[International Journal of Geospatial and Environmental Research](https://dc.uwm.edu/ijger)

Volume 5
Number 3 *Geospatial Teaching and Learning*

Article 3

July 2018

Student and Teacher Response to Use of Different Media in Spatial Thinking Skill Development

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Student and Teacher Response to Use of Different Media in Spatial Thinking Skill Development

Abstract

The purpose of this research is to advance K-12 geospatial learning by investigating the methods (traditional paper versus digital technology) best suited for delivering content that improves spatial thinking skills. This research was designed to investigate whether instruction through different media, among other variables such as attitudes toward geography and technology, past travel experience, and demographic variables have an effect on the development of spatial thinking skills. Specifically, it examines traditional, paper aerial imagery as compared to digital imagery visualized with 3-D globes. Findings confirm that students taught by both paper and digital media showed improvement in spatial thinking skills with the advantage contingent on different skills being assessed. A subset of students were invited to share their opinions about the activities in order to develop a richer understanding of their experiences. This paper focuses on the qualitative results of the study by analyzing interview data from participating students and teachers.

Keywords

geography education, spatial thinking, geospatial technologies, teacher training

1 INTRODUCTION

Increasing interconnectedness in the modern world demands an unprecedented need for geographic literacy. The ability to think spatially is crucial for making well-informed decisions and these skills are rapidly becoming exponentially more important. Spatial thinking is a distinctive form of thinking defined as the knowledge, skills, and habits of mind to use concepts of space, tools of representation, and processes of reasoning to increase powerful understandings through analysis and inference to fundamentally solve problems in a variety of contexts (NRC 2006). Enhancing levels of spatial thinking in K-12 students is one of the key goals of geography education (GESP 1994; NRC 2006; NGS 2011; Heffron and Downs 2012). Applying intellectual knowledge about space, or geospatial thinking, is critical for students in decision making and solving complex geographic problems (Jo et al. 2010; Metoyer and Bednarz 2017), yet these skills remain severely underrepresented in today's classrooms. A shift in research paradigms toward cognitive processes such as how students process map information (Lobben et al. 2014) coupled with the increasing amounts of spatial data available throughout society have amplified the importance of spatial thinking becoming a compulsory component in education (Janelle and Goodchild 2009). Although a number of spatial thinking skills have been recognized that foster analytical and problem-solving skills in education (Gersmehl 2008), little consensus exists among scholars about how spatial thinking skills are separately distinguished from one another (Gersmehl 2008; Golledge et al. 2008; Janelle and Goodchild 2009). A summary of skills shown in Table 1 illustrate comparisons of similar skills across all three structures.

Geospatial technologies have become ubiquitous throughout society and their uses in education include global positioning systems (GPS), digital globes, and geographic information systems (GIS). Digital globes in particular allow the student to view anywhere on the planet at varying scales offering viewers a different perspective than before these tools were available. Geospatial technologies are often cited as superior tools for teaching and learning spatial thinking skills (Baker 2005; Goodchild 2006; NRC 2006; Shin 2006; Marsh et al. 2007; Milson and Earle 2007; Schultz et al. 2008; Liu et al. 2010; Kulo and Bodzin 2011; Nielson et al. 2011; Goodchild et al. 2012; Henry and Semple 2012; Goldstein and Alibrandi 2013). However, while they may improve spatial thinking acquisition, it should not be implied that geospatial technologies achieve these results alone nor that teachers can implement these technologies effectively (Metoyer and Bednarz 2017).

Paper maps have traditionally been used to display and analyze geographic information, but have been undoubtedly transformed in the digital age. Researchers have found that while instruction utilizing digital maps is effective in learning outcomes, it is not more effective than traditional paper maps (Cunningham 2005; Pederson et al. 2005; Verdi et al. 2003). Furthermore, it has also been established that both paper and digital maps have advantages and disadvantages in instructional use, but paper maps are the preferred medium by both geographic experts and classroom teachers (Hurst and Clough 2013; Collins 2018). Observably, there are multiple variables that best promote spatial thinking which is far too complex to have a one-size-fits-all approach to teaching. The digital revolution has forever changed the teaching and learning of students and student learning must continue to be investigated in order to find the most effective and meaningful ways to teaching spatial thinking skills.

A number of assessments have been developed to measure spatial thinking such as cognitive ability tests (Battersby et al. 2006; Marsh et al. 2007; Golledge et al. 2008;

Lee and Bednarz 2009), a paper-pencil test involving visual manipulation (Newcombe 2010), a spatial knowledge and thinking about locations quiz (Dunn 2011), and a geospatial thinking test (Huynh and Sharpe 2013). The spatial thinking ability test (STAT) (Lee and Bednarz 2012) was selected for this study because at the time this research was conducted, it was the only standardized instrument that had been tested for reliability and validity in addition to integrating geography content knowledge with spatial skills. The STAT was designed to assess individual's growth in spatial thinking skills and was created to assess the spatial thinking components identified in the structures and hierarchies proposed by Gersmehl and Gersmehl (2007) and Golledge et al. (2002) as seen in Table 1. Janelle and Goodchild (2009) have developed similar work, but it was not yet available during to the construction of the STAT.

This research was designed to investigate whether instruction through different media, attitudes toward geography and technology, past travel experience, and demographic variables have an effect on the development of spatial thinking skills. Specifically, it measured spatial thinking skill development as students participated in traditional, paper map instruction or digital map instruction via two intervention lessons designed by the researcher. Each student was tested pre-and post-instruction and scores were tested and analyzed for significant differences. This paper focuses on the qualitative results of the study by analyzing interview data from participating students and teachers and is valuable in furthering our understanding about how to best foster spatial thinking skills with students. However, quantitative findings of this study confirm that students taught by both paper and digital media showed improvement in spatial thinking skills, but students taught using paper maps had a slightly higher significant improvement on STAT scores than students taught using digital maps. When scores were analyzed by individual STAT question, results revealed that the percent correct increased on the majority of questions in both groups with students taught with paper maps increasing on slightly more questions than students taught with digital maps. There were no statistically significant differences in any of the spatial thinking skill categories, however different media appeared to have an advantage contingent on the different skills being assessed. For example, students taught with paper maps had higher improvement on overlaying and dissolving maps while students taught with digital maps had higher improvement on comprehending geographic features. There were no statistically significant correlations between improvement on STAT scores and students' attitudes toward geography, access to technology, travel experience, or demographic variables such as gender. The quantitative results of the study add empirically based research on the learning effects of being taught with different instructional media and a complete analysis may be accessed in Collins 2018.

Table 1. Spatial thinking concepts. (Adapted from Lee and Bednarz 2012.)

Gersmehl and Gersmehl	Golledge et al.	Janelle and Goodchild
Condition	Identity	Objects and Fields
Location	Location	Location
Connection	Connectivity	Network
	Distance	Distance
	Scale	Scale
Comparison	Pattern Matching	
Aura	Buffer	
Region	Adjacency, Classification	Neighborhood and Region
Hierarchy		
Transition	Gradient, Profile	
Analogy		
Pattern	Coordinate, Pattern, Arrangement, Distribution, Order, Sequence	
Spatial Association	Spatial Association, Overlay/Dissolve, Interpolation	Spatial Dependence, Spatial Heterogeneity
	Projection, Transformation	

2 METHODS

2.1 Study Design and Implementation Sequence

To examine student and teacher responses to the use of different media in spatial thinking skill development, a total of 327 eighth grade social studies students and four teachers in suburban South Carolina, USA were invited to participate in a study that measured spatial thinking skill development as students participated in either paper-based or digital-based map instruction. Three groups of students were required for the study that included students taught with paper-based map instruction (111 students), digital-based map instruction (106 students) and a control group that did not receive any designated map instruction (110 students). Students were selected for participation in the study by default based on their enrollment in the required eighth grade social studies course and were given the option of opting out of the study. The school comprises of four eighth grade social studies teachers of which two participated (selected by school administration) in teaching both paper-based and digital-based map instruction as intervention lessons while the other two administered a student survey and pre- and post-tests to the control group. The two participating teachers attended a two-day training session with the researcher to provide step-by-step written instructions for each intervention lesson and detailed demonstrations of each lesson using both the paper and digital instructional methods.

On the first day of the month-long study all students completed an initial survey used to gather information on student attitudes toward geographic content, technology, and map use as well as their access to technology outside of school and their ease of using maps and technology. Implementing a 5-point Likert-type scale, ten questions were used from previous surveys that suggest that attitudes toward geography may be linked to performance (Walker 2006; Kubiatko et al. 2012). Sample questions include: *Maps and globes are easy for me to use* and *I have easy access to the Internet outside of school*. The survey included four additional questions about student travel experience as well as their parents' travel experience, a possible influence on their spatial understanding according to Thorndyke and Hayes-Roth (1982) and Golledge (1999). Students answered travel questions such as *Have you ever traveled outside of the United States* with a response of yes, no, or don't know.

Spatial thinking skills were then tested pre-and post-lesson implementation via the STAT which served as the skills baseline prior to the lesson interventions. This instrument was grade appropriate for this study as it was originally developed by testing junior high, high school, and university students (Bednarz and Lee 2011). Made up of sixteen multiple choice questions, each item was designed to measure one or two of eight spatial thinking skills. These skills include (1) comprehending orientation and direction, (2) comparing map information to graphic information, (3) choosing the best location based on several spatial factors, (4) imagining a slope profile based on a topographic map, (5) correlating spatially distributed phenomena, (6) mentally visualizing 3D images based on 2D information, (7) overlaying or dissolving maps, and (8) comprehending geographic features represented as point, line, or polygon. So that it could be administered as a pre- and post-test to evaluate changes in spatial thinking skills over time, two equivalent forms of the test were created (STAT A and STAT B) with slightly differing questions covering the same spatial thinking skills. Each student in the study took both STAT A and STAT B in its entirety. The STAT may be seen in its entirety at http://people.rit.edu/~bmtski/rw_stat/STAT_baseline_July_2013.pdf Students participated in the initial survey and STAT A on the first day of the study. No feedback was provided to the students concerning their performance. Next, two map intervention lessons were implemented to all students in the paper and digital-based map instruction groups. Each lesson was designed to take one full class period (50 minutes) with one additional class period reserved for review and discussion of the activities. In total, there were four days of lesson exposure for each student. In the class period following the fourth day of lesson exposure, students completed STAT B. Immediately following completion of STAT B, a subset of students was selected by a random number generator to share their opinions about the activities from the study. Two students were selected from each of the intervention classes and a total of twenty-four students were interviewed; twelve from paper-based instruction classes and twelve from digital-based instruction classes.

Student interviews were conducted to ascertain a richer understanding of student experiences from the study that was not accessible through quantitative testing. Students were asked to comment on (1) the easiest question(s) on the pretest, why it was easy, and strategies used to answer it (2) the most difficult question(s) on the pretest, why it was difficult, and strategies used to answer it (3) whether or not exposure to STAT A questions helped answer questions in the activities (4) the level of interest in the types of activities (5) the level of difficulty or ease in answering the questions in the activities (6) the tools most used in answering the questions in the activities (zoom, ruler, compass) (7) whether or not they better learned how to read and use maps after completing these activities (8) whether or not the activities helped better answer questions on STAT B and (9) what was learned from completing these activities. Each student interview lasted approximately fifteen minutes and took place in the school's media center.

The two teachers who taught the intervention lessons were also interviewed and asked to comment on (1) their level of satisfaction with the intervention lessons, as well as, the perceived student level of satisfaction (2) the levels of interest and curiosity among students and teachers in spatial thinking (3) the levels of interest and curiosity among students and teachers in using and understanding technology relative to the subject matter (4) the most challenging aspect of teaching with paper maps (5) the most challenging aspect of teaching with digital maps (6) the value of the lessons for improving spatial thinking (7) their preferred medium and why, as well as, the perceived preferred media of the students and (8) the medium that seemed to better improve student spatial thinking. Lasting approximately thirty minutes each, the teacher interviews were conducted by the researcher during the teacher's planning in their own classroom. These conversations were recorded, transcribed, and evaluated by the researcher for common themes that emerged from teacher responses.

2.2 Intervention Lessons

Two curriculum components were utilized for the intervention map instruction: the existing South Carolina Maps and Aerial Photographic Systems (SC MAPS) curriculum and an updated SC MAPS curriculum that integrates Google Earth without SC MAPS materials. SC MAPS is a standards-based middle school curriculum originally developed with satellite imagery, topographic maps, and other paper materials. Although multiple free digital globes exist, Google Earth was chosen for the digital component of this study due to its popularity and familiarity among the general public. Newer imagery was acquired from Bing Maps to create comparable SC MAPS versus Google Earth activities in order to teach lessons using both instructional media equally. Imagery was captured, printed, and laminated to create 24 x 36 paper maps for classroom use. The exact imagery was utilized for the digital map instruction by framing a polygon on Google Earth so that students were viewing identical imagery in both instructional media groups. Charleston and Myrtle Beach, two existing study sites in the curriculum, were selected and redesigned for this research. An example of the Charleston study site may be seen in Figure 1.

Whether taught using paper or digital instructional media, each student participated in the same two teacher-led lessons. Both participating teachers taught both paper-based and digital based map instruction. Each lesson contained a short introductory reading about the study site area and basic map-reading instructions. Students read these introductions aloud as a class before beginning the activities. Each of the two lessons contained five spatial thinking activities each designed to isolate a specific spatial thinking skill. An example of the intervention lesson activities can be seen in Figure 2. In Activity 4 (Figure 2), students utilize the spatial thinking skill of correlating spatially distributed phenomena to answer the questions. In activity 5 (Figure 2), students utilize the spatial thinking skill of choosing the best location based on several spatial factors. Each of the activities in the two intervention lessons required students to utilize a specific spatial thinking skill to answer the questions. Each lesson was designed to take one full class period (50 minutes) with one additional class period reserved for review and discussion of the activities. In total, there were four days of lesson exposure for each student.

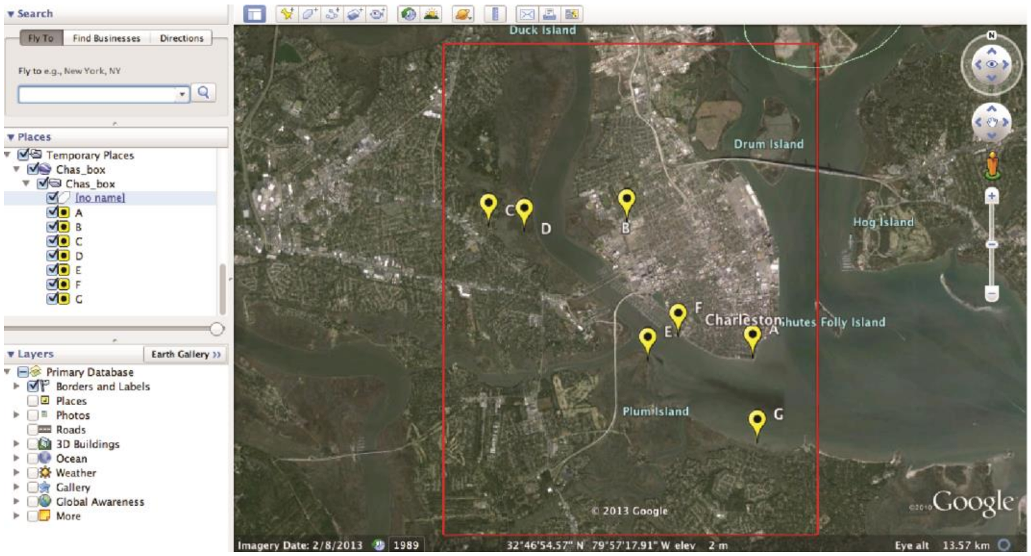

Figure 1. Google Earth, Charleston study site.

Activity 4
Developed land is land covered or "built up" with buildings and roads.

Is Point C developed land or undeveloped land? Explain your answer.

____

Is Point D developed land or undeveloped land? Explain your answer.

____

If you were to travel from Point C to Point D, would you experience an abrupt or gradual change in the look of the landscape? Explain your answer.

____

____

Activity 5
Rivers make traveling around Charleston difficult without bridges and ferries. The City of Charleston wants to improve the ability of people who live south of the peninsula to get over to the peninsula. Two places have been proposed to establish a water ferry: from Point E to Point F and Point G to Point A. Would you choose the first route (Point E to Point F) or the second route (Point G to Point A)? (circle your answer).

Point E to Point F   Point G to Point A

What clues in the map helped you decide?

____

____

Figure 2. Sample intervention lesson activities, Charleston study site.

3 RESULTS AND DISCUSSION

3.1 Student Interview Responses

Following the completion of STAT B, twenty-four students from the intervention groups were interviewed about their experiences with the activities in the study. Students were supplied with a paper copy of the test to help them identify which question they considered easiest out of the 16 questions. The majority of students (63%) argued that questions testing comprehending orientation and direction (questions 1 and 2) and comparing map information to graphic information (question 3) were the easiest. All of the students who selected questions 1 and 2 reported that the questions were easiest because the directions were simple and easy to understand. Another student stated that they noticed the directional indicator did not have "north" pointing up in the typical manner, and thus was able to strategize using that detail. One student strategized that the question was easy if the compass was used and elaborated, "The compass is the first thing I look for on a map." It is interesting to note that multiple students who chose these questions to be the easiest did not answer them correctly. This occurrence is likely due to the fact that students assumed "north" was facing up when it was in fact facing down. Students who chose question 3 as the easiest also reported that the question was easy to understand while several students elaborated that it was easy to see the gradual change in the map because they "do this" in math class. Consequently, students may find these types of questions easier due to learning these skills in other academic areas such as math and science. Based on this small, random sample, students found the beginning of the test to be easier than the latter part of the test. Question 1 may be seen in Figure 3.

Students were also asked to identify which question they considered most difficult out of the 16 questions. The majority of students (71%) found some combination of questions 9, 10, 11, and 12 on overlaying and dissolving maps to be the most difficult. Out of those 17 students, nine students grouped all four questions together as the most difficult while eight of the students narrowed it down to either Questions 10 and 11 coupled together or Questions 11 and 12 coupled together. The students who chose these questions all had very similar responses to why they were difficult. One student remarked, "These questions don't make any sense. I just don't get what they are asking at all." Another student replied, "I had no idea what to do. These just make absolutely no sense to me." Students were not exposed to these types of overlay and dissolve questions in the intervention lessons and were not familiar with basic techniques of GIS, therefore these findings indicate that direct instruction of spatial thinking skills is more effective for student learning than non-direct instruction. Question 9 may be seen in Figure 4.

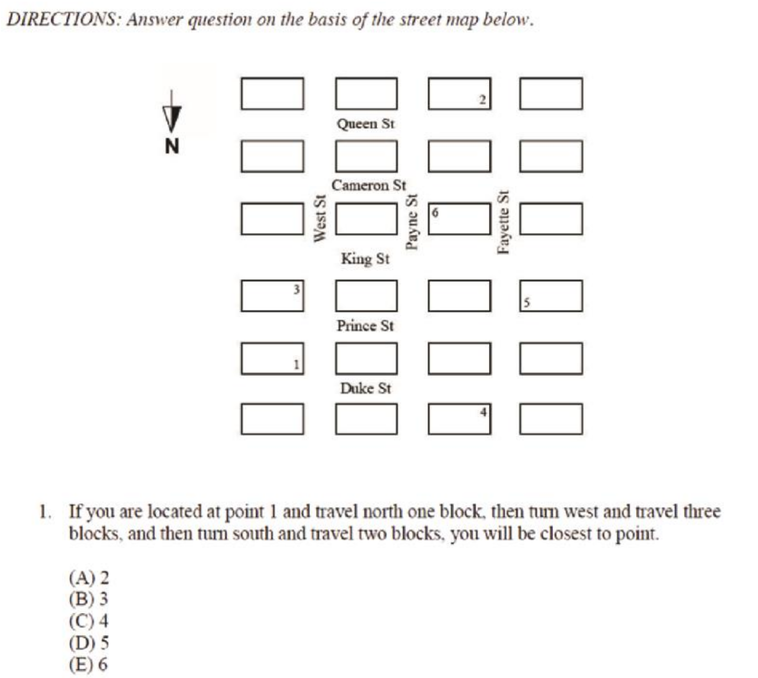

Figure 3. STAT A, Question 1. (STAT Images © 2006 Association of American Geographers (AAG); Dr. Jongwon Lee, STAT author.)

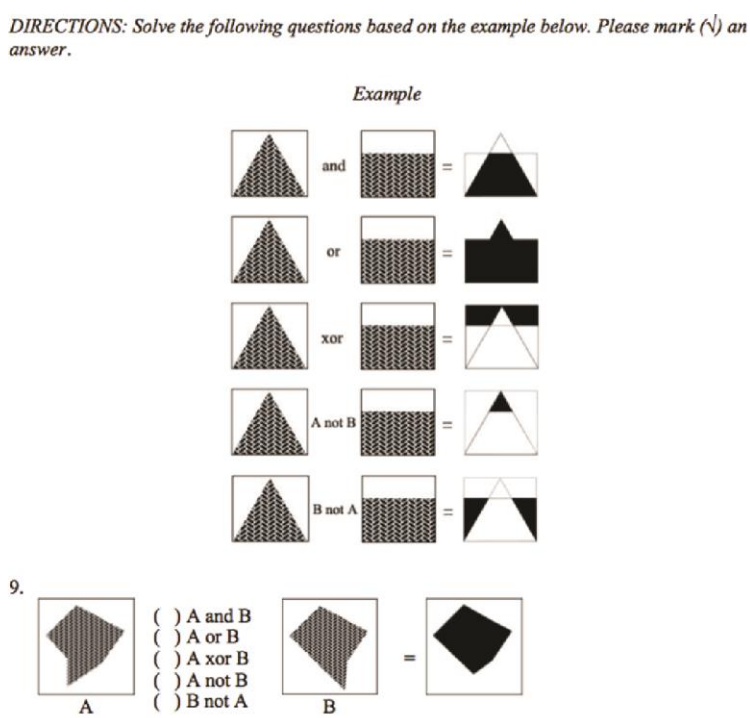

Figure 4. STAT A, Question 9. (STAT Images © 2006 Association of American Geographers (AAG); Dr. Jongwon Lee, STAT author.)

The majority of students (58%) reported that mere exposure to questions in STAT A helped them have a better understanding when completing the activities and on completing STAT B. Five students elaborated they had never seen these types of questions before and when they saw similar questions again it was more familiar to them. The other 42% of students reported that exposure either did not help them or they were unsure if it helped them when completing the activities or STAT B. Moreover, 67% of students used the word "fun" to describe their level of interest participating in the activities with several students revealing that it was different than "normal schoolwork." One student exclaimed, "It was fun because you had to think. I felt smart." This response implies that students prefer to utilize inquiry in schoolwork and not simply rote memorization. When asked to describe the level of ease or difficulty they experienced in answering the activity questions, half of the students described the activities as "easy" while the other half rated the activities as "medium" in difficulty as one student states, "You really had to think, but I wouldn't say it was hard." When asked if they learned how to read and use maps better after completing the activities, 67% of students reported affirmatively, 29% reported marginal improvement, and 4% reported negatively.

Students were also asked which tools they used in answering the questions. The ruler and the zoom tools were utilized the most frequently by students in the digital-map group while in the paper-map group, the compass was reportedly utilized by all students and the scale was utilized by most students. Students who were taught using the digital medium did not report using the compass tool as much as students did who were taught using the paper medium. This difference in tool use could be that the students using digital-maps assumed that "north" was facing up. However, that assumption could prove incorrect if the student uses the rotation tool and thus could lead to false information. While technological savviness is required to use some features, they do not require prior knowledge of map skills nor do they require any active thinking in how to determine distance or location based on skill rather than technology. Consequently, a perceived advantage exists with digital-maps when utilizing certain features such as displaying latitude and longitude as a rollover feature which quickly identifies the location for the user (Pedersen et al. 2005) or in the case of this study, the ruler feature which displays the distance between two objects by simply manipulating the technology. Additionally, 92% of the students interviewed from the paper-map group stated that they physically turned the map in order to help them better orient themselves. These statements are consistent with previous research that notes that tangibility of a paper map is often preferred (Hurst and Clough 2013) and could indicate that the act of physically touching the map uses the mind and hands more effectively than clicking a mouse (Cunningham 2005).

Many noteworthy responses were provided when students were asked what they learned by completing the activities. Some common responses were that they better learned how to read maps, understand maps and recognize what they were viewing, in addition to seeing the world with a different perspective through these activities. One student elaborated that it was now easier to recognize a road from a building and distinguish what it was rather than being unsure of what was being viewed. Another student explained that they can now differentiate between land that is developed and land that is undeveloped. One student reported learning that simply turning a map can offer a different perspective. Several other students commented that they actually learned how to use a compass for the first time, while other students stated that they learned how to use a map scale for the first time. Several students reported that their orientation improved by simply realizing that "north" is not always facing up on a map.

Another student explained that exposure to the maps encouraged the habit of observing more "stuff" on the map and simply understanding maps more because they got easier to read as they got more familiar with them. Another student simply stated, "I don't know what I learned really, but it got a lot easier." Only one student reported not learning anything from the activities.

3.2 Teacher Interview Responses

At the conclusion of the study, the two teachers that taught the intervention lessons were individually interviewed. Both teachers reported that their level of satisfaction with the lessons was very high and described them as being practical and easy to understand for students. Both teachers perceived that students also seemed very satisfied with the activities and reported that most students enjoyed participating.

The level of interest and curiosity in spatial thinking among the teachers was somewhat different between the two teachers. Teacher 1 described his concern about students learning spatial thinking skills using only technology even with the increasing shift to the digital age because some students struggle with using technology. Furthermore, he suggested that there is a significant part of the population that does not have access to technologies at home and therefore might suffer with skills more than students with technology access. Regardless of the equal playing field, he doubted that students will know the skills as much as they will know the technology insisting, "If students know how to use the technology then they can imply that they know the skills when they might not actually know them at all but rather have learned to use the technology." He also believes that the opposite effect is true in that students who suffer with technology skills might in fact learn the spatial thinking skills but because they are not strong in using technology, it may appear that they don't know the spatial skills because they have difficulty in using the technology. Conversely, Teacher 2 revealed that he loves spatial thinking skills and is intrigued by them. He explained that because he is so young in his teaching career that spatial thinking skills will aid in enhancing what is identified in the standards and will shape how he teaches students to think. He offered that it will provide "an added dimension to go beyond the black and white of the standards and will help students better visualize the settlement and development of our state and our world." Perhaps teaching more spatial thinking skills and geospatial technology skills in pre-service teacher curricula will increase the adoption of these critical yet marginalized components in classrooms in the future.

Student interest and curiosity in spatial thinking was reported by both teachers to initially have gone "completely over their heads." Their first introduction to these skills was in taking the pretest, STAT A. Numerous students in both intervention groups complained of the test's difficulty and vocally assumed that they could not do the work. Teacher 2 added that once students were presented with the lessons and engaged in activities that were more understandable, "they could see how it actually applies to geographers in real life and how they are faced with types of spatial questions that consider other factors such as wind direction. That's when they began to better understand the big picture." Both teachers agreed that for some students the sheer novelty of something so different was interesting and peeked curiosity. Teacher 2 pointed out that a lot of interest, confidence, and curiosity in technology among students is generational and that they don't have to think about using it correctly, they just innately know how to use it.

Both teachers valued the lessons and believed they contributed in improving the spatial thinking skills of students, as well as of themselves. Both teachers favored the paper over the digital medium as their preference of best improving students' spatial thinking skills. Teacher 1 responded, "Paper. Hands down paper maps without a doubt because I can assess it much better." He explained the difficulty in deciphering whether a student actually understands the skill or the technology more when using a computer. He elaborated that students couldn't tell whether the water was abrupt or gradual on Google Earth, so they just wanted to locate a tool to give them the answer without thinking about it. He observed that several students did not finish reading the questions clearly before wanting to locate an identified place on the map. For example, in the Charleston lesson, one question identified the Citadel Football stadium as being located at Point B. However, upon reading the words "Citadel Football Stadium," some students immediately typed those words into the search bar so that the application would locate it for them, not yet realizing that the question, in fact, specifically identified the proper location. He made a similar observation when students engaged the "roads layer" feature of the application to identify Interstates that were not labeled. Rather than trying to locate them on their own, many students used the application tools to find the answer for them. These situations are prime examples of knowing how to manipulate the technology to do the "thinking". Teacher 2 remarked that he preferred paper maps more because they relate more with history. However, he also claimed that Google Earth helps students understand that these places are real and not just something old drawn on a map.

Additionally, both teachers argued that the paper medium worked the best for their students largely in part due to issues with technology. Teacher 1 explained that it was easier for him to assess student understanding with the paper maps because he could hear them talking with each other, hear how they were reasoning, and see them touching, pointing and moving the map. He noted that with the digital maps, most students just clicked the mouse in silence which made it harder to assess student learning as well as student difficulties. This observation could be the result of four to five students working together on one printed map versus only two students working together on one computer. He also remarked that it was much easier for students to get sidetracked in the digital sessions than in the paper sessions because of the "bells and whistles" Google Earth contains as opposed to the paper maps. The issue of lack of student focus while using these technologies not only limits the amount of learning taking place, but can also lead to loss of focus by other students in the classroom. He added that once one person in the class got sidetracked and made a comment about something that they were observing on the computer screen, it became a domino effect as other students also lost focus on the task at hand. As an instructor, it can be difficult to manage and maintain group focus when it comes to technology regardless of the age group.

Teacher 2 experienced similar technological issues with the digital session. He stated that many students struggled to find the basic directional indicator (compass) on Google Earth because it wasn't as obvious as it appeared on the paper maps. The application only gives a "north" indicator and does not label the other three cardinal directions. He noted that some students in this group confused "east" and "west" because they were not clearly identified as they were on the paper maps. He reported that he liked the idea of students being able to touch and turn the map and having to utilize the scale to draw off distances and get a measurement rather than knowing how to locate the ruler tool on Google Earth and have it compute the distance for you. He did not like the fact that with the simple click of the mouse the operation automatically completed the task for the user. He contended that this ability takes away human discovery but also acknowledged this attitude may change once he becomes more confident in the technology.

It is interesting to note that both teachers in the study are classified as Digital Immigrants rather than Digital Natives (Prensky 2001). Digital Immigrants are people who were not born into the digital world, but at some point later in life have adopted many aspects of new technologies. Conversely, Digital Natives are people who were born in the digital world and thus are 'native' to the digital languages of computers, video games, and the internet. Prensky argues that Digital Immigrants struggle to teach Digital Natives because the two groups speak an entirely different language (2001). The teachers in this study could have a bias toward preference of paper map use over digital map use simply because they are Digital Immigrants. The confidence levels the teachers possessed about teaching with technology also likely influenced this paper map preference. Interest levels with technology in the classroom between the two teachers ranged from somewhat fearful to embracing it into the curriculum. However, the teacher who embraced using and teaching with technology reported being very confident in teaching with technology before the study began, but expressed in the interview that he in fact was not as confident as he initially perceived himself to be and experienced some frustrations in teaching with the Google Earth application.

3.3 Summary of Interviews

Both teachers reported that a large percentage of students enjoyed doing these activities more than they enjoyed the regular scheduled lessons in his class. Also, both teachers agreed that the students enjoyed doing something different, whether using paper or digital maps which could suggest that the sheer novelty of spatial thinking activities might be a factor in satisfaction levels. These claims are in line with reports of the majority of students interviewed. However, a common statement heard throughout the student interviews was the self-admitting statement by the student that he/she was not good at maps. It is uncertain whether this statement is true or simply perceived so by students. However, the frequency of the statement leads to the question of why the statement was made by multiple students. Is it due to a simple lack of map exposure or is it a deeper cognitive issue? Weeden (1997) suggests the concept of maps being drawn looking vertically down on an area is one that needs to be introduced and practiced because it is an unfamiliar viewpoint compared to the view from the ground as multiple students in this study described. Students and teachers alike reported that activities became easier with time as students were more exposed to maps and direct instruction of spatial thinking skills became more familiar. Overall, many students were heard commenting that the second lesson was easier than the first lesson. This statement is interesting because some students participated in the Charleston lesson first, while other students participated in the Myrtle Beach lesson first. These comments suggest that one lesson was not necessarily "easier" than the other lesson, but that perhaps the second lesson seemed easier to the students based off of a more developed sense of familiarity and simple increase in exposure to maps. Observations and interview responses indicated that the struggles with technology were more pronounced than the struggles with paper maps for both teachers. In turn, these struggles most likely influenced why both teachers preferred the paper medium. Furthermore, the issues of student focus in the Google Earth group also played a role in which media teachers prefer. If a particular medium interrupts classroom control and therefore student learning, it is easily discarded as ineffective and will in turn be used less frequently. It is important to point out that it is possible that teachers will teach with whichever medium they feel most confident in teaching, regardless of the documented benefits of another medium. Supporting past research (Hurst and Clough 2013; Pedersen et al. 2005) which have established that there is a greater preference for paper maps by both geographic experts and students, respectively, the paper maps medium was preferred by both teachers in this study. Although both teachers described challenges with each of the different media, they ultimately regarded both the paper and digital media as being valuable in the development of spatial thinking skills among students.

4 CONCLUSION

Spatial thinking and geospatial technologies have emerged as critical parts of today's contemporary society. This research investigated whether spatial learning outcomes differ with respect to the use of different instructional media and more specifically explored qualitative findings from student and teacher interviews not accessible through quantitative testing. This research furthers our understanding of how to best cultivate spatial thinking skills with students and demonstrates that these skills have multiple pathways to improvement as both media have their own benefits and weaknesses. Different types of spatial thinking skills are often best taught by differing instructional media (Collins 2018). Ultimately, spatial thinking skills should be taught in the K-12 curriculum through direct instruction utilizing both paper and digital instructional approaches to promote its inclusion in the classroom.

It is necessary to consider input from both students and teachers when preparing how to better foster spatial thinking among students. Both teachers in this study expressed concern that students as a whole are simply not as exposed to traditional paper maps as they once were in both classroom settings and life in general. Garfield expresses a similar concern suggesting that there is "value in getting lost occasionally, even in our pixilated, endlessly interconnected world. Children of the current generation will be poorer for it if they never get to linger over a vast paper map and then try in vain to fold it back to its original shape. They will miss discovering that the world on a map is nothing if not an invitation to dream" (2012, p. 1). Most simply, this research has shown that an increase in exposure to maps and spatial thinking activities regardless of media improve student spatial thinking skills. As students receive more exposure to both paper and digital maps, their awareness of space and spatial thinking skills increases. One of the participating teachers stressed the need to be purposeful about teaching spatial thinking, but went on to suggest that "we can at least start with more exposure to this way of thinking when using maps in addition to what life in general already provides." While this approach may seem less than innovative, it is nonetheless a foundation for inclusion in the curriculum. Furthermore, this study revealed that most students reported enjoying the novelty of this type of thinking and learning. Regardless of the selected media, both paper and digital maps serve as stimulants for geographic awareness in the classroom.

While teachers using geospatial technologies have experienced a multitude of successes in the classroom, teachers in this study support previous research by arguing that there are multiple barriers that accompany their educational use (Kerski 2003 and 2008; Kulo and Bodzin 2011). In addition to lack of student focus and difficulty in assessment of student learning as found in this study, one of the immediate obstacles to classroom use is the lack of training and knowledge about geospatial technologies among K-12 teachers. This lack of knowledge most certainly translates into a lack of confidence to incorporate these tools in the classroom. In addition, there are few opportunities for pre-service and in-service teachers to participate in meaningful training where they have the chance to develop confidence in utilizing these technologies in the classroom, which ultimately leads to competence. As noted, both teachers in this study are considered Digital Immigrants (Prensky 2001) and preferred paper over digital media. These Digital Immigrants often possess a reluctance to adopt geospatial technologies in their own classrooms. It is possible to propose that as more Digital Natives (Prensky 2001) enter the teaching profession in the future, there will be considerable more implementation of geospatial technologies as classroom tools.

Even as society becomes increasingly more and more digital, the results of this study demonstrate that there is still a need for the parallel existence of the use of paper map instruction as well as digital map instruction. However, it is vital that teachers are equipped with effective training to become not only competent, but confident users of geospatial technologies as instructional tools. It is equally important that the input of both students and teachers continue to hold an active influence in spatial thinking curriculum development. Nevertheless, to ensure effective and continuous implementation, our focus must be on pre-service training and equipping future teachers with the expertise of enhancing spatial thinking skills through instruction with both paper and digital maps.

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