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Improving Spatial Thinking Through Experiential-Based Learning Across International Higher Education Settings

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Abstract

Research in geographic education has a strong focus on the improvement of spatial thinking. For Millennials, spatial thinking curriculum could benefit from the inclusion of experiential-based learning activities. However, as universities are faced with larger class sizes, new approaches need to be incorporated by the instructors to offer improved learning environments. Courses introducing basic geography skills often incorporate lessons concerned with spatial thinking and global perspectives. Thus, the instruction of geographic tools such as Global Positioning Systems (GPS), longitude, latitude, and remote sensing offer prime opportunities for experiential-based learning in geographic pedagogy. This research aimed to employ a low-cost experiential-based learning method incorporating a geocaching activity to strengthen spatial thinking skills. The method was employed at universities in both the United States and Ethiopia with non-geography major students at different levels of study. The effectiveness of the method was measured utilizing the pre- and post- spatial thinking ability test (STAT). Additionally, the student's perceptions and experience with the activity were further explored through a survey. The results suggest that the geocaching activity significantly ($t(133)=-2.914$, $p=0.004$) improved the spatial thinking of the grouping of all students. These students showed significant improvements in orientation and directional abilities ($p=0.000$), spatial overlay and dissolve ($p=0.033$), and points, networks, regions/ spatial shapes and patterns ($p=0.003$). Additionally, students suggested they strongly agree that they enjoyed the activity (85.83%) and that the activity stimulated their thinking more than a lecture (79.69%). The findings suggest that the incorporation of an experiential-learning activity in the undergraduate classroom may lead to improvements in student spatial thinking.

Keywords

Geocache, GPS Learning, Experiential-Based Learning, Spatial Thinking, Millennial Learning, Spatial Learning.

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1 INTRODUCTION

Spatial thinking is a strong focus of geographic education research (Albert and Golledge 1999; Battersby et al. 2006; Bednarz 2004; Golledge 2002; Lee and Bednarz 2012 Marsh et al. 2007). The inclusion of spatial thinking improvements is essential at all educational levels (Lee and Bednarz 2012) and Millennials would benefit from the inclusion of experiential-based learning to improve spatial thinking (Fulford 2013; Roehling et al. 2011). However, this task is becoming more difficult for both American and Ethiopian higher education faculties (El Mansour and Mupinga 2007; Moore and Gilmatin 2010; Salmi et al. 2017). In the United States, class sizes are increasing while budgets are shrinking creating obstacles for faculty to deliver quality education (El Mansour and Mupinga 2007; Moore and Gilmatin 2010). Over the past 14 years, there has been a rapid growth in Ethiopia from eight universities with 40,000 students to 36 universities with 762,000 students (Salmi et al. 2017). This expansion has caused strain on the country's higher education system and its ability to employ adequately trained faculty members (Salmi et al. 2017). These circumstances for both higher education systems require pedagogical improvements to ensure students are engaged in the ever-growing classroom, especially for the so-called Millennial generation. Thus, this research aims to employ a standardized geospatial learning activity incorporating geocaching to examine Millennial spatial thinking improvement on an international scale.

Millennials are characterized as those born from 1982 to 2002 (Atkinson 2004; Much et al. 2014; Howe and Strauss 2000). Past research (Fulford 2013; Roehling et al. 2011) suggests both Millennials and non-Millennials benefit from the inclusion of experiential-based learning in curricula. Further, Ethiopian higher education researchers (Serbessa 2006; Sulaiman et al. 2008) have called for a transformation in the instructional methods within Ethiopia's learning institutions to move away from a lecture-based teaching methodology to techniques that encourage students to apply and critically think about the learning objectives (Sulaiman et al. 2008). Thus, to better acquire skills associated with introductory-level geography, the development of student-centered spatial learning pedagogies could aid both countries' growing Millennial population.

However, implementing introductory-level geography concepts (i.e., spatial thinking tools) using an experiential-based learning method can be challenging with the difficulties instructors are facing (El Mansour and Mupinga 2007; Moore and Gilmatin 2010; Salmi et al. 2017). Still, current trends in higher education require and recognize students' desire for engagement in their learning experiences (Garrison and Vaughan 2008; Sulaiman et al. 2008). To create an engaging learning experience, educators often employ experiential-based learning theory (Fulford 2013).

Experiential-based learning theory is the active participation and subsequent reflection through hands-on activities (Kolb 1984). Kolb and Frye (1974) suggest that the benefits of experiential-based learning come from a four-part cycle: 1) Obtainment of concrete experience with learning objectives/content; 2) reflection of current experience with past experiences; 3) development of new ideas based on this reflection; 4) action taken on new ideas through experimentation in an experiential setting.

This four-part cycle of experiential-based learning theory is rooted in Bloom's (1956) 'levels' of learning. The levels range from remembering (least complex), understanding, applying, analyzing, evaluating, and creating (most complex). In

Ethiopian (and many American) classrooms the 'chalk-and-talk' or lecturing experience only requires students to master the first level of learning (Becker and Watts 1996; Serbessa 2006). Experiential-based learning activities, on the other hand, can ensure that students acquire an opportunity to achieve all six of Bloom's learning levels (Bloom 1956). Additionally, experiential-based learning results in a higher information retention rate than lecture methods (75 vs. 5%, respectively; Fulford 2013). Thus, the inclusion of experiential-based learning methods would be expected to result in improved learning environments for both American and Ethiopian Millennials appropriating introductory-level geography concepts.

Geography, the "science of where," is concerned with spatial relationships between social and environmental phenomena (Kerski 2008). To comprehend this science, a student must be able to understand location and place entirely, thus requiring spatial awareness (Bednarz and Bednarz 2008; Golledge et al. 2008; Kerski 2008). Spatial awareness has been defined as skills associated with the analysis of spatial relationships in the world (Gersmehl and Gersmehl 2006; Gersmehl and Gersmehl 2007). Some of these skills include orientation, direction, overlay, dissolve, and spatial patterns (for more examples see: Gersmel and Gesmel 2007; Golledge et al. 2008; Janelle and Goodchild 2009).

To improve spatial awareness, introductory-level geography curricula focus on the acquisition of global perspective (Linadrkin and Kurdziel 2006; Merryfield et al. 1997) and effective spatial thinking (Golledge 2008). The incorporation of additional geospatial tools in curricula can increase spatial awareness (Berdnarz 2004; Huynh and Sharpe 2013; Lee and Bednarz 2009; National Research Council 2006; Nielsen et al. 2011) and improve understanding of both global and local issues (Bednarz and Van der Schee 2006). Furthermore, the incorporation of geospatial exercises can improve critical thinking, communicative, and analytical skills promoted by Bloom's (1956) levels of learning (Audet and Ludwig 2000; Demirci et al. 2013; Favier and Van der Schee 2014; Favier and Van der Schee 2012; Kerski 2003; Milson et al. 2012). Geospatial thinking can be a useful tool across disciplines, so it is critical to develop experiential learning activities that engage non-geography major students in improving their geospatial reasoning capacity.

The geographic curriculum often integrates geospatial tools, such as latitude/longitude, global positioning systems (GPS), and remote sensing (DeMers 2014). These geospatial tools allow students to analyze interrelated spatial phenomena utilizing many data (map) layers (Bednarz and Van der Schee 2006; Favier and Van der Schee 2014). This interrelated spatial analysis can provide an environment for increased spatial thinking (Flynn and Popp 2016). Flynn and Popp (2016) propose an affordable experiential-based learning method introducing students to a geocaching activity. The authors employ geospatial tools such as longitude, latitude, GPS, and remote sensing to improve student spatial thinking. Thus, this research aims to examine the geocaching activity's (Flynn and Popp 2016) effectiveness on spatial thinking in both American and Ethiopian higher education classrooms.

2 METHODS

2.1 Study Areas

This research employed a standardized geospatial learning activity at two universities in two distinct contexts, North America and Africa (Figure 1), to examine spatial thinking improvement on an international scale. The participating universities included the University of Arkansas-Fort Smith[1] (United States; UAFS) and Gondar University[2] (Ethiopia; GU). Established in 1928, and undergoing many higher education advancements since, UAFS (35.386ºN, -94.373ºW) currently serves ~7,000 students in 20 undergraduate programs and one graduate program (www.uafs.edu). GU (12.613ºN, 37.450ºE), established in 1954, currently serves ~22,000 undergraduates and ~2,000 graduates in 56 and 64 undergraduate and graduate programs, respectively (www.uog.edu.et). Both campuses are located on land exceeding 100 acres, serving as prime study areas for the geocaching activity.

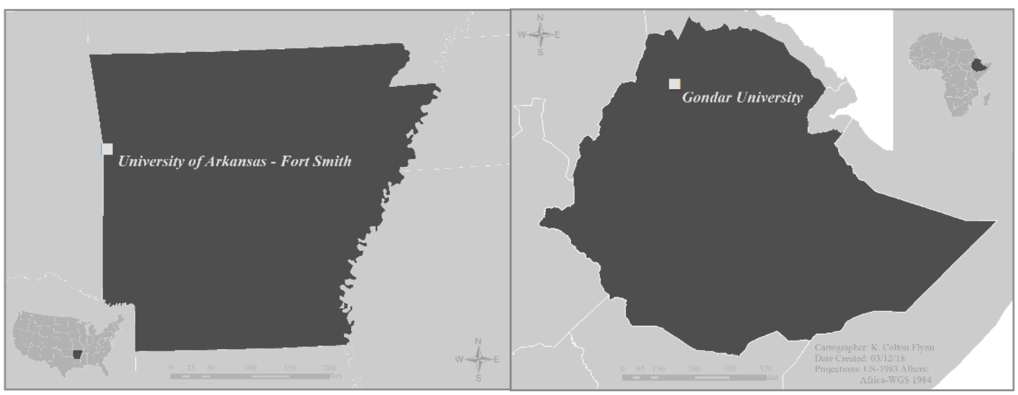

Figure 1. Location of the universities in Arkansas and Ethiopia that participated in the study. Cartographer: K. Colton Flynn.

2.2 Geocaching Activity

The action of 'geocaching' has been around since David Ulmer proposed the adventurous activity in 2000 (Cameron 2004; Schlatter and Hurd 2005). The purpose of geocaching is to pursue hidden items (caches) placed by civilians who provide a latitude and longitude of the caches' location (Kirriemuir 2012; Szolosi 2012). The easy-to-understand premise has allowed educators to utilize geocaching within their curricula (Flynn and Popp 2016; Lary 2004; Matherson et al. 2008; Szolosi 2012). Educators have included geocaching in their curricula as it is expected to improve students' spatial thinking. This study aims to test this expectation by incorporating the geocaching activity proposed by Flynn and Popp (2016). The geocaching activity requires pods to be hidden on the students' campus. These pods hold questions for the students to answer at each of the locations, they are also instructed to take a 'geo-selfie' at each of the locations to prove they were able to find the pod. The activity requires

[1] IRB Approval #14-006

[2] ቁጥር/Ref. #S/N/94011/2009

students to practice the use of latitude, longitude, GPS, and remote sensing to identify a given location (Flynn and Popp 2016). However, in Ethiopia, slight alterations had to be made because of a State of Emergency. The event resulted in a lack of internet, which prevented students from being able to access the cell phone app used in geocaching. Instead, the Ethiopian students (GU students) were provided an aerial photo of the campus with lines of latitude and longitude overlaid, simulating the cell phone app the American students (UAFS students) utilized. All other portions of the geocaching activity adhered to the proposed methods of Flynn and Popp (2016).

2.3 Pre- and Post-Spatial Thinking Assessments

This study uses the spatial thinking ability test (STAT) developed by Lee and Bednarz (2012) to determine whether or not students improved in their spatial thinking after the geocaching activity. Each portion of the 16-question (See Figure 2 for examples) assessment aims to examine components required for high levels of spatial thinking (Lee and Bednarz 2012; Golledge 2002; Gerseml 2005). These components aim to observe students' comprehension of the following categories of spatial thinking: 1) Orientation and directional ability [#1, #2]; 2) spatial patterns [#3]; 3) overlay and dissolve [#4]; 4) spatial form and transition [#5]; 5) spatial associations and comparisons [#6, #7]; 6) ability to transform one-dimensional representations to another [#8]; 7) overlay and dissolving maps [#9, #10, #11, #12]; 8) points, networks, regions; spatial shapes and patterns [#13, #14, #15, #16]. Lee and Bednarz (2012) created two versions (A and B) that were tested for use as pre- and post-assessments for analyzing improvements in spatial thinking. Their study found that students from three universities did not significantly (p>0.05) improve from test 'A' to test 'B' when provided no additional instruction (p. 24). Thus, American and Ethiopian students were provided with Lee and Benardz's (2012) version 'A' as the pre-assessment, while version 'B' was utilized for the post-assessment. Students were provided with little instruction prior to either assessment and were asked to mark each exam with a unique non-identifying number (the last four digits of their cell phone number was suggested) on each document for subsequent matching and analysis.

2.4 Experience Survey

Following the post-spatial thinking assessment, students were asked to participate in a survey to identify their perception and experience with the experiential-based learning activity. The survey tool consisted of four sections: General information, grades, experience, and personal information. The general information section asked simple 'yes' or 'no' questions that included students' experience with geocaching, familiarity with latitude and longitude coordinates to locate a point, and prior use of GPS. The grades section of the survey asked participants the percentage they believed was earned on the pre- and post-spatial thinking assessments. The experience section of the survey tool consisted of six questions with Likert-scale formats (i.e., strongly disagree, disagree, neutral, agree, and strongly agree). These questions were incorporated to provide an idea of the students' perception of the activity and to understand the relationship of their perceptions versus overall performance on the STAT pre- and post-assessment. The Likert-format statements were as follows:

1) This project stimulated my learning more than a lecture;

2) I would like to see more hands-on projects in my courses;
3) I would like to see projects similar to this project in my courses;
4) The learning objectives of this project were clear;
5) After completing this project, I have a stronger understanding of latitude and longitude;
6) I enjoyed this project.

The final section of the survey included demographic information including gender, students' chosen non-identifying number, age, year of college, and major.

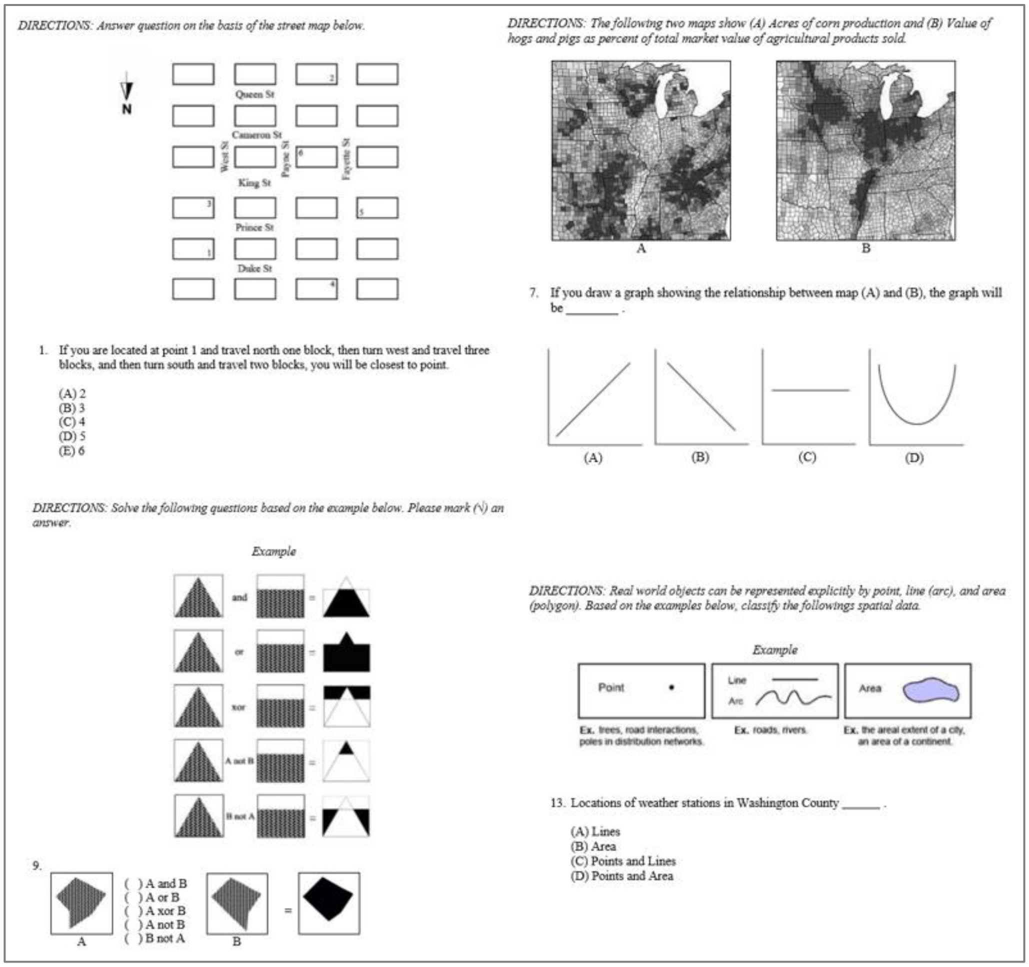

Figure 2. Examples selected from the spatial thinking ability test (STAT). As seen in: Lee and Bednarz (2012).

2.5 Statistical Analyses

Descriptive statistics were employed to analyze both the results of the STAT assessments and the experience survey. Pre- and post-assessment scores were compared using a paired-samples *t*-test to identify whether students significantly ($p<0.05$) improved their spatial thinking as a result of this activity. The assumptions (i.e., normality, skewness, and outliers) associated with a paired-samples *t*-test were adhered to before conducting the statistical analysis.

A McNemar test with a Yates correction was employed on each of the questions between the STAT pre- and post-assessment. The purpose of this test was to determine the component of spatial thinking that resulted in significant ($p<0.05$) improvement through participating in the experiential-based learning activity. This test was analyzed for American and Ethiopian student groups independently, as well as collectively.

Finally, a Pearson chi-square test was employed to determine a potential relationship between past experiences (i.e., having previously geocached, used latitude and longitude to identify a point, or operated a GPS) and a spatial thinking improvement. This test utilized the questions from the general information portion of the experience survey where yes (1) and no (0) were statistically analyzed for a significant ($p<0.05$) relationship with increased (1) and no increase (0) in spatial thinking.

3 RESULTS AND DISCUSSION

The pre- and post-assessment, geocaching activity, and experience survey were completed by 134 students. American students comprised 106 participants and a smaller sample of 28 Ethiopian students participated. The number of males (65) and females (69) were nearly equal. The average age of the student participants was 21.59 with a range from 18 to 54, suggesting most of the participants were Millennials (3 outliers; <1%). Most of the participating students were freshmen (32.80%) and sophomores (40.80%) early in their academic careers while higher level students (22%) and graduate students (4%) also participated.

3.1 Pre- and Post- Spatial Thinking Assessments

Descriptive statistics for the pre- and post-assessment (Table 1) suggest that the performance on each component of the STAT for the American students are at the level expected of higher education students from other states (i.e., Ohio, Texas, Illinois, and Oregon), while the Ethiopian students performed closer to the level of United States junior high or high school students on each of the components (Lee and Bednarz 2012).

Nevertheless, both groups of students independently improved their performance on 11 of 16 components from the pre- to post-assessment (Table 1). Furthermore, the mean score from the pre- to post-assessment improved for both groups independently and combined (Table 1), suggesting a correlation between the experiential-based learning activity and spatial thinking.

Table 1. Percentage correct per question and mean overall score for American, Ethiopian, and all students.

Spatial Thinking Comprehension Measures	**Question**	**All Students (Pre)** ***n*=134**	**All Students (Post)** ***n*=134**	**American Students (Pre)** ***n*=106**	**American Students (Post)** ***n*=106**	**Ethiopian Students (Pre)** ***n*=28**	**Ethiopian Students (Post)** ***n*=28**
Orientation and Direction Ability	**#1**	68.66	85.82	74.53	92.45	46.43	60.71
	#2	73.88	76.12	84.91	85.85	32.14	39.29
Spatial Patterns	**#3**	88.06	85.82	96.23	94.34	57.14	53.57
Overlay and Dissolve	**#4**	53.73	65.67	61.32	73.58	25.00	35.71
Spatial Form and Transition	**#5**	52.24	41.04	58.49	48.11	28.57	14.29
Spatial Association and Comparisons	**#6**	77.61	77.61	84.91	83.96	50.00	53.57
	#7	41.04	39.55	44.34	36.79	28.57	50.00
Ability to Transform One-Dimensional Representations to Another	**#8**	35.82	35.82	40.57	42.45	17.86	10.71
Overlaying and Dissolving Maps	**#9**	51.49	60.45	55.66	66.04	35.71	39.29
	#10	67.16	75.37	67.92	77.36	64.29	67.86
	#11	46.27	44.03	44.34	48.11	53.57	28.57
	#12	22.39	31.34	24.53	31.13	14.29	32.14
Points, Networks, Regions; Spatial Shapes/Patterns	**#13**	63.43	58.21	74.53	66.04	21.43	28.57
	#14	38.06	54.48	43.40	60.38	17.86	32.14
	#15	68.66	73.88	79.25	83.02	28.57	39.29
	#16	44.03	47.01	46.23	51.89	35.71	28.57
	Mean Score	8.93	9.52	9.81	10.42	5.57	6.14
	(*SD*)	3.29	3.16	2.63	2.62	3.39	2.71

Paired *t*-test were included in the statistical analyses for all students, American and Ethiopia, to further understand the impact of the experiential-based learning activity on student spatial thinking. Additionally, student groupings were subject to verification of paired samples *t*-test assumption individually. The assumptions were met by each of the groupings when concerned with normality and skewness. The 'all' student grouping had a single outlier for the pre- and post-assessment scores, though the outlier was kept for the statistical analysis as it did not result in any significant changes to the outcome.

The paired-samples *t*-test for all students' performance from the pre- (M= 8.93, SD=3.29; Table 1) to post-assessment (M= 9.52, SD=3.16; Table 1) resulted in a significant increase ($t(133)$=-2.914, p=0.004; Table 2). This result suggests that the incorporation of an experiential-based learning activity, such as geocaching, can increase spatial thinking. Thus, international higher education introductory geography curriculum would benefit from the inclusion of such an activity, as it may significantly (p=0.004) increase spatial thinking among participating students.

Similarly, the paired-samples *t*-test for American students analyzing performance from the pre- (M= 9.81, SD=2.62; Table 1) to post-assessment (M= 10.42, SD=2.62; Table 1) resulted in a significant increase ($t(105)$=-2.455, p=0.016; Table 2). Again, suggesting that geography curriculums within the United States may benefit more than Ethiopia from the incorporation of experiential-based learning techniques to increase spatial thinking.

Despite the increase in scores from the pre- (M= 5.57, SD=3.39; Table 1) to post-assessment (M= 6.14, SD=2.71; Table 1) the paired-samples *t*-test for the Ethiopian students did not result in a significant overall increase ($t(127)$=-1.816, p=0.080; Table 2). To benefit from higher levels of learning, the foundations of the field of study (geography) are required (Bloom 1956). Thus, while Ethiopian students' spatial thinking can benefit from the inclusion of an experiential-based learning activity, the inclusion of curriculum to build basic *understanding* (level 2 of Bloom (1956)) of spatial thinking skills prior to *application* (level 3 of Bloom (1956)) would greatly benefit their ability to increase spatial thinking.

Table 2. Paired-samples t-tests for pre- and post-assessment results.

Student	**Paired Samples Correlations**		**Paired Samples Test**		
Grouping	*Correlation*	*Significance*	*t*	*df*	*Significance*
All	0.732	0.000^{**}	-2.914	133	0.004^{**}
American	0.539	0.000^{**}	-2.455	105	0.016^{*}
Ethiopian	0.879	0.000^{**}	-1.816	27	0.080

$^{*}p<0.05$, $^{**}p<0.01$

To improve the understanding of spatial thinking components advanced by students participating in the experiential-based learning activity, each question was compared using a chi-square test for all, American, and Ethiopian students, respectively (Table 3). The McNemar (Yates corrected) tests resulted in three of the 16 components experiencing a significant increase from the pre- to post-assessment. Questions assessing students' spatial comprehension of direction and orientation [#1] (p=0.000, p=0.001) as well as points, networks, regions/spatial shapes and patterns [#14] (p=0.003, p=0.005) resulted in highly significant (p<.01) increases for 'all' and American students, respectively (Table 3). Additionally, the 'all' student grouping also experienced a significant (p<0.05) increase in spatial abilities involving overlay and dissolving [#4] (p=0.033), following the experiential-based learning activity.

The significant ($p<0.01$) increase in student direction and orientation spatial thinking [#1] has a direct relation to the experiential-based learning curriculum as students are required to self-orient in space utilizing a map. This is required to self-direct to a given location to retrieve caches or pods. The significant results for groupings 'all' and American students in spatial thinking involving points, networks, regions/ spatial shapes and patterns [#14] is a result of the geocaching activity requiring students to utilize an aerial view (remotely sense) to identify location. This spatial thinking component focuses on students' ability to 'comprehend spatial shapes and patterns' (Golledge 2002; Lee and Bednarz 2012). To complete the activity students must identify buildings, roads, sidewalks, and other major landmarks represented by 2-D shapes on their aerial photographs. Therefore, requiring students to utilize an aerial photograph to self-orient encouraged comprehension of familiar shapes and patterns in space. The spatial component related to comprehension of overlay and dissolving of layers (question #4) also had a significant (p=0.033) relationship for 'all' students. While the proposed experiential-based learning activity did not require dissolving of layers, it did require students to comprehend the relationship of interrelated spatial phenomena utilizing multiple data layers (Bednarz and Van der Schee 2006; Favier and Van der Schee 2014). The comprehension of interrelated spatial phenomena provides a rudimentary experience with the overlay component of spatial thinking (Golledge 2002; Lee and Bednarz 2012).

3.2 Experience Survey

The experience survey was implemented to obtain an improved understanding of the students' perceptions and experiences with the geocaching activity. Within the general information portion of the survey, most students (>76%; Table 4), from all three groupings, suggested that they had not geocached prior to this activity. Around half (50.94%; Table 4) of the American students had utilized latitude and longitude to locate a point. However, the Ethiopian students had limited participation in such an activity (32.14%; Table 4). An even greater difference was noticeable between American (95.28%; Table 4) and Ethiopian (14.29%; Table 4) students having utilized a GPS. This is likely due to a difference in technological access. The Ethiopian students nearly absent experience utilizing geospatial tools such as latitude, longitude, and GPS speaks to some of the difficulties experienced in conducting the geocaching activity as well as their spatial thinking performance. Future students in Ethiopia could benefit from increased exposure to these tools to improve spatial thinking and basic geographic knowledge.

The grading portion of the experience survey requested students estimate the score (%) earned on the pre- and post- STAT assessment. This question was included to gauge whether students believed their spatial thinking had improved following the geocaching activity. In all three groupings, the average predictions suggested that students believe they increased their spatial thinking skills (Table 5). While this was true for the average actual STAT scores (Table 5), the increase was not as high as what the average student predicted. Thus, it is possible that the experiential-based learning activity provides the students with greater confidence in their geospatial skills, which is a positive outcome of the activity that was not predicted prior to implementation.

Table 3. Results (*p*-values) of the McNemar (Yates Corrected) tests between pre- and post-assessment components for American, Ethiopian, and all students.

Spatial Thinking Comprehension Measures	**Question**	**All Students *n*=134**	**American Students *n*=106**	**Ethiopian Students *n*=28**
Orientation and Direction Ability	**#1**	0.000**	0.001**	0.219
	#2	0.701	1.00	0.688
Spatial Patterns	**#3**	0.581	0.727	1.00
Overlay and Dissolve	**#4**	0.033*	0.060	0.508
Spatial Form and Transition	**#5**	0.053	0.144	0.219
Spatial Association and Comparisons	**#6**	1.00	1.00	1.00
	#7	0.878	0.215	0.109
Ability to transform one-dimensional representations to another (and reverse)	**#8**	1.00	0.871	0.727
Overlaying and Dissolving Maps	**#9**	0.073	0.080	1.00
	#10	0.126	0.110	1.00
	#11	0.780	0.636	0.065
	#12	0.081	0.281	0.180
Points, Networks, Regions; Spatial Shapes/Patterns	**#13**	0.349	0.175	0.688
	#14	0.003**	0.005**	0.388
	#15	0.324	0.572	0.508
	#16	0.644	0.345	0.791

$^{*}p<0.05$, $^{**}p<0.01$

Table 4. Percentages of whether participating students have past experiences with geospatial activities/tools.

Past Geospatial Experience	**All Students** ***n*=134**		**American Students** ***n*=106**		**Ethiopian Students** ***n*=28**	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
Geocached	20.90	79.10	23.58	76.42	10.71	89.29
Utilized Latitude and Longitude to Locate a Point	47.01	52.99	50.94	49.06	32.14	67.86
Utilized GPS	78.26	21.64	95.28	4.72	14.29	85.71

Table 5. Predicted versus actual scores (%) earned on the pre- and post- STAT assessment.

STAT Scores	**All Students** ***n*=134**		**American Students** ***n*=106**		**Ethiopian Students** ***n*=28**	
	Pre (%)	*Post (%)*	*Pre (%)*	*Post (%)*	*Pre (%)*	*Post (%)*
Predicted	66.78	75.97	69.40	78.97	53.81	61.24
Actual	55.81	59.50	61.31	65.13	34.81	38.38

The final portion of the experience survey employed the use of a Likert-scale (i.e., strongly disagree, disagree, neutral, agree, and strongly agree) providing students with statements related to their perceptions of the experiential-learning activity. For all statements, over 70% (Figure 3) of students suggested they agreed or strongly agreed. Meaning most (>70%; Figure 3) students understood the learning objectives (89.84%; Figure 3) of a project that stimulated their thinking more than a lecture (79.69%; Figure 3). The students enjoyed the project (85.83%; Figure 3) and would like to see similar (70.87%; Figure 3) hands-on (77.34%; Figure 3) projects in their courses. Most importantly, for spatial thinking tools and introductory geography curriculum, most students agreed or strongly agreed that the experiential-based learning activity strengthened their understanding of latitude and longitude (74.22%; Figure 3).

3.3 Spatial Thinking Improvement and Experience Survey

To further support the significance of past experiences on the level of students' spatial thinking, Pearson chi-square tests were utilized to determine significant ($p<0.05$) relationships between questions within the general information portion of the experience survey and the STAT assessments. While there were no significant relationships between increased spatial thinking and having utilized latitude and longitude to locate a point ((1, n=134)=0.071, p=0.791; Table 6); there was a significant result for those that had not geocached prior to the pre-assessment ((1, n=134)=4.571, p=0.033; Table 6). This statistically significant ($p<0.05$) result suggests that students' spatial thinking benefits from participation in a geocaching activity, such as the exercise (Flynn and Popp 2016) analyzed in this study.

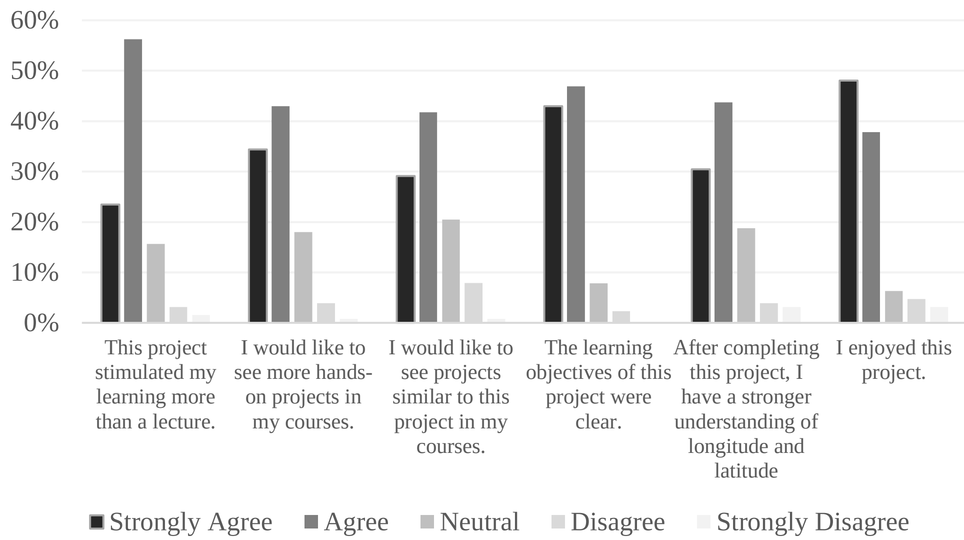

Figure 3. Graphical depiction of ‘all’ students’ (n=134) responses to the Likert-format statements.

Table 6. Pearson chi-square analysis results for relationships between past geospatial experiences and spatial thinking improvement.

Past Geospatial Experience	**Chi-square value**	***df***	***p*-value**
Geocached	4.571	1	0.033*
Utilized Longitude and Latitude to Locate Point	0.071	1	0.791
Utilized GPS	0.958	1	0.328

*p<0.05

4 CONCLUSIONS

The inclusion of geographic experiential-based learning in higher education classrooms can be difficult due to growing course enrollment sizes, tight budgets, and a lack of lab hours (El Mansour and Mupinga 2007; Moore and Gilmatin 2010; Salmi et al. 2017). However, advancements and creativity in geography curriculum can make the difficult, possible. Thus, this study aimed to analyze the effectiveness of a new method (Flynn and Popp 2016) of experiential-based learning employing geocaching to improve spatial thinking of American and Ethiopian students. Additionally, the study intended to investigate students’ experience and perception of the geocaching activity.

Working with 134 students from two countries, the STAT (Lee and Bednarz 2012) pre- and post-assessment suggests that students significantly (p=0.004) increased their spatial thinking following the experiential-based learning activity. However, while both subsets of students increased their spatial thinking, American students (p=0.016) significantly benefitted from the activity while their Ethiopian counterparts (p=0.080) did not. This result is likely associated with the lack of *understanding* of basic geographic skills before the *application* of those same skills (Bloom 1956). Nevertheless, all students significantly increased three components of spatial thinking following the geocaching activity. The components included improvements in comprehension of direction and orientation (p=0.000), shapes and patterns in space (p=0.003), and overlay and dissolve (p=0.033).

One important limitation of this study is that the survey and learning activity were conducted in English by an American-English instructor. While Ethiopian higher education does utilize English as the language of instruction, it is possible that students learning geospatial reasoning in their non-native language may require additional support and time to understand the concepts. It is also possible that limited exposure to GPS, maps, and other geospatial tools impacted the scores obtained in during this activity. Further research should look to identify culturally appropriate means of providing experientially based learning activities.

Nevertheless, student perception of the experiential-based activity suggested most (>70%) students understood the learning objectives of a project that, in their opinion, stimulated their thinking more than a lecture. The students suggested they enjoyed the project and would like to see similar hands-on projects in their courses. Most importantly, for spatial thinking tools and introductory geography curriculum, most students perceived the experiential-based learning activity as a tool to strengthen their understanding of latitude and longitude. Moreover, while the geocaching activity's effect on the development of latitude and longitude skills was not analyzed, the activity's effect on increased spatial thinking was included in this study. A Pearson's chi-square test suggested a significant ((1, n=134)=4.571, p=0.033) increase in spatial thinking skills for those that had not participated in a geocaching activity before this project.

The results of this study suggest that an affordable and easy-to-implement experiential-based learning activity proposed by Flynn and Popp (2016) could aid American and Ethiopian universities in their pursuit to ensure an environment conducive to improving spatial thinking and that future geospatial activities may benefit from being tailored to students' baseline levels of knowledge and cultural context.

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