Auburn University Student's Knowledge about Groundwater

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Groundwater is the main source of freshwater consumption for approximately 40% of the United States' population and closer to 50% worldwide (Mandler, 2017). As the demand for freshwater increases, so does the need for protection and management of groundwater resources. Despite its importance, there are many misconceptions and inaccuracies about groundwater in the classroom (Dickerson, 2017) and in the general public (Roche, 2013). A critical aspect to improve groundwater management is to quantify groundwater knowledge and to identify what factors may be affecting this knowledge.

The purpose of this research was to understand the relationship between groundwater knowledge and various factors such as a student's classification, a student's educational experience related to earth science courses, and a student's field of study. To do this, we first designed and implemented a groundwater concept inventory (GWCI) to quantify student's groundwater knowledge. This groundwater concept inventory contained 14 questions that tested concepts related to academic and applied aspects of groundwater knowledge as shown in Table 1.

Table 1. Concepts and learning goals associated with each concept included in the groundwater concept inventory that was used to measure groundwater knowledge.

Concept	Learning Goal	
Academic	Physical Aspects	- terminology in hydrology - origins of groundwater - controls on groundwater flow
	Chemical Aspects	- controls on groundwater quality
Applied	Groundwater Resource Management	- the amount of groundwater available for human use - connectivity between surface water and groundwater

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A survey was then created on Qualtrics that included four sections: the groundwater concept inventory, perceptions of water quality, personal experiences, and demographics. The survey was then submitted to IRB for approval (Protocol 22-509). After approval, the survey was deployed by email to presidents of 127 student organizations at Auburn University. The survey was closed after two weeks with 196 total respondents. This sample size was then edited to 156 after removing entries that did not complete all questions.

Rasch analysis was used to validate the GWCI. Briefly, Rasch analysis is a psychometric model that follows item-response theory (IRT). IRT proposes a link between a person's performance on individual items and their performance on the test overall (Hambleton, 1991). Figure 1 illustrates the person ability-item difficulty histogram which is an output of the Rasch analysis. The mean item difficulty (bottom) generally matches the person ability (top) and is one line of evidence that supported an acceptable Rasch model. It is important to note that the mean person ability is set to zero, and the range of the Rasch-adjusted GWCI scores ranges from -4.05 to 4.03.

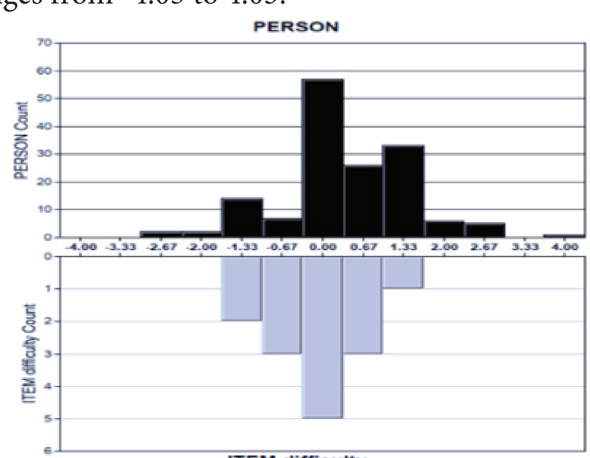

Fig. 1. Person ability-item map for GWCI from Rasch model.

Here, we focused on four specific factors that we hypothesized would correlate to groundwater knowledge: student classification, field of study, high school Earth Science class experience, and college Earth Science class experience. We hypothesized that 1) upperclassmen will have higher groundwater knowledge scores compared to underclassmen because of more advanced coursework, 2) students from the College of Science and Mathematics will have higher groundwater knowledge scores compared to other colleges because it contains the Department of Geosciences, 3) students who took an Earth Science in college will have higher groundwater knowledge scores compared to those who did not, and 4) students who took an Earth Science class in high school will have higher groundwater knowledge scores compared to those who did not. For each hypothesis, the GWCI scores were extracted for each group and statistically compared as described below.

For hypothesis 1, the effect of student classification on GWCI, the Rasch-adjusted GWCI scores were averaged for freshman, sophomore, junior, and senior student classifications. Analysis of variance and least squares means were used to compare GWCIs as a function of student classification. Our analysis showed there was no statistical difference across the groups proven by a p-value of 0.937. This implies there is no statistical difference in groundwater knowledge as measured by the GWCI across student classifications for this population.

For hypothesis 2, the effect of different colleges on GWCI, the GWCI scores were averaged for each college. If a college did not have a sample size of n>20 it was excluded because of an insufficient number of respondents for the statistical test. The colleges that were included in the analysis were the College of Agriculture, Samuel Ginn College of Engineering, the College of Pharmacy, and the College of Science and Mathematics. Analysis of variance and least squares means were utilized to compare GWCIs as a function of college. Figure 2 illustrates the comparison of the average groundwater knowledge scores between the four different colleges. The College of Pharmacy had significantly lower groundwater knowledge scores compared to the College of Agriculture (p-value of <0.001), compared to Samuel Ginn College of Engineering (p-value of <0.001), and compared to College of Science and Mathematics (p-value of 0.0026). We interpret these differences being related to the curriculum taught in each college. For example, on the College of Agriculture's website a main objective of curriculum listed states, "natural resource conservation and utilization, environmental stewardship, and anticipation of changing climate needs" (Mission Statement, 2023). This focus drives the curriculum to teach concepts related to groundwater like, management and water quality. On the other hand, curriculum from the College of Pharmacy does not contain these concepts that are relevant to groundwater knowledge.

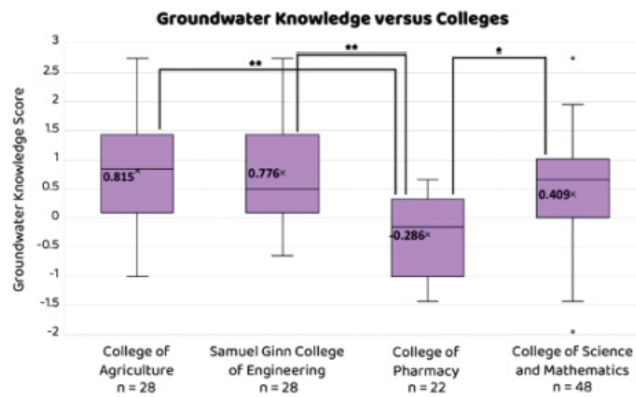

Fig. 2. Comparison of average groundwater knowledge scores between four different colleges at Auburn University. (*p<0.05, **p<0.01)

For hypothesis 3, the effect of an Earth Science course in college on GWCI, the GWCI scores were averaged for either if an individual had taken an Earth Science class in college (Yes) or had not (No). Student's t-test was utilized to compare GWCIs as a function of taking an Earth Science course in college. As shown in Figure 3, students who did take an Earth Science course had a statistically higher GWCI score (0.147 ± 1.023) compared to those who did not (0.395 ± 1.048), proven by a p-value of 0.025. This suggests that taking an Earth Science course in college has a positive effect on groundwater knowledge.

For hypothesis 4, the effect of an Earth Science class in high school on GWCI, the GWCI scores were averaged for individuals had either taken an Earth Science class in high school (Yes) or had not (No). Student's t-test was utilized to evaluate the effect of a high school Earth Science class. It was found there was no statistical difference (p-value of 0.818) between the scores of students who had taken an Earth Science class in high school and those who did not. Potentially, this lack of difference may be due to a deficiency of teaching concepts relevant to groundwater knowledge in high school. In fact, groundwater is not even mentioned in the National Science Education Standards, despite direction to teach the water cycle (Dickerson, 2017).

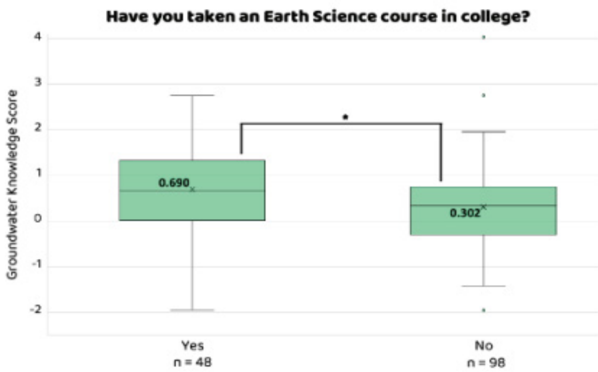

Fig. 3. Comparison of average groundwater knowledge scores between students who did take an Earth Science course in college (Yes) compared to those who did not take an Earth Science course in college (No). (*p<0.05, **p<0.01).

The purpose of this project was to understand the relationship between groundwater knowledge and various factors such as a student's classification, a student's educational experience related to earth science courses, and a student's field of study. A limitation of this project relates to the low sample size from other colleges at Auburn University, and so our current understanding is limited by the population of this survey. Still, our results suggest that other colleges that do not teach curriculum related to groundwater would score similar to students from the College of Pharmacy. Our results support that the GWCI does constitute a valid measurement of groundwater knowledge. Moving forward, the GWCI can be applied to different stakeholder groups (water resource managers, private well users, legislators) that are involved in groundwater decisions and management. Comparing the GWCI scores across these groups can help tailor resources to address misconceptions and ensure decisions are made based on solid foundations of hydrogeology.

Statement of Research Advisor

Charlotte's work has helped to create the first large-scale instrument to measure groundwater knowledge. Constructing and validating the survey involved many iterations and discussions with students, faculty, and professionals both within the world of water resources and outside of it. Ultimately, the GWCI will be a valuable tool as we better quantify groundwater knowledge across stakeholder groups and develop resources to empower sound water management decisions.

- Ann S. Ojeda, Department of Geosciences, Auburn University

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Authors Biography

Charlotte A. Jannach is a senior-year student pursuing a B.S degree in Biomedical Sciences with a Pre-medical concentration. She has worked in the AU Contaminants lab since her freshman year. As a 2022-2023 Undergraduate Research Fellow, she created a survey to quantify groundwater knowledge of Auburn University students dependent on varying factors.

Dr. Ann Ojeda is an Assistant Professor in the Department of Geosciences. Her research is focused in geohealth, primarily in stressors on groundwater quality.