The Math-alachian Trail

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Abstract: *This practitioner article highlights the use of digital math trails with in-service mathematics teachers at all levels. The purpose of a digital math trail is to connect learners with a physical space while engaging them in open-ended mathematics problems that promote critical thinking and problem-solving savvy. This article also provides simple steps to help teachers learn how to create their own digital math trails for their students.*

Keywords: *culturally responsive pedagogy, problem solving, critical thinking*

Introduction

Math Trails

A few years ago, I began reading about math trails. These are activities designed to "get students out of the classroom so they can (re)discover the math around" them (King, 2018). For many students, especially given today's emphasis on performance through testing, they may be discovering mathematics in the world around them for the first time. Even for teachers, it can be easy to exchange the beauty of mathematics for quick results on standardized test performance. Looking around any given situation in the physical world, mathematics can be found if you train your eye to see it. It may be in architecture, city planning, artwork, or nature. The key is to have opportunities to look for it. The intention of math trails, for me, is to engage students in mathematics in their community and/or other areas they would like to explore in order to see the beauty of mathematics while also engaging in high levels of mathematical thought.

Campus/Mathematics Connections

The university where I work, Appalachian State University, is nestled in the beautiful Blue Ridge Mountains of the North Carolina High Country. As a mathematics education professor, I became interested in connecting the unique scenery of our campus to the mathematics content of my methods courses offered and the work I do with in-service teachers. Connecting learners to mathematics outside the classroom creates authentic learning experiences that can help students connect to the subject in meaningful ways (Garrat, Huang, & Charleton, 2016; Newman, Cicada Wehlage, 1995). Not only that, but math trails allow teachers opportunities to open their curriculum using inquiry-based methods that help students move away from more traditional textbook problems that require a singular solution (Boaler, 2016; Meyer, 2010).

Challenges with the COVID-19

During the 2020 Coronavirus Pandemic, finding ways to get out of the classroom has proven challenging to teachers across the world. Many teachers have been teaching solely in virtual spaces using video conferencing applications like *ZOOM* and *Google Meet*. The prospect of taking a classroom full of students on a math trail may be out-of-bounds for many teachers who are simply

trying to make it through a given day. Figuring out how to create authentic, inquiry-based learning experiences for students is challenging in a physical, face-to-face classroom much less an online learning environment marked by countless limitations. This is where a digital math trail may be appealing for many during this time of social distancing and remote learning.

Digital Math Trails

During the summer months of 2020, I was given an opportunity to lead in-service teachers through an online professional development institute. I wanted to highlight ways in which teachers could explore and utilize virtual resources that could serve in place of what they may have in their physical classrooms. Along with that, I hoped to provide time and space for them to engage with other online tools like *Google Maps* that are free to use and easy to navigate. The following paragraphs detail what went into one of my digital math trails designed as an example to help teachers think about ways to help their students explore the world from their homes while also engaging in high levels of mathematical inquiry. My hope is to illustrate how digital math trails can engage students in learning mathematics while also sharing how and why this math trail was created.

Introducing the Math-alachian Trail

Leading a group of students outside for a scavenger hunt can be challenging in the best of circumstances; but, given the time constraints of a traditional classroom, not to mention when we find ourselves in the midst of a global pandemic, it may be too much to ask teachers to lead students on a math trail of their own. My hope with the Math-alachian Trail was to create an engaging, online experience that would be intriguing enough to help participants in my summer professional development interact with mathematics using real-world scenarios. Using *Google Maps* provided an opportunity to use a free, online service while also engaging with open-ended mathematics questions using physical spaces. In particular, this digital math trail follows a path around Appalachian State University's campus looking at landmarks and other points of interest that have mathematics questions associated with them. Figure 1 illustrates the map created using `http://mymaps.google.com`. After providing participants access to the map, their task was to follow the directions on the highlighted trail, stopping at each point along the way to solve an open-ended mathematics question. The trail created in this instance focuses primarily on estimation and geometry questions.

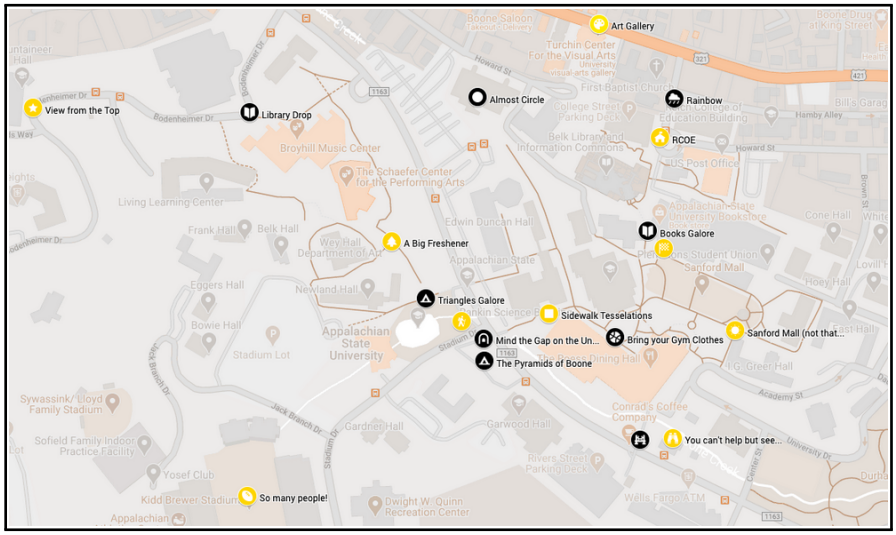

Fig. 1: *Map of Appalachian State University's Campus with Points of Interest.*

Creating a Math Trail

Creating a math trail is pretty straightforward and just takes a little practice to become familiar with the tools involved. I generally start by taking a walk through the physical space if it at all possible. In the case of the Math-alachian Trail, my two-year-old daughter and I explored campus one Saturday morning for points of interest that could be used to integrate into the trail. In all, it took about an hour and a half to walk from our home near campus taking pictures of interesting geometric structures, landmarks, and physical spaces that could potentially lend themselves to an intriguing problem. Our photos consisted of buildings, the football stadium, outdoor art, statues, bridges, and green spaces. Figure 2 contains samples of photos we captured.

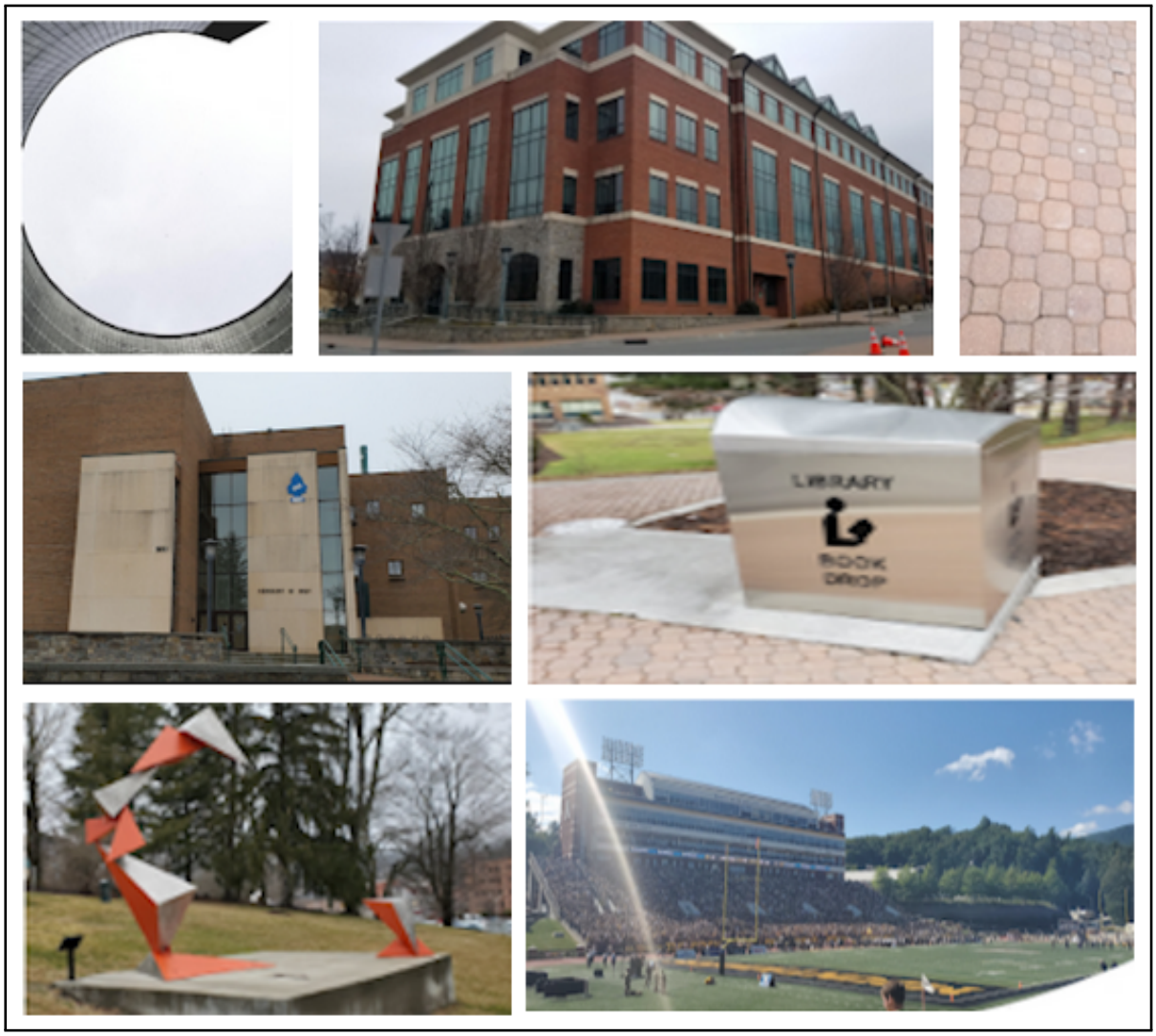

Fig. 2: *Images from the Math-alachian Trail.*

At the time of photographing the images, I did not have a clear mathematical objective in mind. However, after uploading the pictures into *Google Maps*, ideas for inquiry-based problems primarily around estimation and geometry began to surface in my mind. I began conjuring ideas like, "I wonder how many books could fit in the book drop?" and "What types of polygons exist on that building?" Thinking about mathematics through the lens of my less-than-professional photographs prompted interesting questions that related to my class content and provided opportunities for students to potentially explore their curiosities without being locked into gimmicky, "real-world" word problems. Not to mention, my daughter and I got plenty of exercise that morning!

Implementing the Math Trail

To engage with the virtual math trail, participants were encouraged to follow the path outlined in *Google Maps*. At each stop, they were to click on the icon which indicated a problem to solve. Figure 3 illustrates an example of what this looks like. Sometimes quality photos have been difficult to come by. If this is the case, I have encouraged teachers to take screen grabs of free images found in *Google Streetview* or those that fall under a Creative Commons License. The problem in Figure 3 is an estimation problem that connected my course content exploring similarity and proportional reasoning. It reads, "On the facade of Wey Hall there is a large air freshener. How much larger do you think it is compared to one that hangs from a rearview mirror?" The question situates itself in the context of both the physical space of the trail and within the purview of the content of my class. Moreover, the question is intended to be open in the sense that it has a "low flow, high ceiling" (Boaler, 2016). This means that the problem can be accessed by participants on various levels of mathematical understanding, but is rigorous enough to challenge those that need to be challenged in their thinking. Additionally, there could be multiple solutions to the problem in this scenario. One may not know the precise scale of the giant air freshener to the remainder of the building or even how tall it is. But, they can use their problem solving savvy to make an educated guess based on some of the objects found in the foreground and background of the image. Based on that, they can work to think through possible solutions, justifying their reasoning and working collaboratively to come to a consensus with their peers.

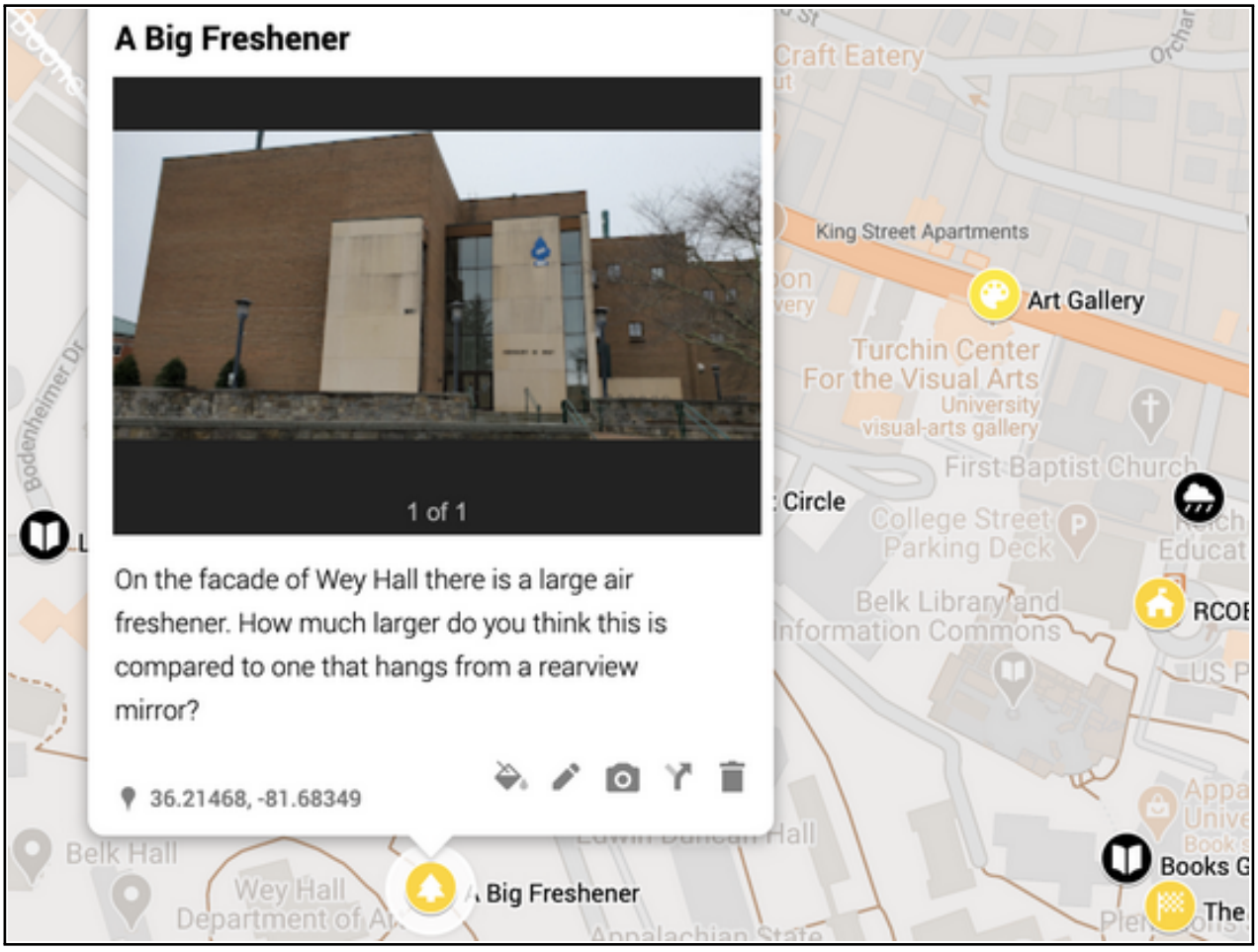

Fig. 3: *A sample Question from the Math-alachian Trail.*

A Rationale for Math Trails

Authentic Problem Solving

So, why engage your students in this way? In a world where it is difficult, and potentially unsafe, to be around one another, virtual math trails like the Math-alachian Trail give students and teachers a way to foster authentic teaching and learning within their hybrid and/or virtual classrooms. Students can explore the world around them by engaging in mathematics they may find in their community or in a setting they may have never dreamed of visiting, which seems to be consistent with engaging students in place-based pedagogies that are intended to help connect with their world and lived experiences (Wells Sprott, 2020). Not only that, but the open-ended nature of the problems one can conceive using a platform like this gives students a chance to engage with mathematics in the real-world. Rather than solving traditional word problems from textbooks, students can work to develop their problem-solving skills while seeing an actual object or setting that exists in the world.

Collaboration and Inquiry

From my experiences implementing math trails like the one highlighted in this paper, I have been encouraged by what both my students and in-service teachers have said. They have enjoyed the process of exploring, working collaboratively while discussing inquiry-based problems, and using mathematics to make sense of their world. Further, students who have engaged with these activities must work to consistently justify their reasoning which is consistent with authentic mathematics contexts (Garrat, Huang, and Charleton, 2016). Since there are often multiple solutions to any given problem, students have to explain their mathematical reasoning, engage in substantive conversations, and share their problem-solving strategies. These elements are built on inquiry-based learning strategies revolving around students' curiosities and interests (Boaler, 2016).

Making Mathematical Connections

Further, teacher educators can use the ideas found with this math trail to create their own for pre-service teachers they may be working with. Creating a trail around their campus not only engages students, but it also helps mathematics educators see mathematics in their everyday setting. If they are so inclined, assigning students to create a digital math trail of their own for a project could be a worthwhile endeavor. If there are particular topics, such as classifying quadrilaterals or uncovering trig ratios, instructors can ask students to explore their neighborhood, campus, or town in order to find mathematics and create their own trail. If venturing out in the elements is not an option, students can also find interesting images using *Google's Street View* platform for digitally exploring.

Teacher Perspectives

As previously mentioned, I worked with K-8 mathematics teachers during a professional development in the summer months during the coronavirus pandemic. One participant, a middle school mathematics teacher, had the following sentiment about integrating the ideas behind the Math-alachian Trail into her classroom:

> The math trail, as I envision it, takes place mostly outside of the classroom setting. This is another way to see math in the real world and experience math outside of textbooks and worksheets. Students will begin to think about math as it relates to real objects.

> A math trail would also create a sense of exploration and adventure outside of the classroom walls. I can see students getting excited about this.

This teacher was excited about taking ideas she has had for teaching mathematics and integrating them into a digital space for her students to explore. She had some reservations about how to go about creating a virtual math trail, which seemed understandable given her limited experiences with Google Maps. Working with her to develop her confidence in the online tools, she was able to gain hands-on experiences with this particular tool.

Another teacher had similar feelings, finding the digital math trail to be a practical resource while they transitioned their face-to-face classroom to a hybrid format. She said, "The use of [Digital] Math Trails is brand new to me, so I look forward to enacting it as a way for my students to discover math in their everyday environment, even as we 'social-distance' during this pandemic." In both cases, teachers were encouraged by the digital platform to authentically engage students in mathematics in non- traditional ways. My hope is that this resource can be used by other mathematics educators at any level to engage students in high levels of mathematics during a challenging time we face in our world. Finding opportunities to create open, authentic tasks is a worthwhile task that I hope teachers are able and willing to take.

Supporting Students

Supporting students (either at the K-12 level or undergraduate pre-service teachers) can be challenging when using digital math trails. The main reason for this is due to the open-ended nature of some of the problems. One of the best ways to support students when they are engaging with these is to first think through possible solutions to many of the problems and where students may potentially struggle. Anticipating pitfalls can provide a good amount of structure for you students if they become flummoxed. Additionally, using digital math trails may be a bit of a learning curve for many students; so, it is encouraged to provide flexible time if students finish sooner or later than anticipated. This also allows for teachers to have opportunities to check-in regularly with students and to ask probing questions about how they are thinking about problems.

Steps for Creating Math Trails

Finally, in the Appendix, I've outlined a series of simple steps I use to create math trails like the Math-alachian Trail. If images are not readily available for you, *Google Maps* has an enormous repository of images available, many of which are under a Creative Commons license, as they are often freely provided by internet users.

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Appendix: Simple Steps for Creating a Digital Math Trail

1. In a web browser, navigate to http://mymaps.google.com.
2. Make sure to create a google account or sign into your existing account Once you are in the web applet, select "Create a new Map" in the upper left corner
3. Next, find a location of interest. This may be an area you live, have explored previously, or hope to explore someday.
4. Once you find your area, use the navigation tools (Undo, Redo, Select Items, Point of Interest, etc.) to add points of interest to your map. These can be whatever you like.
5. Once you've added some points, you can use the "Add Directions" feature to connect the points for your students to navigate.
6. As you finalize your map, add photos to each point of interest by clicking on the point on the map. If you are unable to take photos yourself, using Google Street View can provide an option to add free images that are part of Google Maps.
7. After adding photos, create open-ended problems for students to engage with. These can be fitted to your content in ways you deem appropriate. Try to avoid asking questions with only one answer or way to solve.

Feel free to access some of my existing maps for ideas or examples found at the following links: https://tinyurl.com/mathalachian-trail and https://tinyurl.com/old-dusty-trail.