Session Number

Using an Assessment Test to Identify Important Aspects of Education

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Introduction

Quite often, in addition to teaching technical skills, we must teach some abstract and intangible skills. In the field of geological engineering, one of these skills is the ability to use geologic information to design optimal subsurface investigations of sites for foundations, chemical contamination, or geologic hazards. In order to teach this skill, a computer simulation program was developed, so that students could complete realistic investigation exercises in real time. In conjuction with the program, an assessment test has been used to track students' site investigation skills by comparing trends in test scores. A number of practicing professionals also completed the assessment test, and an analysis of the results of their tests, and the accompanying background questions, has been used to identify important educational and experience components that contribute to site investigation skills. Consequently, it is our conclusion that similarly designed assessment tests can be used in any field to identify and verify the value of specific classes or other educational experiences towards development of intangible skills.

Program and Assessment Test

We began developing BEST SiteSim in 1998, a computer simulation program that would place students squarely in the midst of a realistic site investigation. The program is part of the Basic Engineering Software for Teaching (BEST) series developed by the Instructional Software Development Center at the University of Missouri-Rolla. With BEST SiteSim, students are responsible for selecting boring locations and depths, using their geologic knowledge to develop a three-dimensional understanding of the subsurface, requesting lab tests and interpreting the results, and completing evaluation and design based on their conclusions.

We have used the databases from BEST SiteSim for five years (1998-2002) in a Subsurface Exploration class at the University of Missouri-Rolla, and we have used the computer program for two years (2002-2003) in a Site Investigation class at the Colorado School of Mines, impacting over 140 students. Students have overwhelmingly supported the use of simulated investigations, and they recognize the value of integrating their knowledge and applying it to solve complex, open-ended problems. [1]

As one of several methods to evaluate the program's effectiveness, we created an open-ended assessment test to gauge an individual's abilities to plan and carry out a site investigation. Because the test also requests information on educational background and work experience, it is possible to relate these items to test scores, thereby identifying important factors that influence site investigation skills.

The test consists of a series of educational and experience questions followed by 14 investigation strategy questions. The educational and experience questions included check off boxes for the following:

- college level classes (26 listed)
- college degrees earned (BS, MS, or PhD in geology, geological engineering or civil engineering)
- professional registration (seven options listed)
- professional experience (several ranges in years listed)
- experience conducting drilling investigations (several ranges in years listed)
- locations of professional experience (12 different regions within the U.S. listed)

Examples of the investigation strategies questions are:

- In which of the following geologic environments would you need the <u>fewest</u> samples in a boring 100 feet deep to adequately characterize the materials encountered (vertical variability)?
- Which of the following investigation methods would be the <u>easiest</u> way to obtain a soil sample at a depth of 20 feet to test for chemical contaminants?
- Which of the following types of investigations would require the <u>most closely</u> spaced borings (lateral variability)?

The full test may be viewed at http://www.web.umr.edu/~psanti/survey.html. Santi and Kowalski present a detailed analysis of test results. [2]

The investigation strategy questions had multiple choice answers, and the point value for each answer (there was no single correct answer) were developed from responses given by 157 practicing professionals. The number of points awarded for each possible response corresponded to the number of individuals who selected that response (i.e., if 16 people chose answer "A," those who selected "A" would be given a score of 16 for that answer).

The underlying assumption in this study, as well as for any use of this assessment test, is that the test is a valid measure of a very abstract parameter: an individual's ability to apply geologic knowledge to enhance site investigations. We would argue that the test is a valid measurement, for two reasons. First, the questions themselves cover a broad range of geologic and site-investigation topics. Questions 1 through 5 deal specifically with the material properties and lateral or vertical variability controlled by site geology. Questions 6 through 8 deal with investigative techniques and sample collection. Questions 9 through 14 relate the purpose of the investigation to the sampling program.

The second indication of validity is the breadth of responses selected for each question. Most questions had a several answers selected by 15% and 40% of the respondents, showing a true multimodal distribution, and indicating that the test was open-ended as designed. Very few questions showed a unimodal response, which would indicate closed-ended questions. Even for the most strongly unimodal response, the dominant answer was selected only 61% of the time. The second most common answer was selected 25% of the time, so the responses show a strongly bimodal distribution, confirming that the question indeed has more than one valid answer.

Conversely, no question shows more than two dominant answers. If a question had multiple answers receiving similar numbers of responses, we would conclude that the responders disagreed as to the best answer or answers, and that the selection of an answer was somewhat random. This situation was not observed, and every question in the assessment test had a few valid, consensual answers. Therefore, the questions were not only open-ended, but based on the judgment of a group of experienced professionals, the possible answers could be narrowed to a distinct small set.

Analysis of Test Results

The average score for professionals who took the assessment test was 586, with a standard deviation of 111, and a range of 229 to 811. Chi-squared testing confirms that the scores are normally distributed. Two types of statistical tests were conducted on the data. The student's t-test was used to evaluate binary questions, such as, "did those who took a certain class score better than those who did not take the class?" Linear regression analyses were used to gauge the significance of numerical data, answering questions such as, "does increasing years of experience improve test scores?"

Influence of College Classes

Figure 1 summarizes the statistical analysis for the influence of various college classes on test scores. A dramatic and statistically significant increase in score was observed for those professionals who had taken Introductory Geology (aimed at geologists, not engineers), Geomorphology, Regional Geology (all at the 5% level of significance, or LOS), Field Camp, and Case Histories (at the 10% LOS). Other important courses, though not statistically significant, include Stratigraphy, Structural Geology, Engineering Geology, Sedimentology, Rock Mechanics, and Hydrogeology, listed in descending order of importance. Our conclusion is that the classes associated with higher scores have the common element of improving students' abilities to apply geologic principles to engineering practice, to think in three-dimensions, and to predict subsurface conditions given limited geologic information. [2]

Lower test scores are associated with several courses, particularly Soil Genesis, Geophysics, and Soil Physics. The differences were not significant even at the 5% level. It is unlikely that these classes actually weakened site investigations skills, but they may have displaced more useful courses in the student's curriculum. [2]

A plot of the total number of the listed college courses versus test scores showed a positive correlation, statistically significant at the 10% level. From this we conclude that the more courses students take, the more likely they will acquire geologic insight and enhance the visualization and prediction skills they may have already developed. [2]

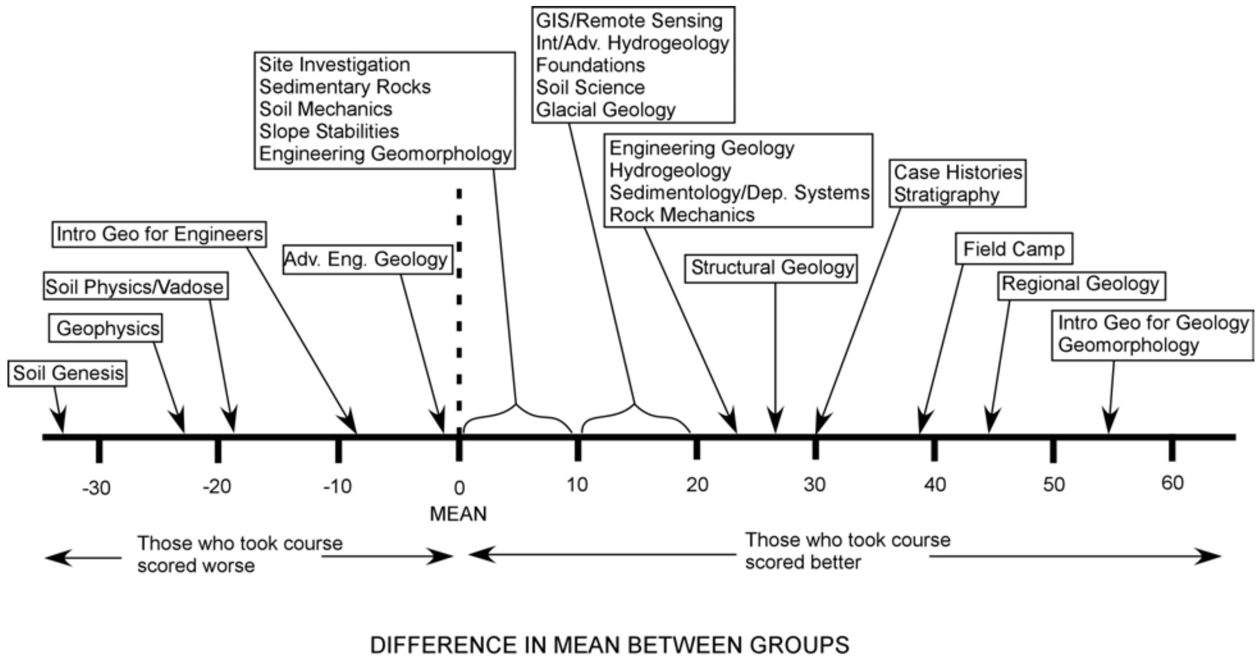

Figure 1. Influence of coursework on test scores. The plotted value shows the difference in the mean scores of those who took the class compared to those who did not. [2]

Influence of Experience

Figure 2 summarizes the improvement of scores for groups with experience in specific geographic regions. Scores were highest for those with experience in the Rockies (statistically significant improvement in scores at the 5% level of significance), California, the Piedmont, Gulf Coast, and New England, in order of decreasing importance. Scores were lower for those with experience in the Appalachians and the Mid-West. A distinctly lower average score was recorded for those with experience in Florida, which was 92 points below those who had not worked in Florida (a statistically significant difference at the 5% level). A possible explanation for this difference in scores is that regions with more homogeneous geology do not offer the breadth of experience to develop generalized site investigation skills. [2]

A plot of the total number of regions in which an individual worked versus test scores showed a statistically significant (at the 2% level) positive correlation, implying that those who have worked in more regions have better site investigation skills. [2]

A plot of the number of years of experience versus test scores shows a positive correlation, statistically significant at the 5% level. If only individuals with less than 25 years experience are plotted, the correlation is statistically significant at the 1% level. This indicates that the number of years of experience is a good indicator of an individual's site investigation skills, but the importance diminishes once a certain amount of experience is gained. [2]

A plot of the number of years of field experience versus test scores shows a statistically significant increase (at the 5% level) in scores corresponding to more time spent working in the field. [2]

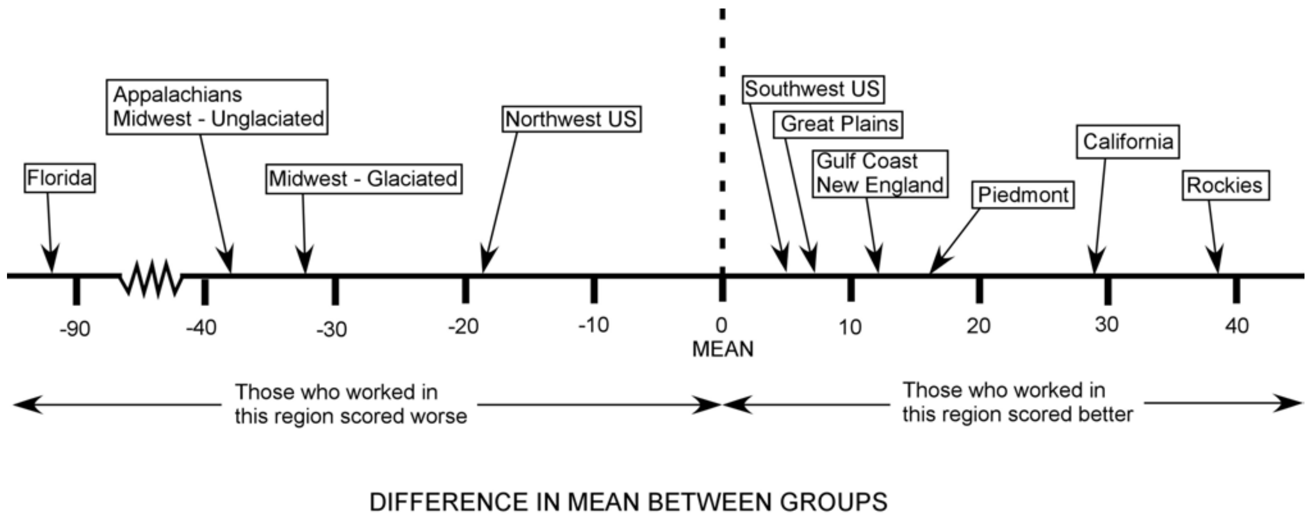

Figure 2. Influence of geographical experience on test scores. [2]

Other Influences

Santi and Kowalski (2004) also analyze the influence of college degrees earned and professional registrations. [2] They conclude that the most important degrees are those that include the highest number of relevant courses, as identified above. They also found that professional registration of any type was valuable, as it demonstrated a minimum experience level and capability in site investigation. Individuals holding registration with more rigorous requirements, such as exam-based second-tier registrations (those that required another type of registration before they could be obtained), tended to score higher than those with less rigorous requirements.

Conclusions

The assessment test is a valid measurement of the abstract skill of applying geologic knowledge to develop and carry out site investigations. The test could also be used to identify critical college classes and work experiences that improve site investigation skills. This type of analysis could be completed in nearly any field to identify the important college classes or even topics within classes that contribute to some abstract and intangible skill we are trying to teach.

Bibiography

1) Santi, P.M. and Petrikovitsch, J.F., 2002, "Learning Site Investigation Skills Through Computer Simulation," ASEE Annual Conference, Montreal, Quebec.

2) Santi, P.M., and Kowalski, R.J., in press, "The Role of Education and Experience in Developing Site Investigation Skills," *Environmental and Engineering Geoscience*.

Biographical Information

PAUL M. SANTI is an Associate Professor of Geology and Geological Engineering at the Colorado School of Mines. He has taught courses on site investigation and the application of geology to interpreting subsurface conditions for nine years, and he conducted site investigations in the engineering consulting industry for six years. His investigation simulation program, BEST SiteSim, was a finalist for the 2002 Premier Award.

RYAN J. KOWALSKI is a graduate student in Geology and Geological Engineering at the Colorado School of Mines. He has a bachelor's degree in Geological Engineering from the same program. In addition to his research work on BEST SiteSim and evaluating its effectiveness, he is also researching the influence of geology and geomorphology on the Lewis and Clark Expedition.