Influence of Geographic Affiliation on Student Performance in Online Geology and Meteorology Courses

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ABSTRACT

The online learning environment can add substantial advantages to learning such as continuous access to material and the ability to foster learning through additional visual supplemental materials, but it can also add further challenges that may not be as evident when teaching traditional, face-to-face courses. An individual's place affiliation may impact learning outcomes in geographically-dependent science content-specific science courses such as geoscience courses. This study focused on challenges associated with teaching and assessing geographically-dependent content in online master's level geology and meteorology courses. Students in these courses were asked to identify their home regions prior to the start of the master's program. When assessments for both courses were analyzed using a repeated-measures test, meteorology courses revealed significant differences between students' home regions for multiple assessments. © *2017 National Association of Geoscience Teachers*. [DOI: 10.5408/15-139.1]

Key words: geographic affiliation, online learning, sense of place

INTRODUCTION

The understanding of an individual's sense of place/geographic affiliation in conjunction with his or her ability to acquire new knowledge in an online environment is an innovative field. Under the constructivist mindset, an individual enters a classroom with myriad previous location-based experiences. These experiences enable a student to apply new information to relevant past experiences involving specific places. In this fashion, previous place knowledge may allow for a higher level of understanding and application (e.g., as associated with Bloom's [2004] revised taxonomy) as opposed to simply remembering or recalling information. Understanding a student's previous place knowledge is a helpful educational strategy, and it is often used by geology and meteorology university instructors in traditional classroom settings when giving local or regional examples of landforms and weather. This concept presents a greater challenge for instructors of online courses where additional geographic challenges may arise.

In online courses, students enter the classroom from multiple geographic locations. Whereas the instructor in a traditional classroom typically is aware of students' past experiences and cultural backgrounds—because this often represents a local population—this is not the case within an online classroom. Do the various geographic backgrounds of students, influencing their sense of place, influence students' performance on geoscience content in an online classroom?

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BACKGROUND

Online Learning

Online course enrollment and students wishing for online opportunities has continued to rise over the past decade with a 21% growth in enrollment from 2009 to 2010 alone (Allen and Seaman, 2010). Taking a course in an online setting can offer many advantages, especially for nontraditional and working students. An online course can offer a more flexible schedule, and allows for further collaboration over space, continuous access to learning materials, student-centered self-assessments, and the true employment of constructivist learning pedagogies (Ritter, 2012). Other advantages include the notion that instructors are better able to focus students on pertinent material and reduce information overload, and supplemental materials such as videos, charts, graphs, and other visual aids can be more easily used to enhance the learning experience (Barton, 1998). A shift from teacher-centered to student-centered and student-driven learning also may be a positive outcome of online learning environments (Ritter, 2012). This shift allows for enhanced critical thinking, essential to scientific learning, by students when completing online assignments and projects (Ritter, 2012). Online courses may be the ideal setting for fostering critical thinking skills and creating scientifically literate citizens, but this same environment can add many challenges when creating and running online science courses. A notable challenge is the ability to tailor course material to individual students when the students vary greatly not only demographically but also spatially. To address this issue, it is important, based on the constructivist learning theory, to first establish what the student already knows (Ausubel, 1968).

Human Constructivism and Sense of Place

The pioneering work of science educational researcher Novak (1963), and longitudinal studies in the learning theory of human constructivism (Mintzes et al., 1998, 2000), posited that humans construct meaning from lived experiences as they integrate new concepts within existing frameworks. For effective instruction and student learning to occur, our students must be able to assimilate the new concepts into their cognitive structures. Therefore, it was not surprising when our previous research that probed students' sense of place within traditional classroom environments revealed that the local environment appeared to have the greatest impact on students' reflections and interests (Clary and Wandersee, 2006). Within online environments, a "local environment" for students was disparate, but research demonstrated the importance of including online students' local environments within course assignments (Clary and Wandersee, 2010) as well as local environmental correlation with student concern for environmental issues (Clary et al., 2013). As a result, instructor awareness of students' geographical backgrounds—as well as students' incoming content knowledge—is important as instructors plan and implement effective instruction within both traditional and online classrooms.

Geographical Location and Sense of Place

The concept of a "sense of place" in geosciences encompasses multiple variables, including geographic location, aesthetic values, and cultural affiliations (Semken and Butler Freeman, 2008; Semken et al., 2009). Sense of place has been linked to a variety of traits including cognition, emotional as well as interest modifiers, behavioral alterations, and pro-environmental ideas and intentions (Jorgensen and Stedman, 2001). Although not the only variable affecting sense of place, geographic affiliation was found, in some circumstances, to have a strong correlation with sense of place among online students (Sumrall, 2015). Therefore, in this research, we focus upon geographic location; we consider the definition of sense of place as an individual's attachment and place meaning to a specific geographic location (Buttimer, 1976; Tuan, 1976). Because an individual creates many place attachments throughout his or her life, the attachments are internally ranked in a hierarchical system of importance, and the primary place attachment, or *idiotopy*, may stand out as a point of reference for future place meanings (Pascual-de-Sans, 2004). A person may leave a primary place and its associated attachment behind, but childhood place attachments can be etched in the individual's mind and influence the understanding of future geographic settings, as well as a person's interests and content knowledge (Clary and Wandersee, 2006; Clary et al., 2013). The learning theory of human constructivism acknowledges that we build upon our previous "place," underscoring the influence of geographic affiliation.

Place attachments are shaped through sense perception within a particular geographic location, and they can be enhanced by social interactions within these settings (Tuan, 1976; Shamai and Ilatov, 2005). In this way, an individual's sense of place involves place, social interactions, and cultural knowledge. Stedman (2002) stated that a place's meaning is a vital component to the physical place itself. Sense of place is not merely a bond or attachment to a place; it contains a cognitive aspect. This knowledge and attachment to physical places can dictate an individual's perception, which may influence a student's comprehension of geoscience material.

Therefore, an individual's geographic affiliation, and theoretically his or her sense of place, plays a role in the learner's cognitive, affective, and connotative domain (Canter, 1991; Riley, 1992), and has a potential link to an individual's incoming knowledge in online geology and meteorology courses (Sumrall et al., 2015). This study probes the connection between geographic affiliation, an important variable in sense of place, and an individual's understanding of geology and meteorology concepts within online introductory geoscience courses.

METHODS

The research subjects were enrolled in an online master's program that targets in-service teachers. Institutional review board approval through the university review board was obtained prior to the start of the study. Students beginning this online master's program in the 2012 and 2013 fall semesters were asked to participate in a longitudinal study that would follow them throughout their program. Out of the total 115 possible participants (61 in the fall of 2012 and 54 in the fall of 2013), 47% of the students ($n = 54$) selected to fully participate in the initial offering of the study. Most participating students are current K–12 science teachers. Benchmark data were collected through the use of pre-surveys prior to the start of the program, and students were asked to identify their "home" region (Fig. 1). Previous course knowledge was addressed using a concept based test to determine any previous knowledge gaps within and between regions. No overall previous knowledge gaps between regions were identified (Sumrall et al., 2015). Additionally, participants were encouraged to complete sense of place writing templates in meteorology and geology (Clary and Wandersee, 2006; Clary et al., 2013). These templates were coded in order to verify the linkage of "home region" to the individual's primary childhood sense of place. The results of these templates, as well as interviews with individual students, are the subject of another manuscript in process. The participants agreed to allow the researchers to collect and analyze test scores throughout the program. Scores for the Geology I and Meteorology I courses are analyzed in this paper.

A total of 31 participants completed the Geology I course between the fall of 2012 and the spring of 2014, and 52 participants completed Meteorology I between the fall of 2012 and the spring of 2014. The Geology I course is typically taken in the spring of a student's first year and is taught by one instructor, whereas Meteorology I is often the first course that incoming students take during the fall of the first year, and it is also only taught by one instructor. Quizzes were open book and there were no time limits, as long as they were completed by the due date and time. The content area of each quiz is described in Table I. The midterm and final exams had time limits. The assessment scores for both Meteorology I and Geology I were analyzed using a repeated-measures test in SPSS software, (IBM SPSS Statistics for Windows, Version 22.0; IBM, Armonk, NY) and a Bonferroni adjustment was applied to reduce the possibilities of Type I errors. Although the Bonferroni adjustment reduces Type I errors, it is a conservative adjustment, so p values pre- and post- adjustment are included for comparison. These tests were performed to determine the relationships between the different assessments and whether certain assessments garnered higher or lower means scores. This helped determine if certain assessments may have been harder or easier overall than other assessments. This also helped to further understand

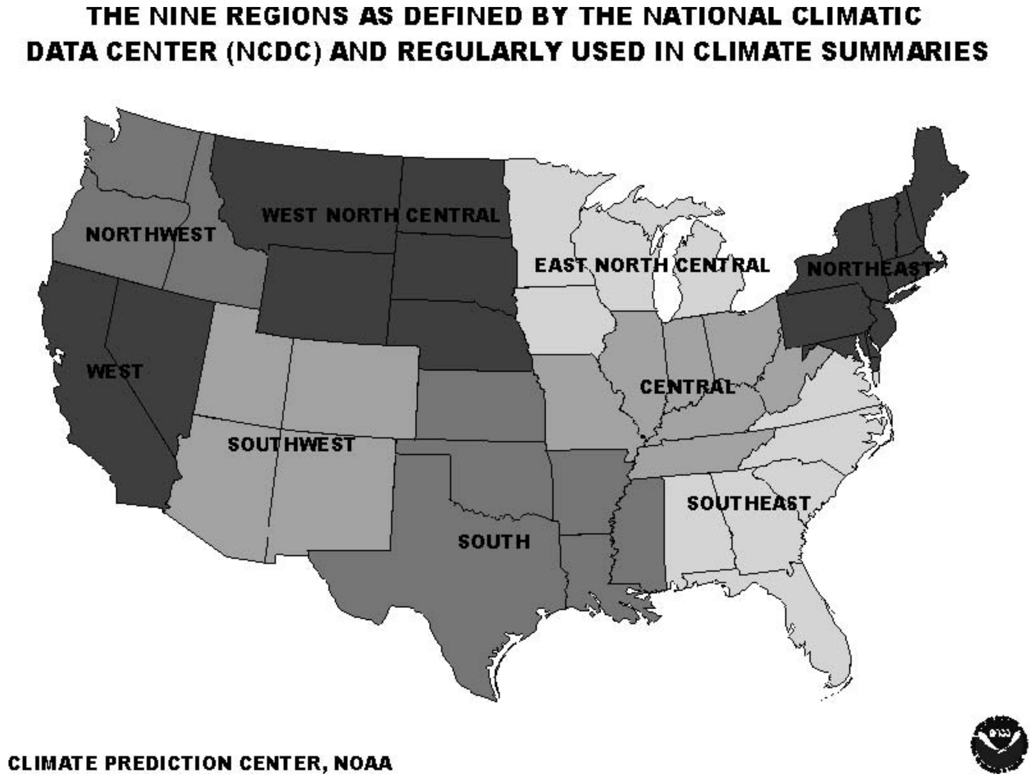

FIGURE 1: Each study participant identified his/her home region based on this map. This is a climatic region map created by NOAA and available on the NOAA website.

larger variations within certain assessments for the overall group of students.

RESULTS

Figures 2 and 3 represent the distribution of mean values for the assessments in the Meteorology I and the Geology I courses for the fall of 2012 to the spring of 2014. Table II reports the meaning of each assessment value. Overall, the quiz grades, of relatively low point value, have higher relative means than the assignments, midterm, and the final exams.

To determine the differences in mean assessment score values between the regions where students call "home," Kruskal–Wallis ranking tests with an alpha of 0.05 were run in SPSS for each assessment. This nonparametric statistical analysis was performed multiple times for each assessment. The first time, all regions with two or more students were included in the test. The Kruskal–Wallis test is known for being robust, but it is generally accepted to require at least three or more participants within a given category for more

TABLE I: A representation of the content area for each quiz in Meteorology I (Met I) and Geology I (Geo I).

Course	Quiz Number	Content	Course	Quiz Number	Content
Met I	1	Structure/Composition of the Atmosphere	Geo I	1	Introduction
Met I	2	Atmosphere/Earth-Sun Relationships	Geo I	2	Minerals and Igneous Rocks
Met I	3	Radiation, Heating/Cooling, Temperature	Geo I	3	Weathering and Soil
Met I	4	Atmospheric Moisture	Geo I	4	Sediments and Sedimentary Rocks
Met I	5	Adiabatic Processes and Stability	Geo I	5	Metamorphic Rocks
Met I	6	Clouds and Forms of Condensation	Geo I	6	Deserts, Wind, Glaciers and Glaciations
Met I	7	Precipitation: Process and Forms	Geo I	7	Oceans and Shorelines
Met I	8	Atmospheric Pressure, Wind, and Circulation	Geo I	8	Running Water
Met I	9	Local Winds and Global Circulations	Geo I	9	Groundwater and Mass Wasting
Met I	10	Jet Streams, El Nino, and Teleconnections	Geo I	10	Plate Tectonics and Crustal Deformation
Met I	11	Air Masses, Fronts, and Mid-Latitude Cyclones	Geo I	11	Volcanism and Geologic Time
Met I	12	Mid-Latitude Cyclone Weather	Geo I	12	Earthquakes and Earth's Interior

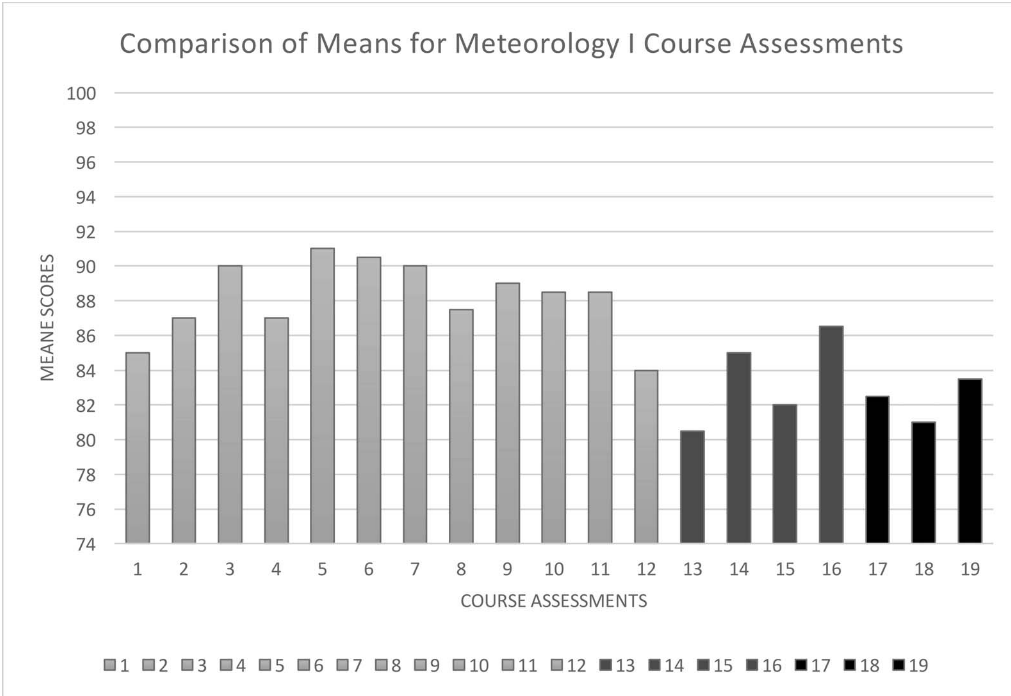

FIGURE 2: Comparison of means for Meteorology I assessments. Mean values for assessments from Meteorology I courses from the fall of 2012 to the spring of 2014. Blue bars represent quiz scores, purple bars represent assignment scores, and red bars represent exam scores.

accurate results (Zar, 2010). Therefore, the test was run again for each assessment, and only regions with three or more students were included in the analysis (n = 6 for Meteorology I) and (n = 3 for Geology I). Table III illustrates the number of students within each region for each of the courses.

Meteorology Assessments

Specific Meteorology I assessments show significance between certain regions. Table IV records the overall Kruskal–Wallis statistical value for each assessment. The significant *p* values for quizzes are identified by asterisks

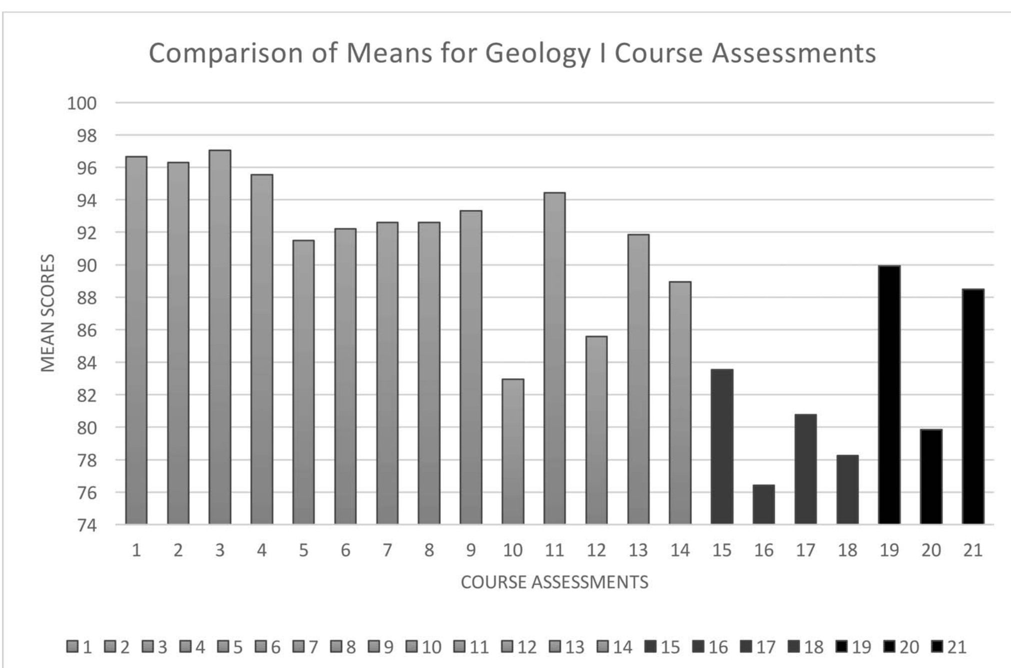

FIGURE 3: Comparison of means for Geology I assessments. Mean values for assessments from Geology I courses from the fall of 2012 to the spring of 2014. Blue bars represent quiz scores, purple bars represent assignment scores, and red bars represent exam scores.

TABLE II: Assessment key for Figs. 2 and 3; key for Figs. 2 and 3 assessment names.

Meteorology Assessment Key		Geology Assessment Key	
Graph Value	Assessment	Graph Value	Assessment
1	Quiz 1	1	Quiz 1
2	Quiz 2	2	Quiz 2
3	Quiz 3	3	Quiz 3
4	Quiz 4	4	Quiz 4
5	Quiz 5	5	Quiz 5
6	Quiz 6	6	Quiz 6
7	Quiz 7	7	Quiz 7
8	Quiz 8	8	Quiz 8
9	Quiz 9	9	Quiz 9
10	Quiz 10	10	Quiz 10
11	Quiz 11	11	Quiz 11
12	Quiz 12	12	Quiz 12
13	1st Quarter Assignment	13	Mineral Quiz
14	2nd Quarter Assignment	14	Rock Quiz
15	3rd Quarter Assignment	15	1st Quarter Assignment
16	4th Quarter Assignment	16	2nd Quarter Assignment
17	Midterm	17	3rd Quarter Assignment
18	Final Exam	18	4th Quarter Assignment
19	Final Grade	19	Midterm
		20	Final Exam
		21	Final Grade

TABLE III: Number of students per region in Geology I and Meteorology I.

Geology I		Meteorology I	
Region	n	Regions	n
Central	12	Central	13
East North Central	2	East North Central	3
Northeast	6	Northeast	13
South	2	South	5
Southeast	5	Southeast	9
Northwest	1	Northwest	2
Southwest	1	Southwest	3
West	1	West	2
West North Central	1	West North Central	2
Total	31	Total	42

TABLE IV: Kruskal–Wallis values for Meteorology I assessments. Statistical values of a Kruskal–Wallis test on each of the Meteorology I assessments. Assessments 3, 4, 7, and 11 show between-region statistical significance. Significant values are denoted with an asterisk.

Assessment	Chi-square Value	df	*p* Value
Quiz 1	7.074	5	0.215
Quiz 2	1.743	5	0.883
Quiz 3	13.129	5	0.022*
Quiz 4	12.846	5	0.025*
Quiz 5	3.758	5	0.585
Quiz 6	1.455	5	0.918
Quiz 7	18.683	5	0.002*
Quiz 8	4.843	5	0.435
Quiz 9	3.310	5	0.652
Quiz 10	8.712	5	0.121
Quiz 11	14.033	5	0.015*
Quiz 12	6.643	5	0.249
1st Quarter Assignment	8.133	5	0.149
2nd Quarter Assignment	2.753	5	0.738
3rd Quarter Assignment	7.058	5	0.216
4th Quarter Assignment	1.758	5	0.882
Midterm	8.768	5	0.119
Final Exam	8.852	5	0.115
Final Grade	9.192	5	0.102

within the table. There was a significant difference in assessment scores between regions for quiz 3, quiz 4, quiz 7, and quiz 11. It is important to note that there was no significance found between regions for the overall final grade in the course.

To determine where the significance lies between the regions, a pairwise comparison was run and a Bonferroni adjustment was used to reduce Type I errors when interpreting results. Pairwise comparison tables (V, VI, VII, VIII) for each of the assessments showing significance were created to represent overall significance, and significance after the Bonferroni adjustment was applied. The Bonferroni adjustment, though limiting Type I errors, is robust and it can increase the chances of a Type 2 error (the acceptance of the null hypothesis when it should be rejected). Therefore, both the unadjusted and the adjusted *p* values for the regional pairwise comparisons are listed in the tables. The acceptance or rejection of the Bonferroni adjustment results in little change in the statistical interpretation (Tables V–VIII). Table IX shows the mean scores by region for the quizzes showing significant differences between regions. A more detailed description of the assessment contents will be examined in the discussion section.

Geology Assessments

A Kruskal–Wallis statistical test was also run for each of the Geology I assessments. Students now typically take Geology I in the spring semester of their first year in the program, but some opt to schedule only one course per

TABLE V: Pairwise comparisons for Meteorology I quiz 3 (radiation, heating/cooling, temperature). Pairwise comparison table indicating comparisons between specific regions for quiz 3. Both the *p* value and the adjusted *p* values using the Bonferroni adjustment are provided. Significant *p* values are denoted with an asterisk.

Regional Comparison	Test Statistic	Standard Error	Standard Test Statistic	*p* Value	Adjusted *p* Value
Southwest–South	1.1	9.308	0.118	0.906	1
Southeast–Southwest	1.611	8.497	0.19	0.85	1
Southwest–Central	12.769	8.163	1.564	0.118	1
Southwest–Northeast	14	8.163	1.715	0.086	1
Southwest–East North Central	23	10.406	2.21	0.027*	0.406
Southeast–South	−0.511	7.109	−0.072	0.943	1
Central–South	11.669	6.707	1.74	0.082	1
South–Northeast	12.9	6.707	1.923	0.054	0.816
East North Central–South	−21.9	9.308	−2.353	0.019*	0.279
Southeast–Central	11.158	5.527	2.019	0.043	0.652
Southeast–Northeast	12.389	5.527	2.242	0.025*	0.375
Southeast–East North Central	−21.389	8.497	−2.517	0.012*	0.177
Central–Northeast	−1.231	4.999	−0.246	0.806	1
East North Central–Central	−10.231	8.163	−1.253	0.21	1
East North Central–Northeast	−9	8.163	−1.102	0.27	1

semester, and finish the meteorology courses first. We had a smaller number of total participants who finished the Geology I (n = 31) course compared with the Meteorology I (n = 52) course over the same time period. Due to the lack of numbers in certain regions, only five of the regions had two or more individuals to make comparisons between regions, and only three regions had three or more students to make comparisons. Unlike the Meteorology I assessments, the Geology I assessments showed no overall significance between the regions. Content areas for quizzes suggest that certain quizzes, such as quiz 6 and quiz 7, may list geographically specific concepts. But these may be broader concepts with less locational specificity than some of the meteorological topics and questions. For instance, quiz 6 encompasses concepts involved in deserts, wind, glaciers, and glaciation, and quiz seven tested the students on concepts regarding oceans and shorelines. Table X illustrates the statistical values for the different Geology I assessments.

TABLE VI: Pairwise comparisons for Meteorology I quiz 4 (atmospheric moisture). Pairwise comparison table indicating comparisons between specific regions for quiz 4. Both the *p* value and the adjusted *p* values using the Bonferroni adjustment are provided. Significant *p* values are denoted with an asterisk.

Regional Comparison	Test Statistic	Standard Error	Standard Test Statistic	*p* Value	Adjusted *p* Value
Southwest–South	6.8	9.205	0.739	0.46	1
Southeast–Southwest	−6.375	8.533	−0.747	0.455	1
Southwest–Central	5.923	8.073	0.734	0.463	1
Southwest–Northeast	13.385	8.073	1.658	0.097	1
Southwest–East North Central	4.5	10.291	0.437	0.662	1
Southeast–South	13.175	7.185	1.834	0.067	1
Central–South	−0.877	6.633	−0.132	0.895	1
South–Northeast	6.585	6.633	0.993	0.321	1
East North Central–South	2.3	9.205	0.25	0.803	1
Southeast–Central	12.298	5.664	2.171	0.03*	0.449
Southeast–Northeast	19.76	5.664	3.489	0.001*	0.007*
Southeast–East North Central	−10.875	8.533	−1.274	0.203	1
Central–Northeast	−7.462	4.944	−1.509	0.131	1
East North Central–Central	1.423	8.073	0.176	0.86	1
East North Central–Northeast	8.885	8.073	1.101	0.271	1

TABLE VII: Pairwise comparisons for Meteorology I quiz 7 (Precipitation: Process and Forms). Pairwise comparison table indicating comparisons between specific regions for quiz 7. Both the *p* value and the adjusted *p* values using the Bonferroni adjustment are provided. Significant *p* values are denoted with an asterisk.

Regional comparison	Test Statistic	Standard Error	Standard Test Statistic	*p* Value	Adjusted *p* Value
Southwest–South	16.167	9.19	1.759	0.079	1
Southeast–Southwest	2.611	8.39	0.311	0.756	1
Southwest–Central	7.205	8.06	0.894	0.371	1
Southwest–Northeast	21.513	8.06	2.669	0.008*	0.114
Southwest–East North Central	19.667	10.275	1.914	0.056	0.834
Southeast–South	13.556	7.019	1.931	0.053	0.802
Central–South	−8.962	6.622	−1.353	0.176	1
South–Northeast	5.346	6.622	0.807	0.419	1
East North Central–South	−3.5	9.19	−0.381	0.703	1
Southeast–Central	4.594	5.457	0.842	0.4	1
Southeast–Northeast	18.902	5.457	3.464	0.001*	0.008*
Southeast–East North Central	−17.056	8.39	−2.033	0.042*	0.631
Central–Northeast	−14.308	4.936	−2.899	0.004*	0.056
East North Central–Central	−12.462	8.06	−1.546	0.122	1
East North Central–Northeast	1.846	8.06	0.229	0.819	1

DISCUSSION

When the Meteorology I and Geology I course assessment were analyzed using a repeated-measures test, it became clear that there were differences between the mean scores of individual assessments. As one might expect, the final comprehensive exam for both courses garnered one of the lowest mean values. It also became apparent that the quarterly assignments and midterm exams may have been more challenging for the students than the weekly quizzes. It is important to note that the quiz protocol versus the midterm and test protocols was a possible reason for this difference in scores. Although quizzes and examinations were open-book format, quiz protocol allowed outside resources (e.g., internet websites) while the quiz was in progress. There were also no time limits on quizzes, which could be accessed multiple times before submission.

TABLE VIII: Pairwise comparisons for Meteorology I quiz 11 (air masses, fronts, and midlatitude cyclones). Pairwise comparison table indicating comparisons between specific regions for quiz 11. Both the *p* value and the adjusted *p* values using the Bonferroni adjustment are provided. Significant *p* values are denoted with an asterisk.

Regional Comparison	Test Statistic	Standard Error	Standard Test Statistic	*p* Value	Adjusted *p* Value
Southwest–South	2.933	9.394	0.312	0.755	1
Southeast–Southwest	0.333	8.576	0.039	0.969	1
Southwest–Central	3.987	8.239	0.484	0.628	1
Southwest–Northeast	15.795	8.239	1.917	0.055	0.829
Southwest–East North Central	20.833	10.503	1.984	0.047	0.71
Southeast–South	2.6	7.175	0.362	0.717	1
Central–South	1.054	6.769	0.156	0.876	1
South–Northeast	12.862	6.769	1.9	0.057	0.862
East North Central–South	−17.9	9.394	−1.905	0.057	0.851
Southeast–Central	3.654	5.578	0.655	0.512	1
Southeast–Northeast	15.462	5.578	2.772	0.006	0.084
Southeast–East North Central	−20.5	8.576	−2.39	0.017	0.252
Central–Northeast	−11.808	5.046	−2.34	0.019	0.289
East North Central–Central	−16.846	8.239	−2.045	0.041	0.613
East North Central–Northeast	−5.038	8.239	−0.612	0.541	1

TABLE IX: Mean quiz score comparisons by region for the quizzes showing between-region significance.

Region	n	Quiz 3	Quiz 4	Quiz 7	Quiz 11
		Mean	Mean	Mean	Mean
Central	13	93.1	89.2	86.2	85.1
Northeast	13	93.8	90.0	97.7	96.5
South	5	80.0	90.0	94.0	82.0
Southeast	9	80.0	75.0	82.2	74.7
East North Central	3	100.0	86.7	96.7	100.0
Southwest	3	83.3	80.0	83.3	76.7
West	2	90.0	100.0	85.0	100.0
West North Central	2	95.0	85.0	90.0	75.0

Meteorology I Course Assessments

Although there was overall significance between certain assessments within the Meteorology I course, it is interesting to note that the individual assessments that showed regional significance were either not significant when compared with any other assessment overall, or only showed significance when compared with the final exam and the first quarter assignment The final exam and the first quarter assignment had the lowest overall mean scores (80.6 and 81.2, respectively) when compared with all other assessments. The four assessments that showed regional significance had mean scores that were neither the lowest or the highest when compared with all other assessments (quiz 3 = 90.0; quiz 4 = 87.6; quiz 7 = 90.2; quiz 11 = 88.5) suggesting that these four assessments were neither more or less challenging to the students overall when compared with other course assessments.

The final course grades were also included in the Kruskal–Wallis tests to determine if one region simply scored higher overall in the course than another region. If this were the case, it could be argued that there are many variables that could contribute to this variation in student abilities. For instance, students from one region were potentially smarter or simply more motivated than students from another region, or they could have been better prepared due to previous college courses and or teaching experience in the subject matter. No overall significance was found in existing knowledge between regions (Sumrall et al., 2015). As mentioned in the Methods section, the students had the same instruction (the same video lectures, etc.) for the courses, so no differences between instructors should be noted. Also, no significance between regions was found when the final course grades were analyzed or in the initial overall knowledge test, rejecting the hypothesis that one region may have "better" overall students than another region.

To better understand why students from one region might score significantly higher or lower than students from another region, a closer look at the assessments themselves is necessary. Quiz 3 encompassed concepts such as radiation, heating and cooling, and temperature. The questions focused on atmospheric concepts involving energy radiating to the earth from the sun, and back out to space. It also included questions involving temperature ranges between different geographic locations. One such question was stated, "Based on the concepts covered in Lecture #3, which of the following cities should have the greatest range between the average temperature in January and the average temperature in July?" Answers included, Miami, FL, Omaha, NE, San Antonio, TX, New York, NY, and Los Angeles, CA. There were also questions about daily heating and cooling of the atmosphere, the albedo effect, urban heat island effects, and reasons for geographic temperature differences. Interestingly, everyone from the East North Central region scored 100% on this particular quiz. This region scored significantly higher (without the very robust Bonferroni correction) than students from the Southwest, South, and Southeast regions. Students from the Northeast also scored significantly higher than students from the Southeast on this assessment. Because the researcher did not have full access to each course, it cannot be determined exactly which questions each student got wrong. It is still interesting to note that students from the southern regions scored more poorly on this assessment than those from some of the northern regions, which experience marked seasonal changes in temperature and radiative heating throughout the year. Other possible explanations for this significant difference cannot be ruled out, but it should be noted that the one region where every student scored 100% on this assessment shows great seasonal radiative changes, producing large ranges in temperature, and where snow events occur during

TABLE X: Kruskal–Wallis values for Geology I assessments. Statistical values of a Kruskal–Wallis test on each of the Geology I assessments. No assessments show between-region significance.

Test/Assignment	Chi-square Value	df	*p* Value
Quiz 1	2.322	2	0.313
Quiz 2	2.849	2	0.241
Quiz 3	0.117	2	0.943
Quiz 4	2.357	2	0.308
Quiz 5	0.863	2	0.650
Quiz 6	0.266	2	0.876
Quiz 7	1.708	2	0.426
Quiz 8	1.514	2	0.469
Quiz 9	1.908	2	0.385
Quiz 10	2.298	2	0.317
Quiz 11	4.285	2	0.117
Quiz 12	0.633	2	0.729
Mineral Quiz	1.828	2	0.401
Rock Quiz	0.631	2	0.730
1st Quarter Homework	4.010	2	0.135
2nd Quarter Homework	1.765	2	0.414
3rd Quarter Homework	2.022	2	0.364
4th Quarter Homework	0.672	2	0.714
Midterm	2.993	2	0.224
Final Exam	1.043	2	0.594
Final Grade	0.966	2	0.617

the winter months (potentially helping with the understanding of the albedo effect).

Quiz 4 focused on atmospheric moisture, water phase changes, and latent heat. The list of questions included ones like, "Frost is an example of____?" with possible answers including deposition, evaporation, sublimation, transpiration, and infiltration. Students from the Southeast scored significantly lower on this quiz than students from the Northeast and Central regions. Even when the Bonferroni adjustment was used, students from the Southeast region still scored significantly lower than students from the Northeast region. There are many possible explanations for this significant difference in scores between these two regions, including students' personal study variations. It is also possible that the phase changes of water are more noticeable throughout the year for a student from the Northeast and Central regions than students from the Southeast region.

Quiz 7 was geared toward the examination of precipitation processes and different forms of precipitation. This quiz had multiple questions pertaining to precipitation that may typically be found in specific regions, but not others. For instance, there were multiple questions involving snow and other types of frozen precipitation such as sleet and freezing rain that is more commonly seen in northern regions. These included questions such as, "Which of the following statements are true regarding the measurement of snowfall?" Answers included, "Snow depth is often measured taking several readings using a calibrated stick;" "The ratio of snow to water is constant at exactly a 10:1 ratio;" "usually only the snow depth is measured and recorded;" "All of the above; and "None of the above." Students not familiar with frozen forms of precipitation may have a harder time with questions like this one. Students from the Southeast, Southwest, and Central region may not be as familiar with different forms of precipitation as students from the Northeast and East North Central regions. Students from the Northeast region scored the highest of the regions overall, and students from the East North Central region also performed well on this assessment. Even with the Bonferroni correction, students from the Northeast region still performed higher on this quiz than students from the Southeast region.

Finally, quiz 11 discussed different air masses, fronts, and midlatitude cyclones. Many of the questions on this quiz mentioned specific locations. The quiz also encompassed specific weather events that only occur in certain regional settings such as lake effect snow. One question asked, "Why are Marquette, MI, Rochester, NY, and Buffalo, NY among the snowiest cities in the United States?" Answers include: "cP air crossing the Great Lakes during the winter warms and acquires moisture from below, and then produces lake effect snow in the lee of the lakes;" "mP air from the North Atlantic is forced upward by the extreme topography of the area," "Alberta Chinooks bring frequent heavy snow squalls to this entire region," "mT air crossing the Great Lakes during the winter cools and acquires moisture from below, and produces lake effect snow in the lee of the lakes, because these cities are close to Canada." Other questions included air masses moving over snow covered areas, weather associated with cold fronts and warm fronts, occlusions (which typically start out near the center of a low pressure system), and other specific geographic air mass questions. Students from the East North Central region (which surrounds most of the Great Lakes, and sees most of the aforementioned air masses and fronts) all scored 100% on this quiz. Students from the Northeast, located next to the East North Central region (refer to Fig. 3) and receiving much of the same weather systems, also scored high on this quiz. Students from the Central, Southeast, and Southwest regions all scored significantly lower on this quiz. The Central region does include a few small areas around the Great Lakes that would be included in the "Snow Belt," but all of the cities mentioned in this particular question were either in the East North Central region or the Northeast region. The other two regions do not see lake effect snow events, and some of the other air masses and occluded fronts may not be as typical.

Geology I Course Assessments

None of the Geology I assessments showed between-region significance. There are a few possible reasons for the lack of regional significance in this course as compared with the Meteorology I course. First, there are less survey participants that completed this course during this research. The only regions with three or more participants were the Northeast, Southeast, and Central regions. These regions do have some different geologic features, but they all include portions of the Appalachian Mountains, and none of them are known for active tectonic areas like the West and the Southwest. The differences may not be as great between these regions as other regions. More data from each region may help to better define these regional differences. It is also possible that the Meteorology I course offered more regionally specific questions in the assessments than the Geology I course. Finally, it is possible that many of the weaker students that participated in the original surveys did not continue in the program. It is possible that the students who made it to Geology I were better overall students, and therefore, there were not as many differences between the grades for any of the regions.

To further rule out other factors that may affect the outcomes of this research it is suggested that the study, and other studies, continue over a greater period of time with additional participants. It would also be beneficial to gather more background information on future participants to better define the demographics of the individuals. For this study it was assumed, due to the overall demographics of the K–12 teachers in geosciences focus of the program, that the participants had similar careers and background of teaching in earth science classrooms. Additional demographic information could focus on potential confounding factors such as income levels, previous teaching experiences, backgrounds of the instructors, etc. Another area of future research to consider would be the quarterly assignments for each course. None of these showed significance between the regions (Sumrall et al., 2015). These assignments often require the students to take a closer look at their local areas in comparison to other geographic locations (Sumrall et al., 2015). By incorporating place-based assignments that require an understanding of a student's local environment, while also assigning projects that require acquainting students with environments that are foreign to them, an online instructor may be better able to help students build on preexisting knowledge while reducing geographic knowledge biases.

As previously mentioned, the map used to determine the students' regional geographic affiliation was a climate regions map. This could contribute to the between-regions differences in results for the meteorology versus geology courses. To garner more valid results for the geology courses a more geologically specific approach needs to be considered. It may be beneficial to group students by geologic features such as coastal regions versus mountainous regions as opposed to geographic region.

CONCLUSION

When analyzing grade data from online meteorology and geology students, we found interesting statistically-significant results related to regional differences. It is important to note that there was no statistical significance between regions for the Geology I course or for the Meteorology I course when the students' overall grades were examined. Though there was no statistical significance between regions for the Geology I course or for the Meteorology I courses when overall grades were compared, statistical differences between regions were found in Meteorology quizzes 3, 4, 7, and 11. Though other possibilities cannot yet be ruled out, these differences may be associated with the material that was covered, and the specific, potentially regionally significant questions that were asked on the assessments.

No significance was found between assessments for the Geology I course, and there are a few possible reasons for this difference. First, the Geology I course is typically taken in the spring of a student's first year, whereas Meteorology I is often the first course that incoming students take during the fall of the first year. There were more study participants who finished the Meteorology I course ($n = 52$) in the allotted two-year time frame than the Geology I course ($n = 31$). Regional differences were harder to detect with these smaller numbers. It is also possible that the material covered, and questions asked, for each of the assessments in Geology I was less regionally driven. More robust studies are needed to better assess Geologic sense of place in online courses.

As instructors of online courses, trying to deliver the educational material in a way that is personalized to individual students is a challenge, especially with the knowledge that an individual's way of knowing and understanding the world is intricately linked to his or her primary sense of place. The great geographic differences in our online student populations can exaggerate these different ways of knowing. This may differ from traditional classrooms at regional universities where the demographics and geographic understanding of the student population are similar. Based on this current study, understanding an individual's regional sense of place may help an instructor to better understand, assess what the learner already knows, and plan effective instruction in an online meteorology course for specific regionally-based concepts. More research is needed to determine whether individual's regional sense of place likewise affects specific geological content.

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