3D VISUALIZATION SKILLS - DO STUDENTS POSSESS THE TRAINING & CONFIDENCE NEEDED TO SUCCEED AT CAPSTONE SUMMER FIELD COURSES? (Paper No. 65-14)

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Abstract

Capstone field camp courses provide unique opportunities to assess aspects of student preparedness and confidence that are often difficult to evaluate with program learning outcomes and exit interviews. Geologic cross section construction and 3D visualization are some of the most significant skills developed at field camp. To better understand student preparedness, we conducted a study of matriculating field camp students (N = 504) drawn primarily from four Midwestern universities. The results of our study suggest that students lack confidence in using their 3D visualization skills to generate admissible geologic cross-sections. Indeed, only 65.1% feel confident in their 3D visualization skills and 37.4% of students are satisfied with their ability to construct cross sections. In general, students with ample practice with formal methods of geologic cross section construction (e.g., Busk and Kink) report having higher levels of confidence employing the fundamentals of cross-section construction. Furthermore, while 59.2% of students have experience producing cross-sections from textbook exercises and published map data, only 43.3% have experience using their own field data. We hypothesize that these reported levels of confidence are likely associated with insufficient formal instruction, curriculum that focuses excessively on rigorous methodologies that are not always applicable at the undergraduate level, and/or a lack of practice using personally collected field data. The survey results also suggest a significant disparity between self-reported levels of confidence between males and females. Females report feeling overall less confident and less knowledgeable than their male counterparts. Interestingly, we found that while males report completing more geoscience courses, females report more practice producing cross-sections. In a parallel study, we analyzed geologic maps and corresponding cross-sections generated by students during their first and final weeks at camp over an eight-year period. Preliminary results suggest that gender differences effectively disappear by the end of the sixth week, supporting the hypothesis of Piburn et al. (2001) that gender differences in spatial thinking diminish with practice.

Introduction

The field camp experience is an integral aspect of undergraduate degrees in geology. Traditionally offered near graduation, these courses are an ideal opportunity for assessing students' preparedness for future endeavors. This study presents the results of a nine-year survey of students enrolled at three field camps in terms of their preparation, confidence in fundamental spatial skills, and their need for further development.

For most students, field camp is the first opportunity they have to create geologic maps and geologic cross sections using their own data and observations. Our experience is that students often struggle with the 3D visualization skills needed to perform this synthesis. This struggle hinders the development of key concepts, including the need to maintain thickness of bedding, calculating apparent dips, and reconciling the relationships between topography and the traces of geologic features (**Figure 1**). We also observed that a surprising number of students arrive at camp with low confidence in their ability to visualize relationships in 3D.

We initiated this study to better understand what factors might correlate with poor understanding or low levels of confidence. Specifically, we sought to determine how varying levels of preparation and experience among students entering field camp affected their ability to use spatial reasoning skills. We were successful in this goal, but the data gathered from these surveys is providing unexpected insights into other important aspects of student confidence and preparedness.

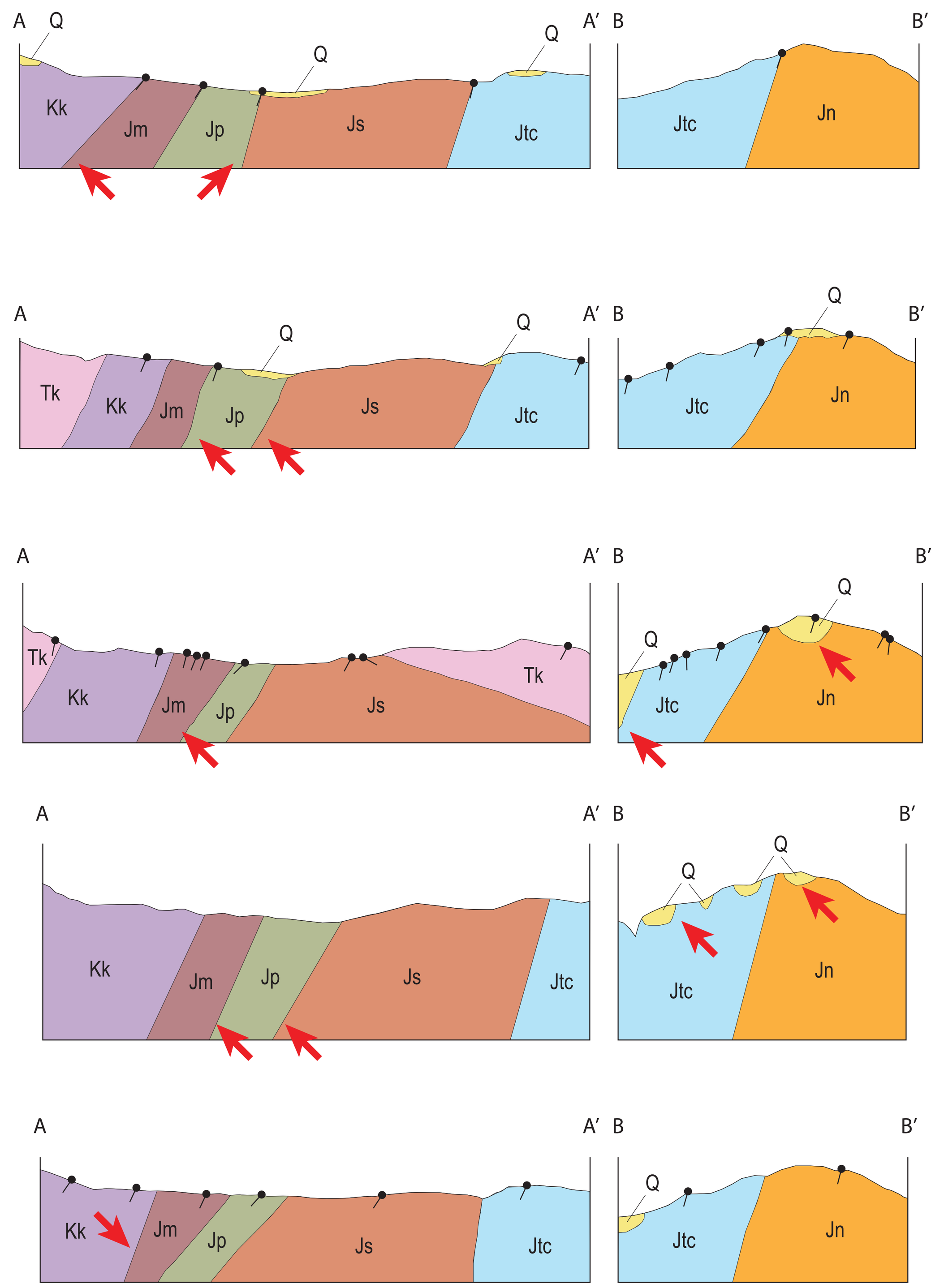
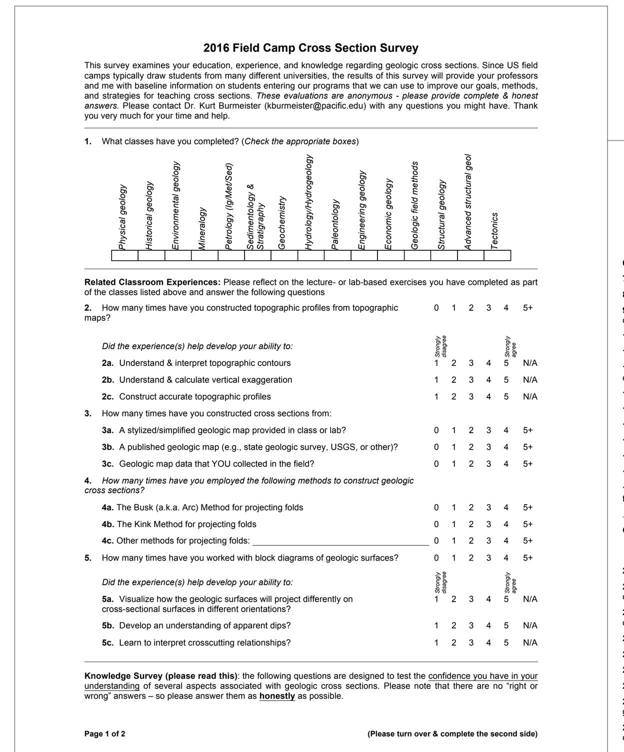
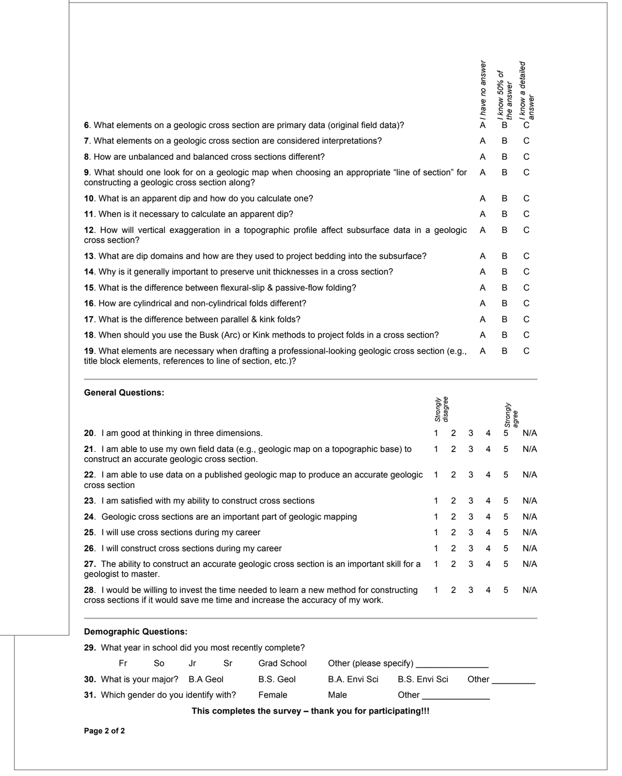


Figure 1. Examples of geologic cross sections produced by students during the first week of camp. Red arrows highlight problems associated with subsurface projections.

Methodology

Between 2008-2015, students at three field camps (N = 504) were surveyed to better understand their level of preparation and how confident they were with 3D visualization skills. Surveys were administered at the start of camp, before students received any additional training. Surveys included questions pertaining to: **(1)** coursework, **(2)** experience working with topographic maps and profiles, **(3)** exposure to cross-section construction methods, **(4)** use of block diagrams, **(5)** exposure to fundamental 3D thinking concepts, and **(6)** levels of confidence and willingness to learn more.





Demographics

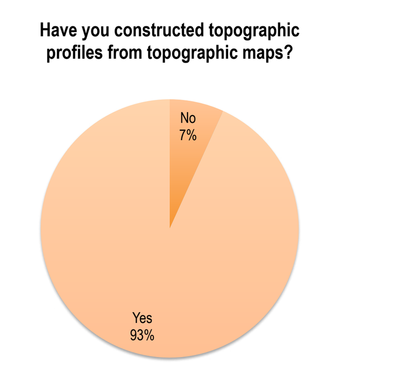
Participants were students at the Wasatch-Uinta, Southern Illinois University, and Northern Illinois University field camps, which represent an aggregate of enrollments from approximately 25 universities. The largest source of respondents is the Wasatch-Uinta Field Camp, which draws students from the University of Illinois, University of Wisconsin, University of Minnesota Duluth, and Michigan State University. Respondents comprise 67.7% male 31.5% female students. A vast majority were pursuing a BS degree in Geology (82.9%). Most students had recently completed their senior year (83.0%), yet a significant number were juniors (8.3%) or in graduate school (7.5%).

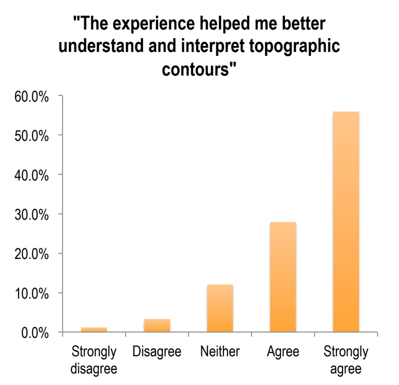
Pre-Camp Experience

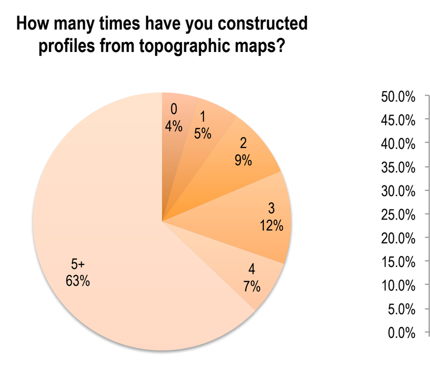
We wanted to understand the breadth of the relevant experiences students brought to field camp. To set a baseline for these experiences, students were first asked to indicate the geoscience courses they had completed prior to camp. Then, students were asked to describe prior experiences with producing topographic profiles from topographic maps, their use of block diagrams to visualize 3D structures, and what types of cross section methods they had been exposed to.

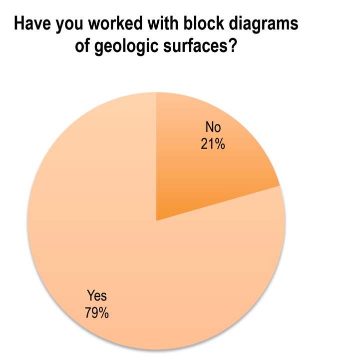
Hands-on learning: Topographic maps and profiles

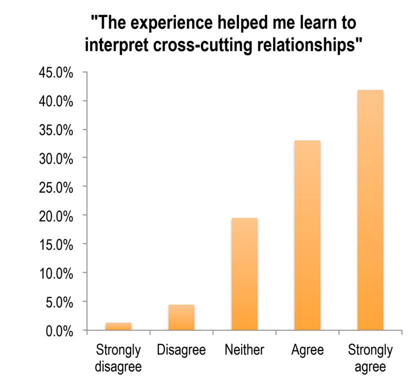
We believe that creating topographic profiles from topographic maps – a common exercise in introductory geology courses – is an essential step in establishing a foundation for building 3D visualization skills. For this reason, we wanted to measure how experienced students were with this skill. We found that while a vast majority of students have experience with this skill, most have experiences that are limited to working with idealized or simplified maps. We found that few had experience working with published maps (i.e. USGS), or maps that they produced themselves.

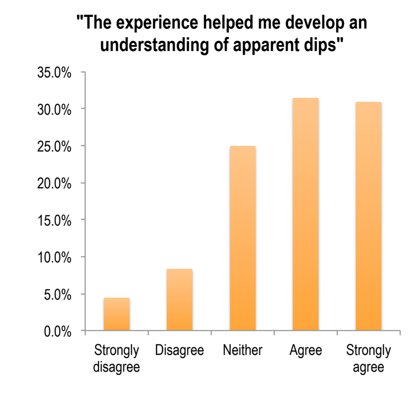


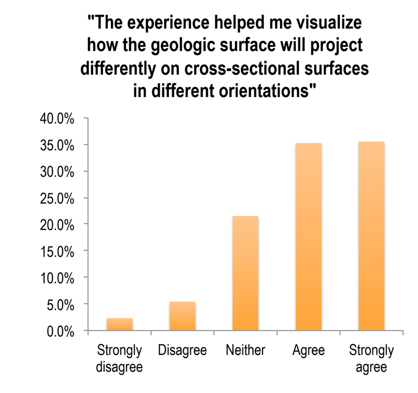












Block Diagram Use

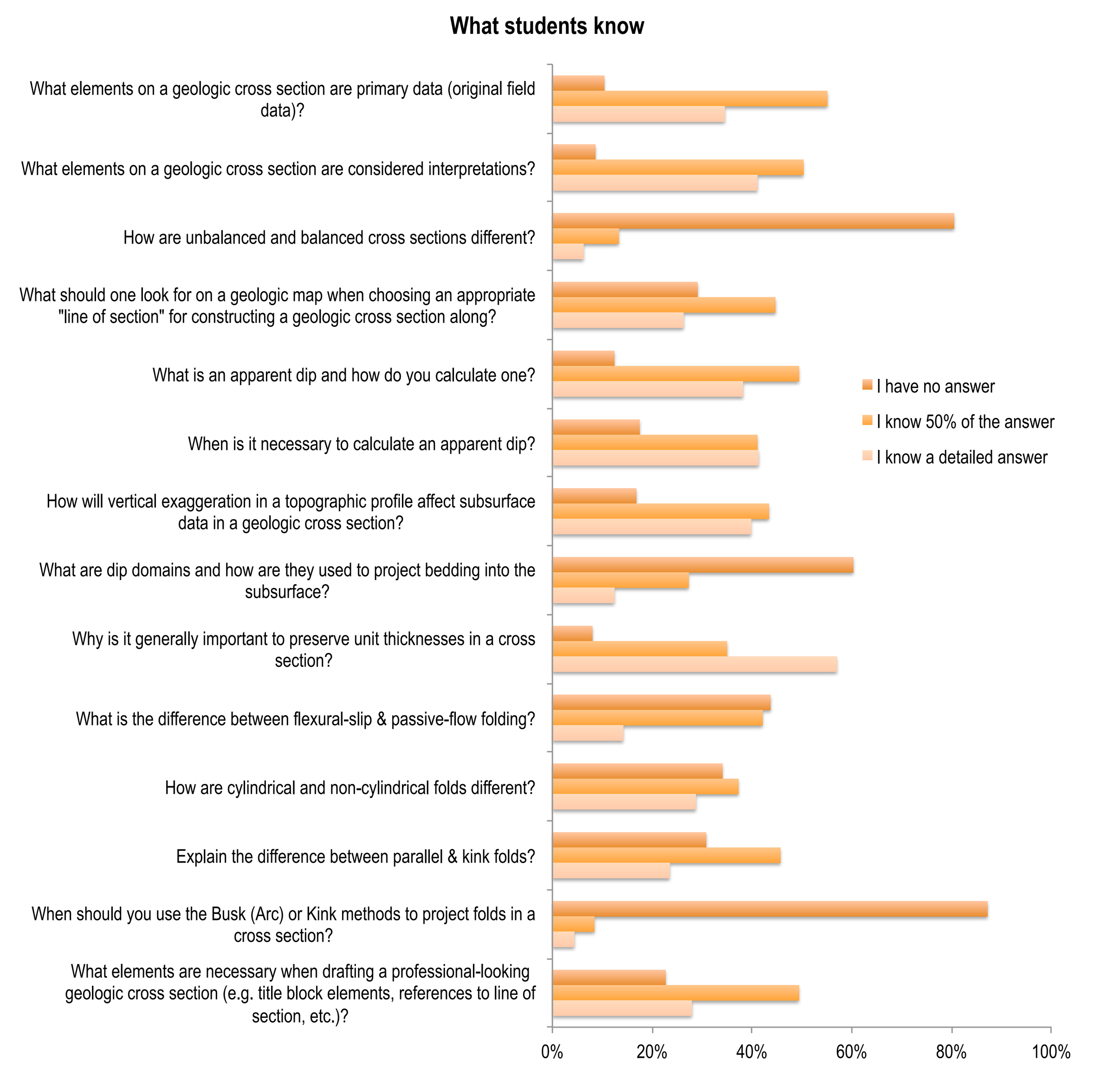
Block diagrams are commonly used tools for visualizing subsurface geologic relationships. We found that most students have experience working with block diagrams and find them very helpful in grasping 3D concepts. However, the ability to quickly and accurately project 3D features onto the 2D surfaces of a block diagram requires a level of spatial reasoning that is often difficult for many undergraduate students.

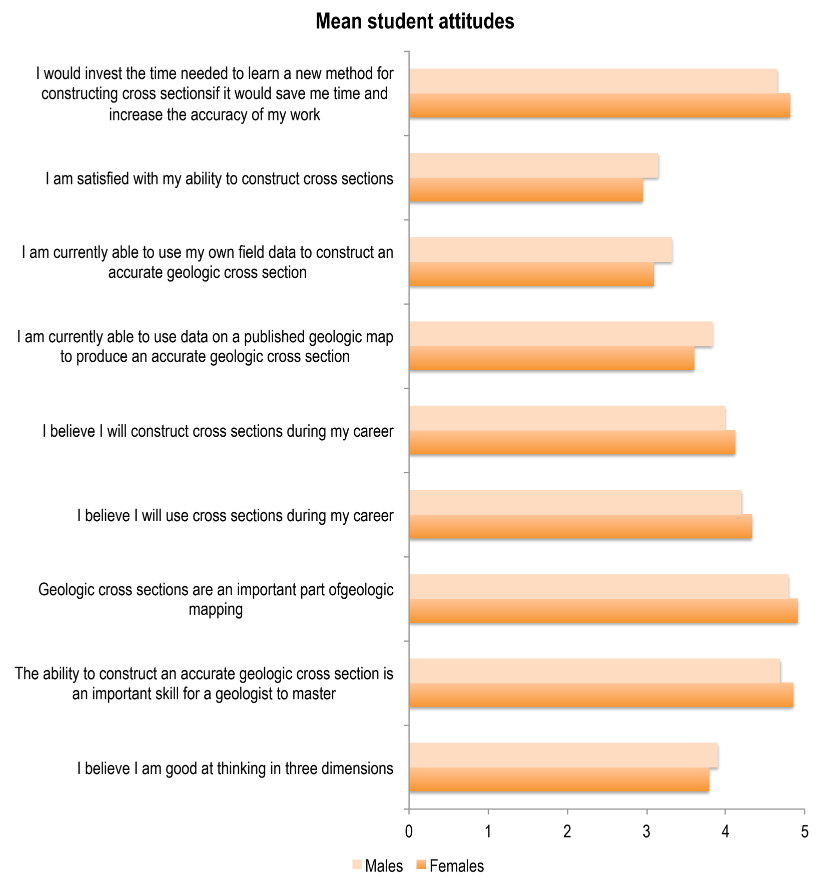
Knowledge Survey Score: Assessing Perceived Knowledge

Students bring a wide range of knowledge to camp – the product of different universities, professors, field trips, and research opportunities. Given this range of experience and preparation, we focused on areas related to the preparation of geologic cross sections to resolve fundamental abilities in 3D spatial reasoning.

Students were asked to complete a "knowledge survey" of fourteen questions. Rather than provide actual answers, they were asked to report how confident they were with the answers they could provide to the questions. These responses were then summed to create a "knowledge survey score," which was then used to make comparisons and observations about the students' knowledge as one single variable.

We found that students have a wide range of understanding regarding key aspects of cross section construction. For example, although students appear to understand why it is important to preserve unit thickness in cross section, they report not knowing the difference between unbalanced and balanced cross sections.



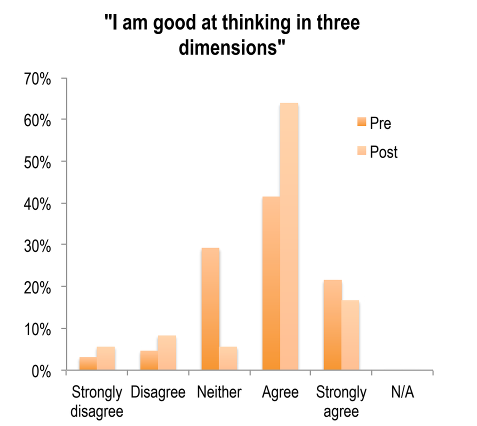


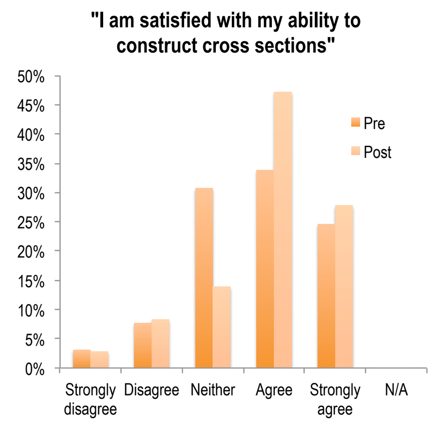
General Student Attitudes

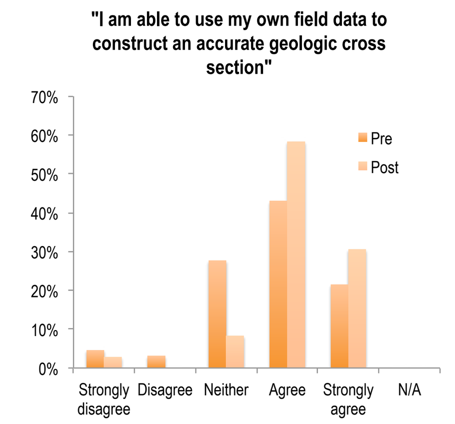
The final portion of the survey uses nine Likert scale questions to assess **(1)** student confidence, **(2)** their willingness to learn, and **(3)** how they expect to use what they have learned in their future. In particular, we were interested comparing the responses provided by men and women to these questions. We ran a comparison of means test (t-test) between male and female respondents. One flaw in our survey design worth noting is the failure to include a gender identify option other than "male" or "female." A two sample t-test comparing means of male and female responses suggests there is a significant difference between gender populations on three key attitudes: **(A)** men report that they believe they are good at thinking in three dimensions more so than women, $p = .000$, **(B)** men feel more confident in their ability to construct cross sections, $p = .000$, and **(3)** women are more likely to invest time learning a new method of producing cross sections, $p = .000$.

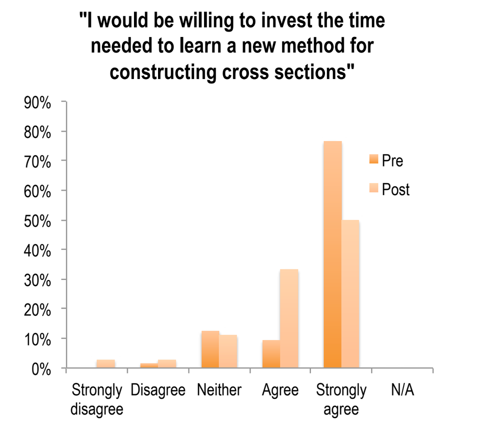
Before & After Camp

The 2016 survey was revised to reflect our evolving interest in students' confidence. The survey questions were rearranged to avoid response bias (e.g. demographic questions were moved to the end of the survey). In addition to distributing a survey at the start of camp, students were also asked to answer some of the same questions at the end of camp. This follow up allowed us, for the first time in this study, to assess the evolution of student attitudes over the course of six weeks of instruction and practice. Not surprisingly, students reported feeling: **(1)** more confident in their 3D thinking abilities, **(2)** their ability to construct cross sections, and **(3)** their ability to use their own field data to construct cross sections at the conclusion of field camp than they did at the beginning. Overall, students appear less interested in learning a new method of producing cross sections at the conclusion of camp.









Conclusions

Students who completed more geoscience courses prior to field camp tend to have much higher confidence levels. However, it remains difficult to determine if those students actually perform better than those who have completed few courses. A student's level in school also has a significant effect on confidence – Seniors report having the greatest level of confidence. There appears to be a correlation between gender and confidence: Women report feeling less confident than men.

Future Directions

In addition to survey data discussed here, we also have also retained all of the geologic maps and cross sections generated during the past eight years at the Wasatch-Uinta camp. We are developing a follow-up study to examine how student 3D visualization skills improve during their time at camp.

A number of studies suggest that although female students tend to have lower starting scores than their male counterparts, this gender gap becomes statistically insignificant after substantial practice or regular participation in 3D visualization exercises. Piburn et al. (2001) suggest that allowing ample opportunities for practice can eliminate gender differences. Giorgis (2015) found that in a pre- and post-test study of 3D visualization abilities among undergraduate students, women showed higher average gains in spatial skills compared to men.

REFERENCES

Jansen, P. and Heil, M. 2010. Gender differences in mental rotation across adulthood. Experimental Aging Research, 36:94–104.

Ormand, C.J., Manduca, C., Shipley, T.F., Tikoff, B., Harwood, C.L., Atit, K., and Boone, A.P. 2014. Evaluating geoscience students' spatial thinking skills in a multi-institutional classroom study. Journal of Geoscience Education, 62;146-154.

Titus, S.J., and Horsman, E. 2009. Characterizing and improving spatial visualization skills. Journal of Geoscience Education, 57:242–254.

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