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Finding the Math in the Mountains: Place-based Learning in the Mountains of Southwest Virginia

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Abstract: The purpose of this article is to provide key aspects and learning outcomes associated with the Math of the Mountains Project. Math of the Mountains was a year long grant project that engaged 60 K12 mathematics teachers in the key concepts and applications of place-based learning and mathematics instruction. Through online coursework and peer support, a four-day immersive field experience, and teacher led field experiences, participants applied elements of PBL to create lesson activities that support real-world learning and problem solving scenarios.

Keywords: Place-based learning, real-world learning, problem solving, professional development, outdoor education, sense of place

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Math of the Mountains

Place-based Learning in the Mountains of Southwest Virginia

Introduction

One of the most dreaded questions that any teacher of mathematics will receive at some point is “When will I use this?” It is in that pivotal moment that teachers must sell the concepts of mathematics like the best car salesperson in the world. We scramble to make histograms or quadratic equations seem like concepts for everyday adult life. Yet, Galileo (1623) wrote “[The universe] cannot be read until we have learnt the language and become familiar with the characters in which it is written. It is written in mathematical language, and the letters are triangles, circles and other geometrical figures, without which means it is humanly impossible to comprehend a single word.” Tegmark (2014) also echoes this idea by writing “There's something very mathematical about our Universe, and that the more carefully we look, the more math we seem to find.” With a universe filled with mathematical concepts and formulas, why do teachers find it so difficult to answer that dreaded question? Traditional learning models of mathematics instruction focus on learning a concept then applying the concept in a simulation of “real world” context. Boaler (1993) surmised mathematical performance is clearly inconsistent across what may be termed as 'school' and 'everyday' situations suggesting that it is the environment in which mathematics takes place, not the problem to which it is applied, which determines the selection of mathematical procedure. If this assumption is true, then many of the transfer strategies long used in mathematics instruction are not as effective to help students make lasting “real world” connections and understandings as previously thought. Instead of asking students to apply math concepts they learn to carefully worded problems, what if students learned the mathematics of a place?

With the goal in mind of helping teachers find ways to support their students' learning through real world applications, I began the process of writing a grant to secure funding for the Math of the Mountains Project. This project is a partnership among The University of Virginia's College at Wise Center for Teaching Excellence, the Southwest Virginia Public Education Consortium, nineteen school divisions in Southwest Virginia, Breaks Interstate Park, Claytor Lake State Park, Natural Tunnel State Park and the Southwest Virginia Council of Teachers of Mathematics. It was designed to improve mathematics education in the nineteen divisions focusing on real world math scenarios and place-based learning principles found in our region's state parks and beyond. The project's goals would be accomplished by guiding sixty participating teachers through a three phase process in which they would create and implement learning modules that focus on concrete examples of mathematical concepts and place-based learning.

Identification of Need

The process of securing a Teacher Quality grant from the State Council for Higher Education for Virginia (SCHEV) began with the identification of need for the project in our region. The teachers and leadership of the school divisions of Region 7 articulated the need for high quality professional development opportunities in mathematics instruction with specific requests for opportunities for technology integration within the mathematics curriculum. To better understand the needs of the region, the project planning team undertook a needs assessment process which included: meetings with key instructional leaders and the board of directors for the Southwest Virginia Council of Teachers of Mathematics, a needs assessment survey sent to both administration and educators, and analysis of regional School Report Card data.

The SCHEV Teacher Quality grants required us to establish need for this type of professional development for a division or divisions that were considered to be high need. According to the Title II, Part A, non-regulatory guidance, a high need LEA is defined as one that A) for which not less than 20 percent of the children served by the agency are from families from incomes below the poverty line, and B) have a high percentage of teachers not teaching in the academic subjects or grade levels in which the teachers were trained to teach or hold provisional certification. Data from the Virginia Department of Education indicated that ten school divisions in Superintendent's Region 7 met these criteria for the 2016-17 School Year: Bristol City Public Schools, Buchanan County Public Schools, Carroll County Public Schools, Dickenson County Public Schools, Grayson County Public Schools, Lee County Public Schools, Russell County Public Schools, Scott County Public Schools, Smyth County Public Schools and Tazewell County Public Schools. According to analysis of School Report Card data, Assessment Statistics for the 2015-16 School Year, eight of the nineteen school divisions had overall mathematics pass rates below 80%. Further breakdown indicated that sixteen of those nineteen school divisions had overall mathematics pass rates below 80% for the economically disadvantaged.

The planning team employed the use of an online needs assessment survey sent to K12 mathematics teachers in Region 7. The survey was created through the SurveyMonkey online tool and administered over the course of ten days. One hundred and two participants rated how valuable they would find professional development in emerging technologies, technology integration in the mathematics classroom, and a host of mathematics topics.

Table 1.1 Grade Levels of Survey Participants

Grade Level		
K-4	46	32%
5-6	25	18%
7-8	26	18%
9-10	24	17%
11-12	21	15%
Total Participants Surveyed	142	

Table 1.2 Needs Assessment Survey Data: Professional Development Topics

Professional Development Areas	Not a Priority	Low Priority	Somewhat Priority	High Priority	Essential Priority
Learning more about emerging technologies used in mathematics teaching and learning	1	3	9	52	34
Learning how to effectively use technology in mathematics teaching	0	3	7	51	38
Learning how to integrate technology in mathematics lessons	0	3	8	50	38
Learning how to teach mathematics emerging technology	0	6	9	51	33
Learning about sources of emerging technology that can be used in mathematics lessons	0	4	12	47	36
K-4 Mathematics	22	6	4	22	37
5-6 Mathematics	23	10	10	20	23
7-8 Mathematics	24	10	12	13	24
Algebra I	26	14	6	16	23
Geometry	29	12	10	18	15
Algebra II	31	11	10	16	15
Trigonometry	35	12	6	13	14
Computer Mathematics	28	13	10	12	21
Probability & Statistics	33	9	8	14	16
Discrete Mathematics	37	11	10	10	11
Mathematical Analysis	32	8	14	10	17
Technology	8	3	14	30	28

The data collected indicated a specific need for professional development in technology integration topics with nearly 85% of participants indicating that professional development in technology was either high or essential priority. The responses for the need in specific areas of mathematics yielded a curious lack of priority for content specific training. Two key forces could have influenced this trend, 1) a majority of the participants were from K-6 and the need for those specific areas would not be a priority and 2) many school divisions have made significant investments of time and funding for content based professional development. These investments include the addition of mathematics instructional coaches, creation of curriculum guides and lesson repositories in the form of a regional comprehensive instructional program, updates to the Virginia Standards of Learning for Mathematics, and various local school divisions bringing in content experts for training. The survey participants indicated the need for more professional development to effectively integrate technology into their mathematics instruction.

To address a clearly indicated need for an innovative professional development approach that helps teachers support students in making lasting connections between conceptual mathematics knowledge and “real world” applications of that information, we began to formulate the Math of the Mountains project, which is deeply rooted in the principles of place-based learning.

Place-based Learning

Whether it is called place, project, or personal, the “P” in “PBL”, implies a strong connection to the subject being studied. Beames (2015) placed the roots of place-based learning in the 1970s, in four principal fields: human geography featured in writings by Yi Fu Tuan, Edward Relph, and George Seddon, eco-psychology driven by Theodore Roszak, deep ecology by Nils Faarlund, and philosophy by Edward Casey. Clark (2012) also connects PBL to Environmental Education that became popular in the 1970s which included curriculum that included Earth Day, the Clean Air and Water acts, and the creation of the U.S Environmental Protection Agency. Beames (2015) traced the origin of PBL literature to the 1990s with writings that used terms like *ecological education, pedagogy of place, a sense of place, and community oriented schooling* (Beames, 2015 p. 28). During the 1990s and 2000s, key works gave weight to the field of study such as Gregory Smith's (2002),"Place-Based Education: Learning to Be Where We Are," and David Sobel's (2005) *Place-Based Education: Connecting Classrooms & Communities*, as well as David Gruenewald's (2003) often referenced paper, "The Best of Both Worlds: A Critical Pedagogy of Place," which made a strong case for teaching through place.

Proponents of PBL suggest that its use in the classroom allows students to be more invested with a sense of agency (Rodriguez, 2008), recognizes them as producers of knowledge rather than simply consumers (Smith, 2002b), enriches students’ educational experience through hands-on, community-engaged learning, and provides relevance of knowledge and experiences to participate actively in real world scenarios that could lead to solutions for social and environmental issues (Coalition of Essential Schools, 2006; Smith, 2002; Smith & Sobel, 2010). However, McInerney, et. al (2011) summarized some key critical issues of PBL such as a lack in critical perspective and theory, and how PBL often fails to make the connections between global and local phenomena. These connections are vital in understanding the causes and effects of economic, social and ecological problems which were key criticisms for researchers such as Cormack et al., (2006); Furman & Gruenewald (2004); Gruenewald (2003); Hayes-Conroy (2008); and Nespor, 2008.

David Orr (1992) wrote that “other than as a collection of buildings where learning is supposed to occur, place has no particular standing in contemporary education”. The educational reform movement has placed standards, accountability, and the role of education to mainly support national and global competitiveness over more traditional reasons for education. Williams (1998) made the point that in pre industrial school systems, skills were ingrained in the local place and basic skills were taught to complement and enhance agrarian life rather than offer alternatives to it, which in turn created strong connections to the information being taught. Many modern day applications and uses of PBL draw from John Dewey’s (1900) view of education that prepared students to be participants in issues such as the environment, experience, and democracy. Dewey (1900) voiced concerns over the disconnects between what students in the early 1900s industrial era traditional schools were learning and their lives and situations outside of the school. These same disconnects are seen in the era of standards based learning where students do not have the connection to real world scenarios for learning to become, as Dewey (1900) referred to as “full members of society.”

To provide a deeper understanding of the importance of "place" in the educational experience, Gruenewald (2003) supposed "articulating a critical pedagogy of place is thus a response against educational reform policies and practices that disregard places and that leave assumptions about the relationship between education and the politics of economic development unexamined" (p. 2). While critical pedagogy has roots in critical theory, place-based learning does not have its own theoretical tradition. However, Gruenewald (2003) linked PBL in terms of practices and purposes to other forms of learning such as: "experiential learning, contextual learning, problem-based learning, constructivism, outdoor education, indigenous education, environmental and ecological education, bioregional education, democratic education, multicultural education, community-based education, critical pedagogy itself, as well as other approaches that are concerned with context and the value of learning from and nurturing specific places, communities, or regions " (p. 2).

Work has continued to conceptualize and formalize a framework and a critical pedagogy of place. Herrboldt (2016) found in the literature a "strong correlation" between the National Research Council's (2012) "A Framework for K12 Science Education" and PBL. Herrboldt (2016) pointed to many points of convergence of the two in terms of constructivist approaches to learning and the way understanding develops over time. Blatt (2013) outlined how children benefit from spending time learning outdoors in ways such as identity development, emotional health, conservation behavior, and improved overall student outcomes, as well as other key benefits such as collaboration and higher order thinking skills, and cross curricular connections. Blatt (2013) summarized the cross curricular connections of a lesson activity project dealing with the mapping of local trees and National Science Education Standards, "this investigation meets each of these criteria while engaging students in an in-depth exploration of local trees, in which they learn not only the science of trees but inquiry skills in science, mathematics, and geography as well" (p. 99).

Promise of Place.org (2017) has summarized the key research findings on place-based learning initiatives into a list of basic principles. The principles of Place-based learning according to Promise of Place are:

- Learning takes place on-site in the school yard, and in the local community and environment.
- Learning focuses on local themes, systems, and content.
- Learning is personally relevant to the learner.
- Learning experiences contribute to the community's vitality and environmental quality and support the community's role in fostering global environmental quality.
- Learning is supported by strong and varied partnerships with local organizations, agencies, businesses, and government.
- Learning is interdisciplinary.
- Learning experiences are tailored to the local audience.
- Learning is grounded in and supports the development of a love for one's place.
- Local learning serves as the foundation for understanding and participating appropriately in regional and global issues.
- Place-based education programs are integral to achieving other institutional goals.

The Center for Place-based Learning and Community Engagement through a project organized by Clark (2012) has produced a PBL manual to provide structure and context as well. This manual draws heavily from Sobel's work. Sobel (2005) provides two guiding principles and six strategies for implementing place-based education. The two guiding principles are: 1) maximize ownership through partnerships and 2) engage students in real-world projects in the local environment and the community. Both of these principles are echoed in many other studies and accounts (Santelmann, Gosnell, & Meyers, 2011, Smith & Sobel, 2010). By engaging the community and building partnerships, Sobel (2005) cited Fontaine's account that by applying PBL, you could build a stronger support for education and provide more ownership of the whole process. Additionally, Sobel (2005) suggested by having students engage in real-world activities, educators inspire and strengthen ties to the community and enable students to participate in activities deemed important and meaningful beyond the classroom.

Sobel's (2005) account dealt primarily with environmental learning but the strategies could be applied across a wider population with varying content. Strategy 1 called for putting an environmental educator in every school. This was meant to develop an instructional coaching resource but could be a teacher who is crossed trained to provide this type of curriculum support. Strategy 2 calls for creating a SEED team built up of two or three teachers, an administrator, the environmental educator, a higher ed facilitator, two or three community members, a school staff person, and a few students to guide the project. Strategy 3 calls for building community connections through the use of "Vision to Action Forums" where the team engages in conversations with 100-200 community members to see challenges faced in the community. Strategy 4 cautions that environmental educators should try to avoid raising public fear by providing strong factual information to the public Strategy 5 calls for continuous improvement models through professional development. The last strategy calls for the need to maintain community exchange to keep the energy of the project going.

The Math of the Mountains Project

Goals and Structure

The Math of the Mountains project was created to help teachers find ways to provide context and real world applications for mathematical thinking and problem solving. Following the principles and theoretical underpinnings of the literature on place-based learning, a one and a half day of professional development was initially planned and implemented by the Executive board of the Southwest Virginia Council of Teachers of Mathematics (SVCTM) and the Center for Teaching Excellence at the University of Virginia's College at Wise (UVAWISE CTE). The success of that endeavor as measured by the enthusiastic feedback of the small group of six participants and two instructors served as a "proof of concept" for further professional learning opportunities. In fall of 2016, a partnership between the UVAWISE CTE, SVCTM, and the Southwest Virginia Public Education Consortium was formed to write a grant to expand the program.

The Math of the Mountains Project was awarded a grant in the amount of $150,000 from the State Council for Higher Education in Virginia. The project was designed to enhance the lesson development and technology skills of up to 60 mathematics teachers in Virginia Superintendents Region 7. Each teacher was guided through training on mathematical concepts, technology tools and applications as well as lesson design, to create learning objects for lesson activity modules. The ultimate outcome of this project was the development of a valuable online resource guide with interactive learning modules available through the Southwest Virginia Council of Teachers of Mathematics' webpage. By using locations that could easily be accessed by the public, such as state parks, teachers would be better able to take their students to complete the modules onsite or online as well as foster interest in learning in nature. The project had five main goals that are listed below:

Table 1.3: Project Goals

Project Goal 1: Develop mathematical thinking and problem solving skills within a key group of math instructors from Region 7.

Objectives:

- Explore and identify mathematical concepts that could be explored at key locations within each park.
- Create lesson activities that include higher order thinking skills and place based learning elements.

Project Goal 2: Develop data collection and inquiry methodology needed for the development of place based learning lesson activities.

Objectives:

- Identify types of data and media needed to foster student understanding of content.
- Recognize and apply the elements of place based learning within the context of the Virginia Standards of Learning for Mathematics and the National Council of Teachers of Mathematics Principles to Action Plan.

Project Goal 3: Advance technology skills needed to design and facilitate mathematical reasoning abilities through place based learning activities.

Objectives:

- Create learning objects and support materials to foster student understanding of lesson objectives.
- Utilize applications for visual media production, augmented reality, and geocaching to provide real world context for problem solving skills.

Project Goal 4: Cultivate resource and learning object development skills.
Objective:

- Create and publish online lesson plan modules that incorporate visual and/or interactive components.

Project Goal 5: Establish and promote online sharing of resources and feedback to foster professional growth and understanding.
Objective:

- Share and exchange feedback for enhancement of lesson modules with project participants.

Phase 1: Pre-Academy

The project was divided into three distinct phases: 1) Pre-Academy, 2) Academy, and 3) Post Academy. During the first phase, details and logistics were finalized for the summer academies as well as the first online course. In January 2017, meetings with UVa-Wise faculty and staff, principal project directors, park guides, and regional key instructional leaders were held to design course activities and establish course syllabi and agendas. During this time and continuing until April 2017, recruitment of teachers was conducted by key instructional leaders and administration of partnering LEAs, The Southwest Virginia Public Education Consortium, The University of Virginia's College at Wise Center for Teaching Excellence, The Southwest Virginia Council of Teachers of Mathematics. Recruitment was focused in all Region 7 school divisions with special focus on the sixteen divisions whose mathematics scores showed less than 80% pass rates for the economically disadvantaged subgroup. Ultimately, there was representation from 18 of the 19 total divisions in the region. In April 2017 participating teachers completed a 1 undergraduate credit hour online course to introduce them to the elements of place-based education and the features of the partnering state/interstate parks. This course was also used to establish a learning community focusing on elements from the Community of Inquiry Theoretical Framework which will foster and support learning together (Garrison, Anderson, & Archer, 2000). Many participants reported that they had a greater sense of connectedness and ease with meeting their fellow participants during the summer academy because they had interacted with each other in the online course.

Phase 2: Summer Academies


In the summer of 2017, participating teachers attended a 4-day Math of the Mountains Academy place-based learning field experience at one of three partnering state/interstate parks: Natural Tunnel State Park, Claytor Lake State Park, and Breaks Interstate Park. Each day included field experiences at major park features to collect data, media, and other needed information followed by group collaboration sessions at the park's education center. To facilitate data collection and lesson design as well as implement lesson components in their classrooms, each participant was given an iPad with appropriate apps. Participating teachers were directed to select one or more features of the park to begin creating a learning module for their students. For example, a middle school math teacher might construct a scenario that utilizes the chairlift at Natural Tunnel State Park. The module could include photos, videos, statistical information, and more to assist students in solving the proposed problem: "How long will it take to move 150 tourists down to see the Tunnel?" To help participants develop their lesson activities, instruction was provided for Google Docs and Google Sites. The culminating activity was to create a lesson plan and companion webpage to help students complete an activity based on park locations and or park information. Each summer academy was different due to a variety of reasons such as park amenities and staffing, variance in experience and skill levels with mathematics and technology, as well as adjustments made to the schedule as needed.

Academy 1: Breaks Interstate Park

"The Breaks" as the locals call the park, is one of two interstate parks in the United States. It is managed by a board comprised of four delegates each from the states of Kentucky and Virginia. It is commonly referred to as the "Grand Canyon of the South" due to its rugged terrain and massive and winding gorge that runs through the park. It has a full service lodge and conference center complete with a wonderful restaurant. The first morning, we completed logistics and an overview of the agenda and grant information as well as a brief tutorial on the use of the Ipad. After lunch, we were greeted by one of the treasures of The Breaks, park naturalist and historian, Carl Mullins. Carl is a treasure trove of information, leading activities on day 1 and day 4. Our Day 1 adventure was a walk in the rain around the lake to the spring while 77 year old Carl, relayed a vast amount of history and botany information. At this point in the academy, both myself and the co-instructor, UVAWISE mathematics instructor, Rachel Clay-Keohane noted that our participants despite their work online to get familar with PBL concepts were not taking pictures, measurements, or notes; nor, were they asking mathematically pertinent questions. To foster a stronger connection to daily activities and PBL concepts, we decided that we needed to clarify our expectations and conducted a demonstration of the thought processes and information that needed to be collected to be prepared for the lesson activity creation part of the academy.

The morning of Day 2 was for touring the stables and horseback trail riding. It was during this activity period that we started to hear the participants begin talking about ways they could apply mathematics in this context. We also saw another interesting trend. We noted that many were hesitant to ride but overcame their fears to complete the activity. As group after group completed their ride, we saw this sense of satisfaction and self confidence. One of our participants remarked that so many times he would have taken his kids or students to do an activity and would be there to watch them do it. But this time, he was participating and feeling what his students felt when they accomplished a new and often scary task. It was this intangible feeling that forged this diverse group of educators together. They formed their own Facebook group to share their media and ideas in addition to the activities that we had them do in the online course. We also completed the idea share activity on posters around the room and talked about each idea shared and what students would need to be able to complete each activity successfully. The participants began thinking in terms of lesson activities and learning objects. We saw a remarkable difference in their participation levels and questioning after that activity. This led to lots of great lesson ideas such as applications for upper level math with determining the local elk population after our Elk tour to see the herd of Rocky Mountain Elk. The elk introduction occurred three years prior to replace the now extinct Eastern Elk that was once dominant in the area.

Days 3 and 4 were filled with breathtaking views of the gorge and the proposed sites for the zipline that were complete later that year, the lake and waterpark, and a special historical presentation and birding tour. The participants were growing more and more anxious about the final project which was their lesson activity and Google Sites page with support materials. We quickly discovered one HUGE problem with our plan. The new Google Sites, which is a very easy to use WYSIWYG type editor, would not work on the iPad. This was particularly worrisome as iPad was the primary device that most people had with them. With no other work around, we were forced to do a quick tutorial that was more demonstration/lecture. This situation frustrated me so much that we immediately sent messages to the next academy's participants to bring a laptop or Chromebook.

The first group really was a learning group for all of us. The grant director, the co-instructor and I sat down and made changes to the agenda for the following week's academy. In our post academy meetings we noted that there was a noticeable difference in the quality of the lessons designed by this group versus the other groups. We ultimately concurred that the delay in making strong connections to PBL principles and not being able to begin the creation of their support materials pages under our guidance during the face-to-face setting was the primary reason for the difference.

Academy 2: The Natural Tunnel

After the first academy filled with ups and downs, we made the aforementioned adjustments to the schedule and logistics. Natural Tunnel is a very different park fully operated by the Virginia State Park System. This park has a very strong educational specialist, Megan Krager. Megan was able to help us by bringing not only her expertise but also other park personnel and allowing us "all access" into day to day operations of the park. This included information such as financials, state reports, and pages upon pages of statistics on everything from park visitors to environmental mapping data.

This group was different from the first group in ways that would become apparent as the week went on. One thing I immediately noticed was the wide gap in experience. We had about half that were teaching 5 years or less and half that had twenty years or more of experience. This was a more severe split than the first group and it seemed to make a difference in how each participant looked at each activity. We also had more people in this group that were very familiar with this park. This led to some inattention to details in the first day's activities. At the end of day 1, we did the Idea share that we had done during the first academy. This again prompted some great discussion and lots of great questions. Questions that came back to what types of mathematical concepts could be explored by visiting the park or by completing the online activities they were to create as well as what media or other support materials students would need to be successful.

Days 2 and 3 were filled with visits to the Tunnel and the chairlifts, the Block House historical site, Stock Creek Nature Center, campfire historical presentation, sunset hayride to see the remnants of the old turnpike and multiple sinkholes and caverns in the area. At each location we asked the participants what mathematical questions could be drawn out of the location. Rachel pushed them further to think about what question could only or best be answered by visiting that location. This again pushed participants to concentrate on the unique characteristics of the location. The online idea shares improved dramatically in terms of detail and ties to PBL principles.

We began the last day with a dramatic hike into the south entrance to the tunnel which included crossing Stock Creek several times and making a narrow "shimmy" along the edge of the railroad track platform. Once inside, we explored the natural formations that continue to shape and change the naturally formed tunnel. The afternoon was spent going over the lesson plan, support page requirements and providing practice on using Google Sites. The resulting lesson activities were better than the prior week's in most cases but did require much editing and feedback to make improvements and meet the required rubrics.

Academy 3: Claytor Lake State Park

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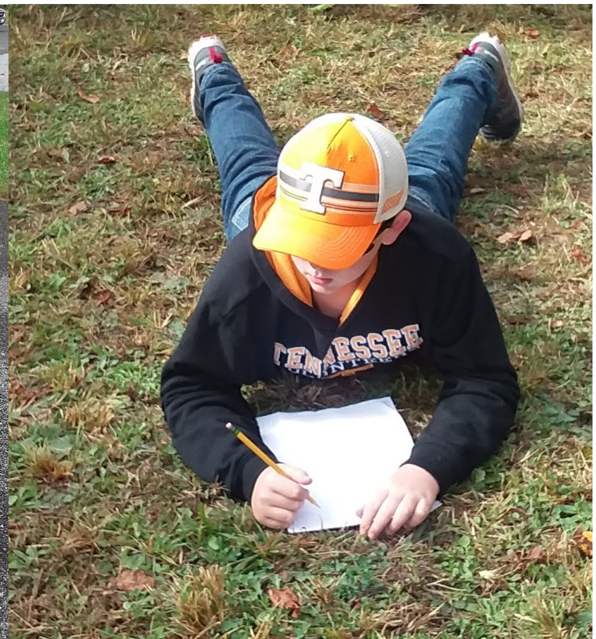
The last academy was held at Claytor Lake State Park in Dublin, Virginia. This park is located about thirty minutes south of Roanoke and is one of the smallest state parks in the state but had the meeting facilities that we required in the desired area.

As mentioned previously, we had participants bring a laptop as well as providing them the iPad. We modeled the idea share on the afternoon of the first day as well as talk about the final project on day 1. Activities at Claytor Lake included scenic hikes along the shoreline and wooded areas, visits to the Howe House, Dunkard's Bottom Historical site, the beach and event grounds, as well as a boat tours and kayaking or paddle board tours. We had a few that were interested in the nearby hydroelectric dam project which unfortunately we were not able to tour but were able to gather data and contact information for those who wished to schedule a tour. We learned much about the history of the area and how the lake was formed. Our participants in this group were equally diverse in terms of grade level but were more evenly spread out in terms of experience in the field.

This group also displayed the same sense of accomplishment and camaraderie that we saw in the Breaks group particularly after the kayaking and paddleboarding sessions. This self confidence and high energy along with more direct information earlier in the week seemed to translate into much more detailed and prolific idea sharing. This group also took more notice of details often times asking for measurements and other pertinent data. The park staff responded very well and was able to provide them with all of the information requested and then some. We decided to move the technology training in Google Sites to Day 3, which allowed them to work on their projects in their hotel rooms in the evening and end the academy with a working session. The session provided an opportunity where participants could ask questions and make adjustments with the comfort of having the instructors there to help if needed. Rachel and I noted a marked improvement in the overall lesson plans and support pages submitted by this group versus the other groups.

Phase 3: Post Academy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On September 11, 2017, the last phase of Math of the Mountains began with the opening of the final two undergraduate credit hour online course, which provided tutorials on technology, place-based learning, and instructional design. The tutorials focused on the creation of learning activities for their learning modules. Support was provided by the course instructors and fellow teacher participants. The first module of the course reviewed some key literature such as Sobel's (2005) two guiding principles and six strategies for implementing place-based education. Participants were engaged in several online discussion forums that also looked at reports such as The Benefits of Place-based Education: A Report from the Place-based Education Evaluation Collaborative (2010), which highlighted successful K12 PBL projects throughout the United States. Each article read during this first module highlighted key aspects and provided concrete examples that came together in one simple goal of place-based learning, which is relevance. One participant remarked, "My biggest take away from [the articles] is this; if you expose students to a problem they care about, they will become invested and learn more about it." Other comments also centered on how applying PBL to their mathematics instruction, enabled them to provide context and relevance for the concepts the students were learning.

The second and third modules of the fall course focused on creating a second lesson plan and activity. The lesson plan was developed and peer reviewed in this online course. Peer review was not implemented during the summer due to time limitations, but added after careful consideration by the course instructors. For the lesson activity webpage, teacher participants were provided with step by step video tutorials on how to create their page using Google Sites. As with the summer lesson activities, we stressed the importance of the elements of place-based learning and providing learning support through their web pages. At the conclusion of the fall course, nearly a hundred place-based learning lesson plans were developed, many with activity support pages. Per grant requirements, the Southwest Virginia Council of Teachers of Mathematics published a sample of the learning modules that can be accessed and utilized by any teacher.

The last aspect of the Post Academy period was the teacher-led field experience. Allotted grant funds were released to school divisions to support the teacher-led field experiences where teacher participants implemented their learning modules with their students, then reflected and reported the lesson impact. Teachers were asked to guide their students in the discovery and discourse of the "Math of the Mountains" as they were guided during each of the academies. The teacher-led field experiences were conducted during the 2017-2018 school year. Each teacher participant submitted a completed follow up report that provided specifics on how the funding was used and the learning outcomes.

Discussion

What began with the most dreaded question heard in the mathematics classroom, "When will we ever use this?", has led a group of 60 math teachers, one mathematics professor, and one instructional technology instructor on a journey through place-based learning practices. At the beginning of each of the academies, I told the participants "once you begin to the see the math all around you, you won't be able to stop". My pedagogical orientation is deeply rooted in constructivism which may be why I loved teaching Kindergarten and first grade so much. I want students no matter if they are five or ninety five to have a learning experience. I want them to make connections to what they already know. Dewey (1900, 1938) often wrote about those connections and their benefits to the learner as he or she takes their place in society. This takes me back to Sobel's (2005) point that "authentic environmental commitment emerges out of firsthand experiences with real places on a small, manageable scale over time". I would take that farther and apply it to a commitment to solve all sorts of problems of culture, government, and environment. The commitment comes through firsthand experience at home then expanding to school, community, state, nation, and then global issues (Clark, 2012).

What we learned from the field experience reports were descriptions of deeper learning experiences where students made connections from the math concepts learned in the classroom to the real world. One teacher reported, "It was great to see the students participate in hands-on math. One student said "we really can use math can't we, Mrs. Boyd?" We also saw evidence of students taking more ownership of their learning through statements such as "The best part of the experience was seeing my students view math outdoors instead of in the classroom. They really got into it and came up with some great pictures for their Geometry projects". Another common theme was that students really enjoyed the activities and the experience had lasting impacts as evidenced through statements such as "they really enjoyed themselves and are still talking about it almost a month later". Another teacher took their student land surveying to Natural Bridge and commented that students remarked that it was the best field trip they had ever taken. One report noted how the teacher enjoyed watching their students work and be excited about the math they were doing. These statements are not often associated with traditional field trips or in class math activities.

The participants responded to pre and post activity efficacy surveys in math and technology. The math survey was based on the Mathematics Teaching Efficacy Belief Instrument (Enochs, et. al, 2000). The technology survey was based on The Technology Proficiency Self-Assessment Instrument (Christensen and Knezek, 2014). Comparison of pre and post scores showed a slight increase in teacher efficacy in math but a decrease in technology. The grant evaluator noted while nothing pointed to a specific reason for the decrease a possible reason was that the introduction of a wide array of technology tools which may have led to them to feel less confident in their technology knowledge. She deemed the goals of the grant met as the teachers demonstrated growth in technology in their completion of the course assignments and ultimately creating their activity pages in Google Sites.

Next Steps

So where do we go from here? I go back to the main areas of need that formed the foundation of this project which was to incorporate elements of PBL and technology into mathematics instruction. Overall, I feel that we accomplished the former and made progress on the latter. Unfortunately, we did not get to the more exciting aspects that applying place-based learning and technology enables, such as augmented reality and the use of GPS technologies and digital data collection tools. Yet, we pushed many of the teacher participants out of their comfort zones with technology as many of them had never created a web page prior to the summer academy. Many gained greater proficiency with G Suite apps and other web tools such as Padlet, Thinglink, and more. We introduced the participants to some basic measurement, photo, and annotation iPad apps. In addition, basic web tools were introduced such as Google maps, Youtube Videos, and weblinks, that could be used to support their students. We also were able to create some excellent examples of PBL that are accessible through the Southwest Virginia Council of Teachers of Mathematics webpage, www.svctm.org.

Many of the participants of the Math of the Mountains Project and other teachers who have learned about the project have asked if there would be another cohort. At this point, the Executive Director of the Southwest Virginia Public Education Consortium and I are seeking additional funding for future Place-based learning experiences in other core content areas. What is my main take away from this experience? I have two key points from this experience: 1) once you can "see" the math in places, it never leaves you, and 2) when you get teachers out of their comfort zones and trying new things no matter whether it is horseback riding or web design, amazing things can happen. I knew there was math in these mountains, perhaps I just did not know how much.

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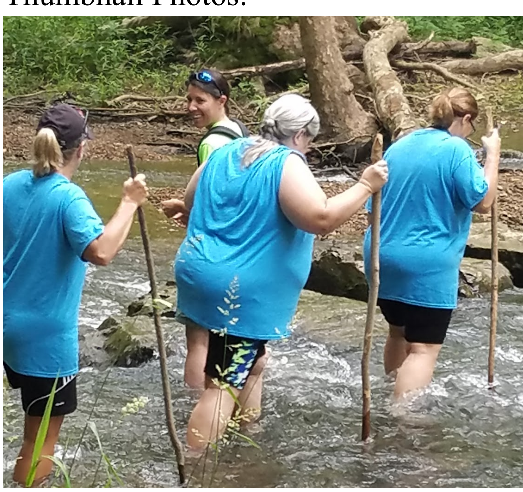
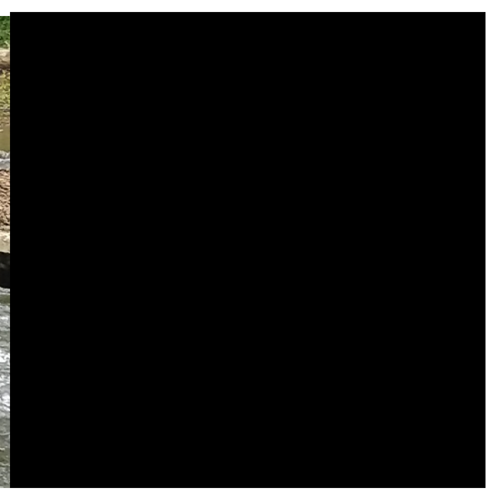
Additional/Optional Media:


Please do not swing or bounce chair
Lower Restraining Bar

Thumbnail Photos:

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