hatched and were released into a local stream. The students loved learning all about how valuable and unique freshwater is.

After taking a biomimicry course last summer, I was inspired to try and teach it to younger students. My thoughts were that this new branch of science would be interesting for younger children who frequently have strong interests in creatures of all shapes and sizes. Biomimicry is learning from nature and mimicking it to create innovative designs and inventions that are gentler on the earth. Another reason why biomimicry struck me as a focal point for my case study was that biomimicry requires the learner to think beyond the facts and define a problem and think of a solution based on nature. This process seemed to provide a linear sequence to observe creative scientific thinking in the lower elementary.

So, in the spring, we dove into a biomimicry unit. The students were really excited about this. Students learned about how all types of creatures have special adaptations to help them survive and thrive in their habitat. They learned how we can learn from these critters and mimic their adaptations to be innovative and create products that are less impactful on the earth. This unit ended with a biomimicry fair, much like a traditional science fair. Every student chose a unique creature to investigate, and then

tried their best to create an invention from their creature's superpower. This jump from book knowledge to creative problem solving was a big leap. Some students showed they were more than capable of doing this, others needed some prompts, and still others were not able to make this jump cognitively. This science project showed how students could think creatively, given enough time and resources.

My research investigates how a slower-paced science curriculum is beneficial, and how there is evidence of creativity in the elementary science class. From the literature, it appears that slower-paced classrooms have similar characteristics that give rise to these supporting questions about creativity in a slower-paced science class.

- What is the relationship between slowing down science instruction and creativity in the elementary classroom?
- How are students taught to think creatively and how is this expressed?
- What are the overall attitudes and sentiments in a slower-paced classroom?
- What implications can I use with creativity, and a slower-paced school model to impact my future teaching?

CONCEPTUAL FRAMEWORK

My capstone consideration is that a slower-paced science curriculum for elementary students fosters creativity. Being creative in science requires the learner to be able to understand the information and then synthesize this information into an original idea, invention or innovation.

It is my belief that this creativity is essential to innovation and invention. These skills, to think outside of the box in science education, are intangible skills that cannot be

found in our search heavy culture brought forth by Google. Because elementary science education should give ample time for curiosity and creativity, my literature review will be emphasizing a slower education in the broad sense as well as some literature specifically about creativity and science education.

It is an unfortunate circumstance, that so much importance is placed on being an advanced student and at the top of the class. Extra-curricular activities are no exception, as kids are increasingly rushed from activity to activity. Research has been done by the American Academy of Pediatrics that warns that putting pressure on children to perform academically and extra-curricular activities can cause physical and psychological harm. (Honore, 2009) points to evidence that children, especially younger ones, learn better at a slower-pace.

A movement is growing where schools are adopting a slow school approach, initiated by Professor Maurice Holt from the University of Colorado. Some professionals see overwhelming evidence of increased creativity and a passion for learning when children can set a slower pace that is based around their interests (Honore, 2009). Stories abound of schools in our country, Canada, and even Japan, that are adopting a more relaxed atmosphere and pace for children in school. Most of these schools are focused in Finland or have been modeled after the Finnish philosophy of education, where a relaxed pace in all their public institutions is the norm, and has been for decades. Formal instruction does not begin until seven in Finland. Finland has a shorter school day, gives more breaks, and shuns most formal assessments (Hancock, 2011).

A comparative study on 120 preschool students was done where half the children were enrolled in a play centered preschool, and the other half went to a preschool more focused on academic achievement. It turns out that the students in the play-centered preschool were less anxious, more excited to learn new things, and able to think independently, due to the slower-paced, choice-centered format (Hirsh-Pasek, 2003).

Science educators have most likely heard of the popular book, *Last Child in the Woods* (Louv, 2005). It is a popular book that speaks of the power of nature for children to heal and learn. The Advocacy for Natural School Reform is particularly interesting. It is an advocacy movement that speaks against the pressure and rush that are put on children. Finland is pointed to again as a model for a slower, more natural school model. The power of play, particularly free, outdoor play, which is so readily available in Finnish schools, is pointed to as a part of their success. The schools in the Helsinki area are let outside for 15 minute breaks for every 45-minute lesson. There is also a strong emphasis on outdoor education, and they move classrooms outside frequently. The slower pace and outdoor play allow for more inquiry. As the head of Finland's Ministry of Social Affairs and Health says, "The core of learning is not in the information...being predigested from the outside, but in the interaction between a child and the environment" (Louv, pp. 204-205).

Today's academic standards, in our country, measure performance by testing, putting schools and students into ranks of order, and then setting goals for improvement. While this may sound like a logical approach, it has been met with some fierce opposition. The notion is, setting higher standards and goals will automatically make

scores go up. But the irony in slow-schooling is counterintuitive, suggesting that a slower approach which “calls for more imagination, more thought and discussion, may be the one that works in the end” (Honore, 2004, p. 257).

The slow school has its real strength in allowing freedom for variety and different approaches, something metaphorically, like a “big tent, with lots of room” (Holt, 2002). There is no certain method or formula for a slow school. But, there are some qualities that are evident in these types of schools. First, the school must understand its own community and work with it. Also, subjects should be linked together in common themes. This creates connection to, and synthesis with what is being taught. Lastly, the slow school is based on accountability, something coined as *narrative accountability* (Holt, 2002). This narrative accountability is much better than testing, as a rite of passage from one grade to the other. In *narrative accountability*, the teachers and parents are stakeholders in the child’s education. Students must personally demonstrate their knowledge with projects, presentations, and drawings. In this way, curriculum is not obtainable with speed, the result being to memorize as many facts as possible. The curriculum is focusing on the method of problem solving, and interacting with peers and educators. Slow schooling is about how students can initiate, and motivate their own learning. This style of teaching is important because it is not just about delivering facts to children, but also about values. Something Holt called the “method of deliberation” (Holt, 2002).

We don’t need to search across the ocean for schools slowing down the pace of education, though. A seasoned teacher and administrator implemented an approach he

developed called, the Responsive Classroom model, and this method has been adopted by schools and classrooms across the nation. Children were being hurried through school with little time to reflect on what they were learning or where their lives were headed. “Schools are once again becoming fact factories, cramming more into every minute of every hour of every day. The schedule is chopped into small pieces of time with little connection or continuity” (Wood, 2002 p. 2). The Responsive Classroom model was created to face these problems.

In the Responsive Classroom model, a few changes can make a big difference. The plan has six components to it. The school day is restructured. Kids meet in groups to greet and share with each other and to plan for the day. They are taught collaborative group methods of how to appropriately greet each other, how to listen with empathy, and ask good questions. Schools are put in slow mode for the first six weeks of the year. While it sounds ironic to gain time by taking time, it really does work. The start of school is a time for slow and thoughtful planning. Trust and relationships are built so students are comfortable to take risks in their learning processes. The Responsive Classroom model allows for reflection and review during the year, especially after vacations. This method adjusts the school schedule so productivity is not as emphasized in the afternoon. Playground is not a privilege, but a priority, and is treated as such. And lastly, the Responsive Classroom model allows for more time for teacher interaction.

Wood (2002) reminds us that, “We must remember that children do not experience or understand time in the same way adults do. Children live in real time, a

world that knows mostly the present moment. True learning requires time: time to wonder, time to pause, time to look closely, time to share, time to pay attention to what is most important” (Wood, 2002 p. 545).

Another irony of the slow school movement, is the assumption that more time in school, more homework, more technology, and more high stakes testing will produce smarter, better-prepared students. Some scholars disagree, citing test scores from PISA, Program for International Student Assessment, and TIMSS, Trends in Mathematics and Science Study, that there is no correlation between time spent at school and levels of achievement (Baines, 2007).

A caveat to this argument is the wasted time on performing non-teaching tasks, paper work, and managing the classroom. Advocates for a slower school model advocate for longer classes, 90 minute periods twice a week. This transformation would eliminate some of the non-teaching tasks, and more importantly provide the time for students to work, complete, and think about subjects more in depth.

The homework debate is inevitably a controversial topic in most schools, and growing opposition is showing studies that homework is unrelated to academic achievement. Baines (2007) agrees, saying, “The relationship between national patterns of homework and national achievement suggests that more homework may actually undermine national achievement” (p. 25).

In addition to homework, technology has been met with some controversy in schools. While technology sounds like a wonderful thing, the time, training, and money it takes to bring technology to students may not be the best idea. Many schools have

spent millions of dollars for computers, and internet connection, thinking it would enhance achievement, but the 2003 administration of PISA has found that, “Across the categories of race, gender, and nationality-the factor most strongly associated with high scores on reading, problem solving, and mathematics was the number of books to which a student had access” (p. 25).

Regarding schools as agents of social change, Lawrence Baines argues that our obsession with standards, testing and curricular excellence has left us looking to educators as the source of success or failure. He notes that underachievement needs to be seen in a broader sense. Looking at other countries that have more family-friendly policies would be more productive in his view than looking to the school to erase the discrepancy with the poor and affluent with school performance. In closing, he states,

Over the past 50 years, the initiatives of an extended school day, more homework, increased technology, and vigorous standardized testing have done little to enhance achievement, promote positive attitudes, or foster good citizenship. Perhaps it is time to learn from the world, to stop thinking in terms of more and consider what might be achieved by doing less (Baines, 2007, p. 26).

Because I did my research at the local Montessori school, a closer look at studies done in Montessori schools was appropriate. In a study that compares students’ academic and social scores with Montessori students, *Evaluating Montessori Education*, students from a regular public school in the area showed that in both the academic and social arenas, Montessori students excelled (Lillard, 2005).

Research for this study was collected from two age groups, preschool aged, 3-6, and elementary children, aged 6-12. The area was mainly urban and minority students from a well-established Montessori school. This Montessori school used a random

lottery system for choosing students. Researchers assigned the students chosen in the lottery as the experimental group, while the students not chosen from the lottery would become the control group, attending local public schools in the area. Choosing groups this way, eliminated the possibility of parents being “different” for choosing Montessori over others. All families filled out a socio-economic form and salaries ranged from 20-50K in both the experimental and control groups.

Children in both groups were given the Woodcock Johnson test for Cognitive and Academic measures. For social/emotional measure, stories about social problems were told to children. In both academic and social arenas Montessori students scored higher in every category. Most interesting is the responses to social problems. Montessori students were much more likely to be involved in peer play with fewer tendencies toward rough play. They also exhibited more advocacies for fairness and justice.

“Montessori education has a fundamentally different structure from traditional education. At least when strictly implemented, Montessori education fosters social and academic skills that are equal or superior to those fostered by a pool of other types of schools” (Lillard, 2005, p. 1894).

A study evaluating Finnish education in preschool was conducted and while it does not show data in the subject of science or lower elementary education, I think it is worth mentioning because of the interviews collected from parents, teachers, and children. This study, (Havu-Nuuti, 2009) showed the principle differences in the philosophy of education. The Finnish teachers interviewed valued that students receive a positive experience about school and that they enjoy learning at the beginning. Parents

generally wanted a school to help with social skills like group activities, interaction skills, and cooperative skills. It was interesting to note that Finnish parents wanted their children's safety and happiness above the practical matters of academics and school organization.

Going into more specifics, I looked for articles about creativity and science and how it is taught in the classroom. In the past, higher order scientific thinking has been thought of as not being able to develop until adolescence. However, an interesting study, (Koerber et al, 2015) shows evidence of the contrary. The development of scientific thinking was tested with 1,581 students in the second, third, and fourth grade. Tests were used to see how students thought scientifically. How students designed experiments', interpreted data and understood the nature of science. The study showed how students' progress from naïve concepts to more advanced scientific conceptions. Results were brought into light with regards to intelligence, schooling, and parental education on scientific thinking. At an intermediate level, elementary kids could understand the gathering of science facts to correlate to a specific question or hypothesis.

METHODOLOGY

My research is a case study that investigates how a slower-paced science curriculum is beneficial, and how there is evidence of creativity. From the literature, it appears that slower-paced classrooms have similar characteristics that give rise to these supporting questions about science education.

- What is the relationship between slowing down science instruction and creativity in the elementary classroom?

- How are students taught to think creatively and how is this expressed?
- What are the overall attitudes and sentiments in a slower-paced science classroom?
- What implications can I use with creativity, and a slower paced school model to impact my future teaching?

The science topic during my action research project was biomimicry. This unit was three months long, and took place from February-May of 2017. During this time, I collected my data. Students learned how to invent and innovate by studying nature's design and principles. The unit wrapped up with a biomimicry science fair in which students displayed their biomimicry-inspired invention or innovation.

During the afternoon science lessons, the subject was the same, biomimicry, but they chose the creature. This creature could be any of the six kingdoms including animal, plant, fungi, protist, eubacteria, or archaeobacteria. I would come prepared for science class with a unique creature I had researched with pictures to show the students. I told them facts about these creatures, including their special adaptations. I would ask students to share ideas about how this creature had special adaptations, and if they could think about possible inventions or innovations that mimicked these. This time served as a good transition into science and gave students the opportunity to engage their brains into thinking about problem/solutions using nature's design.

Children chose whatever creature they wanted to investigate more fully. They had to research facts about their chosen creature and then choose one special 'super power', more commonly known as their adaptations, and then invent something that

would be useful and not as harmful to the earth. I began teaching them about adaptations, but the vocabulary confused some students. When I explained these adaptations as “super powers”, students were much more able to understand what to look for in their research.

I used a series of methods (Table 1) to gather data and to answer my sub questions.

Table 1
Research Sub Questions: Triangulation Matrix

Research Questions	Observations	Parent Survey	Teacher	Student Interview	Reflective
What is the relationship between slowing down science instruction and creativity in the elementary classroom?	*		*	*	*
How are students taught to think creatively and how is this expressed?	*	*	*	*	*
What are the overall attitudes and sentiments in a slower-paced science classroom?	*		*	*	*
What implications can I use with creativity, and a slower paced school model to impact my future teaching?	*				*

The first question was, what is the relationship between slowing down science instruction and creativity in the elementary classroom? To obtain this data I interviewed

the two teachers (Table 2) about how creativity is taught and fostered in the Montessori classroom. The interviews also gave insight into how the students expressed their creativity and what the classroom attitudes and sentiments were given the slow-paced methodology of the Montessori method.

In addition, I answered this question with my reflective journaling that turned into a chart of the children's' creativity in their biomimicry problem/solution.

Table 2

Teacher Interview

How is creativity encouraged at SVMS in science?
What does creativity look like for your students at SVMS?
What does the classroom environment need to be like for creativity to be fostered?
Do you have any specific examples of creativity or critical thinking in science education?

I also felt it would be a good idea to interview students about creativity. (Table 3) This gave me a baseline of what the students knew about creativity and how their school encouraged their creativity. All twenty students were interviewed individually. I would repeat questions as needed, but did not help them with their answers. This interview helped to answer my questions about the school environment and how it helped students be creative. It also helped me understand the children's attitudes and sentiments about their school.

Table 3
Student Interview

What do you think creativity means?
Do you have an example of something or someone that is creative?
How does your school allow you to be creative?
Tell me about a time that you were creative in school?

In general, I wanted to see if the slower pace methodology of the Montessori Method allowed more room for teachers to help students be creative. I observed the process by which students got to the point of thinking beyond science facts. I recognized language that teachers used to help their students think deeper. I used teacher interviews and observations to document these questions.

While not directly tied to creativity in the science classroom, I felt the third question, about the overall attitudes and sentiments in a slower-paced classroom was important to the broad topic, of the benefits of a slower-paced classroom. This question looked at the components of the Montessori classroom to explain the environment and what the attitudes and sentiments of the students and parents were and how this affected science education. I observed the setup and school schedule of the day and handed out parent surveys. The interview I did with the children also gave indication of the attitudes and sentiments.

The fourth and final question was, what implications can I use with creativity, and a slower-paced school model to impact my future teaching? This question was answered by an accumulation of all the data methods employed for this project.

Realistically, assuring my instruments were valid and reliable was challenging. I was a guest teacher for a few days a week. This was not my classroom, so I could not control the environment like I would have. A few things I did do, to make my instruments valid and reliable was to make sure I interviewed with consistency with every student, teacher, and parent. Some children looked to me for prompts or clues on their interview questions but I made sure to not do this. I reassured all of them that there was no right or wrong answer, it was their interpretation. Another reliability and validity check I did was to meet with the two teachers independently three times during this project. I let them know that for this project, I would like them to not suggest, prompt, or give ideas to students who were coming up with a creative invention. It was a challenge, because as teachers we want to help kids struggle through their frustrations with some prompts, suggestions, or ideas. It was important for this data set to be completed without these prompts so I could see how, if, and how long it took for students to come up with a creative invention on their own.

In conclusion, the research methodology used during this AR project received an exemption by Montana State University's Institutional Review Board (IRB) and compliance for working with human subjects was maintained. (Appendix B).

DATA AND ANALYSIS

I interviewed all the students about what creativity meant to them and if they had examples, and how their school allowed them to be creative. A discrepancy I found was that even if some children did not know how to explain creativity in their interview, some of these students could display it in their work. Another challenge of interviewing

younger children is that it had to be an oral interview as they are still working on developing their writing skills. Although the children knew me as a regular figure in the classroom, I was met with some hesitancy on some of the children's part, which appeared to be shyness and nervousness. Because of this, some hesitated in their answers and I wonder how accurate the interviews were for these students. I started by assuring them there was not a right or wrong answer and, they would have time to answer their questions without me rushing them through it. Some children that were hesitant were needing some prompts from me. I explained I could not help them in this way.

Interviewing all twenty students was an integral way for me to understand what the children knew about creativity. It is an abstract concept, and I wondered what their answers would be. I thought that most children would answer the question, about what creativity was, with a simple answer of art. I was surprised to learn that a lot of them saw creativity as inventing, creating, and thinking. One of the students said, "Creativity is having an imagination and being able to create something from nothing but what's in your brain." Another intuitive student said, Creativity is solving problems that no one else can solve!"

The first questions I asked them was plain and simple, *what is creativity?* Some children said more than one attribute of creativity and that is why there are more than 20 answers. Looking over my interviews these patterns arose. (Figure 1):

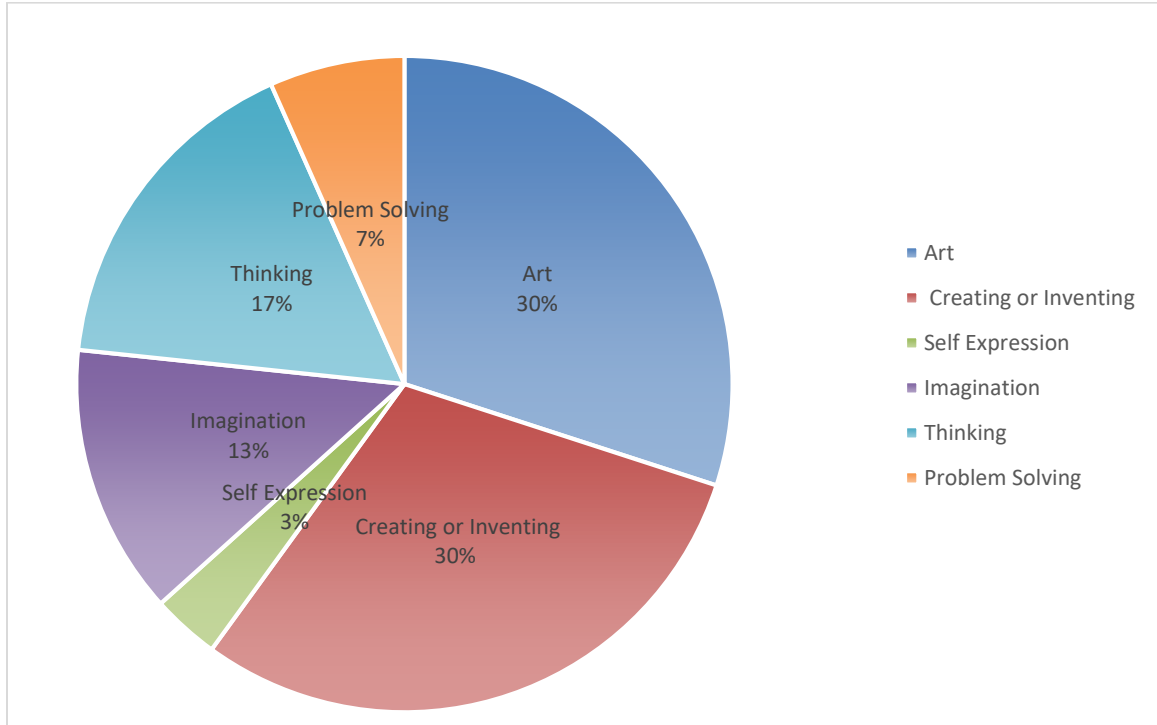


Figure 1. What creativity is according to SVMS elementary students, (N=20).

My last question of the interview was worth noting as well, because it showed what the students valued about their school and class environment regarding creativity. The question was, how does your school allow you to be creative? Again, keep in mind that a distinction of Montessori education is the choice of curriculum within reason.

Because of this, students are free to search the class for what they want to learn about and have ample independence to learn if they can suitably do this. One student said, “My school lets us be creative because we don’t have to all do the same thing.” Another said, “We have lots of materials that we can use. I like having lots of different kind of materials and books.” In general, all but three, understood what creativity was, and expressed how their school accommodated them to be creative (Figure 2).

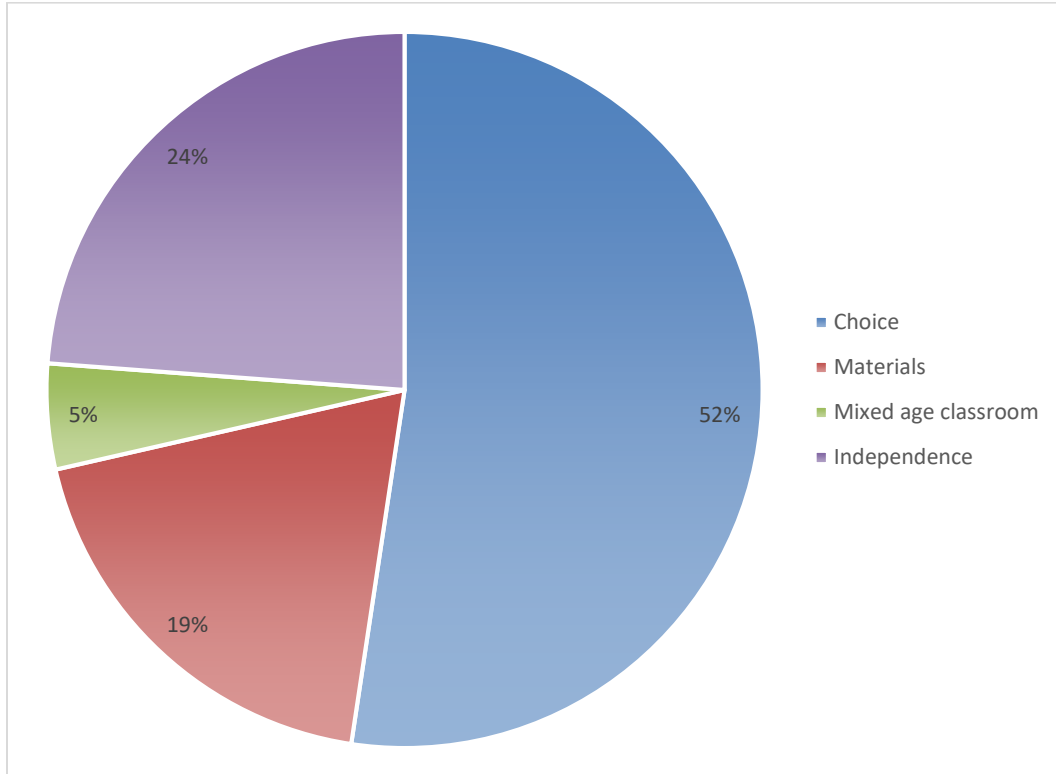


Figure 2. Student perspective on how SVMS allows students to be creative, (N=20).

Going along with the theme of how SVMS fosters creativity in a slower-paced classroom, I administered a Likert survey to parents. (Figure 3). I received eleven back. The survey confirmed that SVMS was a classroom that supported the tenets of a slower-paced classroom through student choices, breaks, free time, working at their own pace, and having enough resources. Parents overwhelmingly expressed that they agreed and strongly agreed that SVMS supported their child's creativity in a slower-paced classroom. The exception to this was the statement, *my child's class environment is conducive to learning*. For this statement, three parents disagreed, with the explanation of the class being too loud and chaotic at times.

At the bottom of the Likert survey, I added two questions for parents. The first question was, *what is your definition of creativity?* and the second question was, *how is creativity important for science education?* Eight of the eleven surveys said that creativity had to do with imagination, thinking of new things, exploration of thoughts and ideas.

Parents agreed that creativity was important. All surveys indicated in some way how creativity was important for science education. One parent said, “Creativity is the basis of science. Without it, we wouldn’t ask questions or develop innovative ways to address those questions. Thus, science education must be able to foster creativity.” And another parent said, “Creativity helps us think differently and ask questions so that real problem solving can occur.”

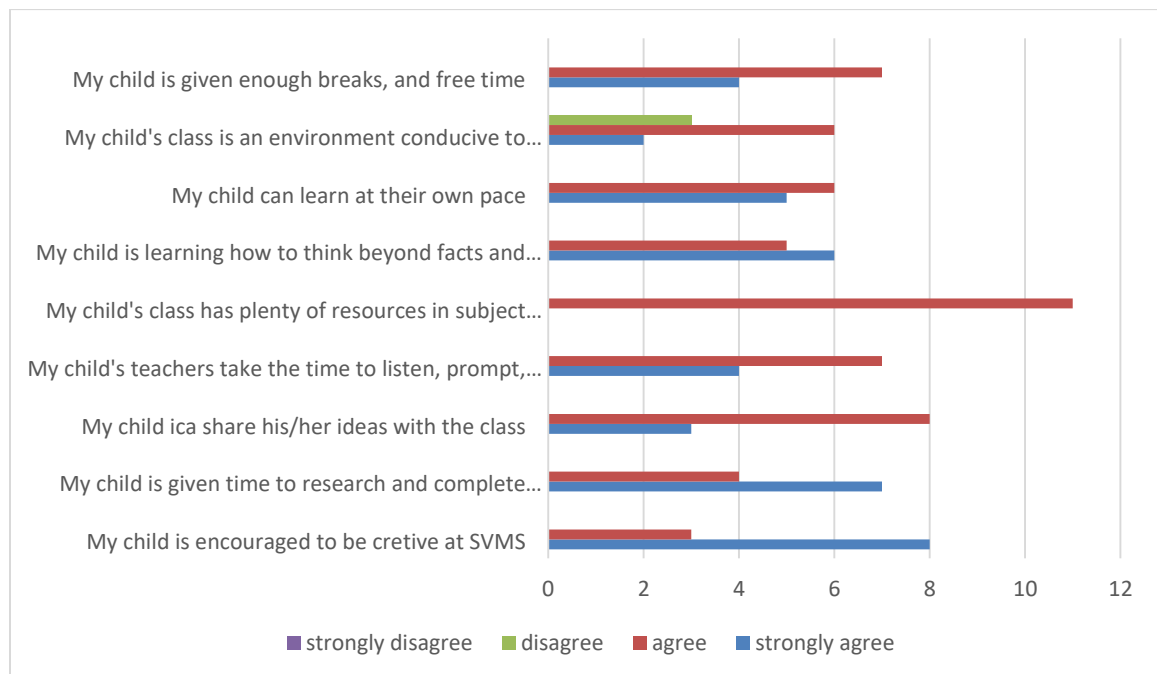


Figure 3. Likert Scale for parent interviews, (N=11).

I also administered teacher interviews with the two main teachers in the class. They are in the lower elementary class full time. The teachers confirmed that creativity was encouraged and fostered in the Montessori Method and in their classroom at SVMS. Jen Hermance, elementary teacher, said, “Creativity is encouraged in all works at SVMS. Creativity comes into all aspects of work and it's truly an outlet for students to express and use their creativity. It's truly amazing to see and experience the creativity that the students put into their work.”

The independence that students are given to choose what they want to learn about, seems to encourage students to be creative by giving them the initiative for their own learning. Students expressed 55% of the time that their choice in choosing their works was the top reason they could be creative.

An environment conducive to creative thought and expression are crucial as well. As Stefanie Wielkopelen, one of the elementary teachers in the study, says, “Respect of the individual child is most important. They need to know that their ideas, talents, and thoughts are not only respected but appreciated. Compassion and a desire to learn more, from students and educators alike, are also important. The feeling of community, collaboration, and the absence of fear regarding failure is needed as well.”

During the biomimicry project, I saw how students could form a problem, and solution, using their chosen creature. It took a while for many of the students to process this information. Investigating a critter of interest to them was fun and many thought they could just stop there. Along with the teachers, Jen and Stefanie, we did our best to

not help students come up with the problem or solution. They had to work through this independently or with a brainstorming group with other children.

The brainstorming groups started by accident, but turned into a great way for students to collaborate. Before we started science, the class would meet in a large group to discuss what we were going to work on with our biomimicry project. As with many elementary classrooms, keeping the excitement at bay was challenging. The children were so excited to share their discoveries with the class. What happened as an interruption by a boisterous student, led to a productive brainstorming session. For example, one student was studying the snow leopard. She had pinpointed that one of the snow leopard's "super powers" was the ability to not sink into the snow. This student didn't know what problem this "super powers" solve. Another student shouted out, "what about spy shoes! Shoes that do not leave marks." It was quite funny. We all laughed. Then other students chimed in with other ideas using the snow leopard's super power. The teachers and I decided to use these brainstorming sessions as productive ways for students to share their creative ideas, inventions, and innovations with each other. I journaled about these brainstorming sessions and use these observations to help inform the creativity indicators for students.

By Week 8, I was surprised, and relieved, that most children could work through their creative process and had an invention, innovation, or design that mimicked their creature to solve a real problem. This is a lengthy amount of time for young children to be involved in one project, but it confirmed that a slower-paced science curriculum was beneficial for students to have the time and environment to be creative in science.

I assessed the time aspect, with a graph of quantitative data of where the children were with their biomimicry project (Figure 4). Taking a creature to research and then applying this knowledge to an invention is a leap in cognitive ability. As confirmed, the children with signs and symptoms of cognitive delay were unable to move from investigating a creature, to coming up with a problem and biomimicry solution independently. This is reflected in the figure 4 with these children in the 10+ category.

I was surprised that a lot of children could do this with minimal support given encouragement and enough time. For the majority, it took two months for them to work it out. I must admit, at the beginning of this project, I was very discouraged that these children could not be creative in science without extensive prompting, but then by the eighth week mark it just started to happen. There was a surge of energy as ideas were flying around the classroom. The students were bursting with creative ideas, and problem solving.



Figure 4. Student progress in problem, solution, and creativity process, (N=20).

Creativity is difficult to assess, and has several components to it. I was specifically looking for features of having a unique or original idea. I made a table that categorized students by their individual projects, noting their problem, and biomimicry solution. (Table 4). Most students expressed creativity by coming up with a unique and original invention using their selected creature.

Table 4
Creativity Expression in Biomimicry Project

Student	Problem stated	Biomimicry solution
1	Coats need to be warmer	Harp seal-has fluffy coat and can be mimicked for better coat design
2	Firehoses are not able to go long enough distances	Spitting cobra-can spit far and with accuracy. Firehoses should mimic the spitting cobra
3	Googles get foggy and are hard to see through	Archer fish can see underwater well. Goggles can mimic an archer fish eyes
4	Kids and adults cannot regrow teeth when they fall out.	Shark-mimic the way sharks can regrow teeth to help people who lose teeth.
5	Those with muscular and other disabilities can't enjoy gardening.	Pizzly bear-mimicking the strength and grip of a polar/grizzly bear to make tools for the disabled in wheelchairs
6	Vehicles often overheat and the radiator is not good enough.	Frilled Lizard-uses bioregulation to cool it down, mimic this to have vehicles bioregulate
7	Why can't boots be beautiful and functional?	Snow Leopard-mimic snow leopard's feet to make boots that don't sink into snow
8	N/A	Caracal-good at hearing long distances
9	Cool buildings without air conditioners	Fennec Fox-big ears to keep cool- use this to cool buildings
10		Liger-hunting strategy
11	N/A	Mexican Hair Dwarf Porcupine-quills for protection
12	Amputees and those with muscular disabilities need mechanisms to help them rehab	Dolphin- has super strong muscles to help it maneuver. A special suit mimics a dolphin's muscles to help them build muscles in the pool
13	Those with asthma have a hard time holding their breath and enjoying swimming	Platypus can hold their breath for long periods of time. Make a mouthpiece to help people can swim and stay under water longer.
14	Camping lights use batteries that have toxic chemicals in them.	Noctiluca-create light using bioluminescence. can mimic this to make camping lights without batteries
15	Mountain climbers don't have special gloves to protect their hands and help their grip	Crested Gecko
16	N/A	Fox
17	Flippers should work better	Leopard Seal-mimic a leopard seals fins
18	N/A	Axolotl Salamander
19	N/A	Cheetah
20	Hard for people to explore or rescue people when visibility is low	Snowy Owl-make specialized goggles to see in stormy conditions like the snowy owl

This table showed what students came up with. The blank boxes represent students who could not completely come up with a creature, superpower, problem, and solution. Some student projects were only partially completed. Note: N/A indicates students unable to find a biomimicry problem and solution.

INTERPRETATION AND CONCLUSION

I saw ample evidence of creativity in the Montessori classroom in science education. It was amazing to see this creativity in such a young group. Using a table to show the problem/solution helped to notice the students' creativity collectively. Using biomimicry as a case study was telling of how, if given enough time, and the right classroom environment, students can flourish with creativity.

Additional studies would be interesting to test other factors in a slower-paced classroom as it relates to creativity. For example, would the creativity be as apparent in a regular school if students were given ample time for projects, or is there a correlation between other elements of the slower-paced classroom that foster creativity as well. Factors such as independence and choice of curriculum, inquisitive language that the slower-paced teacher uses, and the amount of resources that the children are free to access at any time would be additional elements to test in the slower-paced classroom.

A signature characteristic of the Montessori method is the language they use to guide children. Teachers use this language to guide children back into their own learning. This seemed to be significant for helping children work through the frustrations that sometimes arise in learning. This was evidenced in my study when the frustrations were at their peak in weeks 4-6. Continuing to give children the time, resources, and

direction they needed, without suggesting answers was important for the children to come to a creative problem and solution in their biomimicry project.

My data to support this is in Figure 4 and shows the spike in problem/solution progression from week 7-9. Frequently, teachers will change subjects in science every 4-5 weeks. What my research shows, is that there may be a correlation with the amount time given, especially when it is more than 6 weeks, and the ability for students to be creative with their problem/solution solving skills continue to develop.

There were some limitations in this study. First, I was a volunteer teacher and the reliability would have been stronger if I was in the class full time. Second, because a few individuals with cognitive limitations were unable to get the point of problem/ solution I could not confirm or deny their creative process in science education. A discrepancy that explains this is how some students could not express orally what creativity was in the student interviews, but then I would observe them making connections and being creative in their science projects.

Interviews with children, and teachers, as well as parent surveys parents, indicated a strong approval of fostering creativity in science and that SVMS was creating a classroom where this was important. I wish I received more parent questionnaires back. This was a limitation of the study. I received 11 questionnaires back to use as data in a Likert scale. I was hoping I could get a few more back.

This was a case study of how a school with a slower methodology can help students be creative in science education. I suspect, given the time needed for most

students to get to the point of creating a problem and solution would not happen as often in a school that does not have time for these projects, and ideas to take shape.

AR Question and how the data answered the question.

VALUE

In this day and age, we have information at our finger tips. It is not enough to know a plethora of facts about science. Children, especially in the elementary grades, need to be encouraged, and taught how to think creatively in science education. And to be able to think creatively takes time. Rushing from subject to subject does not help our children to invent, create, innovate, and think about what they are learning.

Speaking as an educator, it is difficult to have the patience in the classroom to not hurry about and change subjects if it appears the children are not understanding, but this study confirmed that it can be beneficial to slow things down a bit and let the children work through the problem/solution dilemma. The data confirmed that a project of this magnitude probably need 7-9 weeks (Table 4) with the younger elementary children to get to the place where they can confidently solve problems with creativity in science education.

A few practical implications of this study will influence my teaching. First, is adopting a more flexible policy for deadlines. While I understand the sensibility of deadlines, I feel that having a more flexible policy could produce more creative problem solving. Another similar solution would be to put projects to the side and take a break from them. Sometimes fresh ideas are formed when a break is taken.

A slower classroom environment where independence is fostered through more choice of curriculum, and ample resources available to children is important. Whenever possible and realistic, children should be given some choice into their learning and have resources, especially books available for them.

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APPENDICES

APPENDIX A:
THE SET UP OF A MONTESSORI CLASSROOM



APPENDIX B
IRB EXEMPTION FORM

MONTANA STATE UNIVERSITY
Request for Designation of Research as Exempt
MSSE Research Projects Only
(6/16/14)

THIS AREA IS FOR INSTITUTIONAL REVIEW BOARD USE ONLY. DO NOT WRITE IN THIS AREA.

Confirmation Date: 11/20/15 Mark J. B.

Application Number:

DATE of SUBMISSION: 11/15/15

I. INVESTIGATOR:

Name: **Abigail Helberg Moffitt**

Home or School Mailing Address: **309 S Oconeechee Avenue, Black Mountain, NC 28711**

Telephone Number: **828-450-2801**

E-Mail Address: moffittaj@yahoo.com

DATE TRAINING COMPLETED: 3/3/15 [Required training: CITI training; see website for link]

Investigator Signature _____ **Abigail Helberg Moffitt** _____

Name of Project Advisor: **Walter Woolbaugh**

E-Mail Address of Project Advisor: walter.woolbaugh@ecat.montana.edu

II. TITLE OF RESEARCH PROJECT: What are the benefits of a slower paced classroom?

III. BRIEF DESCRIPTION OF RESEARCH METHODS (If using a survey/questionnaire, provide a copy).

Observations- classroom environment, student engagement, teacher language

Parent and teacher interviews-see questions below

Behavior logs-tally charts of engagement and self-initiated regulation, and independence

Narrative journaling-journaling important observations more in depth

IV. RISKS AND INCONVENIENCES TO SUBJECTS (do not answer 'None'):

V. SUBJECTS:

A. Expected numbers of subjects: 50

B. Will research involve minors (age <18 years)? Yes No
(If 'Yes', please specify and justify.)

C. Will research involve prisoners? Yes No

D. Will research involve any specific ethnic, racial, religious, etc. groups of people?
(If 'Yes', please specify and justify.) Yes No

- ok as exempt
- MSSE Classroom assessment
- Little/no risk
- Principal approved
- No concerns

MEQ
11/20/15

APPENDIX C

TEACHER INTERVIEW QUESTIONS WITH STEPHANIE WIELKOPELAN AND
JEN HERMANCE IN THE LOWER ELEMENTARY AT SVMS

1. How is creativity encouraged at SVMS in science?

As a Montessori class, the curiosity of the child is continually nurtured and encouraged to grow. This is especially true in regards to science. Many times students wonder "why or how" things work. Science experiments are a fantastic tool for students to learn, in a hands on approach, how our world came to be, how it works, and why things are the way they are. When students have questions in the realm of science, they are supported in learning more either through art, experiments, research, critical thinking, or creative writing.

2. What does creativity look like for your students at SVMS?

To me, creativity is hand and hand with learning. Students approach life in distinct ways. To many, the way in which they understand ideas or concepts is through creative expression, projects, or writing. One student may be interested in a specific animal which leads them to researching the animal, writing about the animal, doing an art project based on the animal, and ultimately learning more through science. Students learn about environmentalism and ways to make the world better through experimentation. This is why biomimicry is such a great fit for a Montessori environment. Students not only learn about an animal's unique talent, they learn about the needs of the world that could be addressed with a unique approach based on an animal's qualities.

3. How is critical thinking expressed in science at SVMS?

Critical thinking is a daily task at SVMS. Whether small or grandiose in nature, students are continually asked to think outside the box. After being in a Montessori classroom, students begin to think critically on their own. If a work is not available because a friend is using it, they, at times, come up with unique solutions so they do not have to wait. Whether it is a child making their own materials quickly in order to do the work, approaching the work in a different way, or completing the task without the materials, students learn to compromise and think critically. Cultural studies, problems within the modern world, new approaches to everyday issues, SVMS students, because of their Montessori education, don't take no for an answer usually. They look for other solutions, solutions I may never have thought of as an educator. I have witnessed students carving out a new road instead of accepting a dead end. The students learn science through expressionistic science. From experiments that metaphorically explain the start of the universe, or science lessons with concrete materials that demonstrate how the world operates, the student is asked to not just "read" about the world, but to "see" the world through science and experiments.

4. What does the classroom environment need to be like for creativity and critical thinking to be fostered? I think respect of the individual child is most important. They need to know that their ideas, talents, and thoughts are not only respected but appreciated. Compassion and a desire to learn more, from students and educators alike, are also important. The feeling of community, collaboration, and the absence of fear regarding failure is needed as well.

5. Do you have any specific examples of creativity or critical thinking in science education?

I have been amazed by the creative and critical thinking approaches students have taken during their biomimicry studies. Julia, a student who loves fashion, was able to take her love of creating unique clothes and outfits and use it for her study of the snow leopard. Her design for fashionable and practical boots based on the snow leopards paw was fantastic. She was not only able to be a scientist but she was able to use creativity and unique interest and talent for science. Super cool.

Teacher Interview with Ms. Jen Hermance

1. How is creativity encouraged at SVMS in science?

Creativity is encouraged in all works at SVMS. Creativity comes into all aspects of work and it's truly an outlet for students to express and use their creativity. It's truly amazing to see and experience the creativity that the students put into their work. We love to see their finished products!

2. What does creativity look like for your students at SVMS?

Creativity for our students is detailed and passionate. When the students have an interest and passion for their work their creativity shines in the work they are doing. The passion in their work is evident and their pride is illustrated greatly.

3. How is critical thinking expressed in science at SVMS?

Critical thinking is an ongoing process in a Montessori classroom. The students are encouraged to think about solutions on a daily basis to some of their problems they may be trying to solve. They are encouraged to think "outside the box" at a young age. They are often eager to solve their own problems.

4. What does the classroom environment need to be like for creativity and critical thinking to be fostered?

The classroom needs to foster creative thinking by not always having the answer. We encourage them to think on their own and to come up with solutions to a problem without the help of an adult.

5. Do you have any specific examples of creativity or critical thinking in science education?

Biomimicry for one has been amazing! The students truly shined and rose to the challenge. They came up with some amazing super powers and inventions for all their animals. The students really enjoy critical thinking, there is no right or wrong answer. They feel empowered to use their knowledge and creativity to come up with solutions. The students really enjoy all aspects of science in the classroom and show pride in their creativity when they research/study botany and zoology.

APPENDIX D
LIKERT QUESTIONNAIRE FOR PARENTS

This survey is part of a MSSE Graduate research study. Participation in this research is completely voluntary. Thank you for your time. Please circle the answer which best describes your feelings about the following statements.

My child is encouraged to be creative at SVMS

Strongly Agree Agree Disagree Strongly Disagree

My child is given time to research and complete projects at his/her own pace

Strongly Agree Agree Disagree Strongly Disagree

My child can share his/her ideas with the class

Strongly Agree Agree Disagree Strongly Disagree

My child's teachers take the time to listen, prompt, and challenge them at their level

Strongly Agree Agree Disagree Strongly Disagree

My child's class has plenty of resources in subject areas they are interested in

Strongly Agree Agree Disagree Strongly Disagree

My child is learning how to think beyond facts and create original thoughts, inventions, and creations that prove this.

Strongly Agree Agree Disagree Strongly Disagree

My child can learn at their own pace

Strongly Agree Agree Disagree Strongly Disagree

My child's class is an environment conducive to learning

Strongly Agree Agree Disagree Strongly Disagree

My child is given enough breaks, and free time

Strongly Agree Agree Disagree Strongly Disagree

What is your definition of creativity?

How is creativity important for science education?