Assessing Spatial Cognition Skills Employed by Geoscientists in the Petroleum Industry

Melanie Busch, Bob Krantz, Peter Hennings, Richard Aram, Juli Hennings

ConocoPhillips, Houston, Texas
{melanie.m.busch, bob.krantz, peter.hennings, richard.b.aram, juli.hennings}@conocophillips.com

Abstract: Geoscientists within the energy industry must accurately interpret subsurface geology, which requires an understanding of complex spatial relationships and 3D visualization skills. Little work has explored spatial cognition in the context of subsurface interpretation as practiced by industry employees. Our investigation explores the spatial skills of newly-hired geoscientists and how they relate to subsurface-interpretation ability and course training. Data analysis is still in progress.

Keywords: spatial visualization, geology, subsurface interpretation

1 Introduction

Geoscientists within the energy industry must accurately interpret and understand the subsurface, a task which requires deciphering the orientations and kinematic evolution of units that can not be directly observed. This task is additionally challenging as geoscientists commonly must construct a complete understanding using a data set of variable clarity and resolution derived from only a portion of the area of interest. Consequently, these interpreters must possess keen spatial-visualization and spatial-reasoning skills.

Within the industry, technology is continually improved to meet new challenges and further productivity; however, there is typically little focus, if any, on understanding the cognitive processes involved in meeting these same challenges. Changes occuring across the industry, such as a growing need to understand areas of greater subsurface complexity as well as a personnel shift in which experienced geoscientists are retiring in greater numbers and early-career geoscientists are becoming relatively more numerous, necessitate hastening the learning process. Consequently, we seek to better understand the spatial skills involved in the various aspects of subsurface interpretation, assess the spatial skills of newly-hired geoscientists, incorporate spatial-skills enrichment into geoscience training, and bridge the gap between industry and the expertise of the academic research community.

2 Spatial Skills and the Geosciences

Subsurface interpretation involves constructing 3D mental models of complex spatial relationships from 2D or 3D data, mentally manipulating these models into different spatial arrangements, mentally rotating these models to perceive them from different orientations, and constructing mental pictures of the internal structure, at the very least. Previous research exploring the relationship between spatial cognition and geoscience expertise suggests that visual penetrative ability [1-4], mental rotation [3], [4], spatial manipulation [3], [4], and disembedding [3] are all integral to the practice of geology. Piburn et al. [3] and Titus and Horsman [4] additionally showed that spatial skills can improve with training and practice. We are not aware of any studies that have explored spatial cognition in the context of subsurface interpretation as practiced by industry employees. It is, therefore, our goal to (1) more clearly define the specific spatial cognition skills employed by industry experts, (2) assess the relationships between spatial experiences and spatial skills, and (3) explore the extent to which newly-hired geoscientists' spatial skills can be developed through training.

3 Methods

Participants are 51 newly-hired geoscientists at ConocoPhillips involved in a new-hire training course. To assess the spatial orientation ability [5], spatial visualization ability [6], and visual penetrative ability [4] of these participants, we administered three different tests to 28 participants, both prior to a week of Structural Interpretation Fundamentals training and at the end of the week. A group of 23 participants served as a control group. We additionally collected data about participants' spatial experiences and preferences.

4 Results and Discussion

As this study was recently initiated, we have only preliminary results. There is no statistically significant relationship between undergraduate major, graduate major, gender and spatial tests scores. A statistically significant relationship exists between frequency of playing video games during childhood and surface development test scores. Additional data remains to be collected and analyzed.

As an ongoing effort, the instructors of the Structural Interpretation Fundamentals course incorporate innovative, spatial cognition training and awareness into their courses. They encourage metacognition by discussing various components of 3D spatial skills and their relationship to subsurface interepretation. They encouraging sketching throughout the course. These instructors also lead a field course linking observable geologic structures with 3D mental-model development.

References

1. Alles, M., Riggs, E.M.: Developing a Process Model for Visual Penetrative Ability. In: Feig, A., Stokes, A. (eds.) Qualitative Inquiry in Geoscience Education Research, Geological Society of America Special Paper 474, 63-80 (2011)
2. Kali, Y., Orion, N.: Spatial Abilities of High-School Students in the Perception of Geologic Structures. J. Research in Science Teaching. 33(4), 369-391 (1996)
3. Piburn, M.D., Reynolds, S.J., McAuliffe, C., Leedy, D.E., Birk, J.P., Johnson, J.K.: The Role of Visualization in Learning from Computer-Based Images. Int. J. Sci. Educ. 27(5), 513-527 (2005)
4. Titus, S., Horsman, E.: Characterizing and Improving Spatial Visualization Skills. Curriculum & Instruction. 57(4), 242-254 (2009)
5. Bodner, G. M., Guay, R. B.: The Purdue Visualization of Rotations Test. The Chemical Educator. 2(4) (1997)
6. Ekstrom, R. B., French, J. W., & Harman, H. H.: Manual for Kit of Factor-Referenced Cognitive Tests. Educational Testing Service, Princeton, NJ (1976)