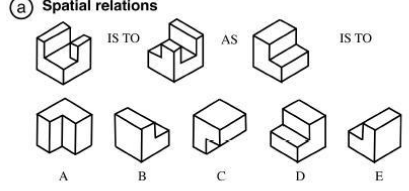
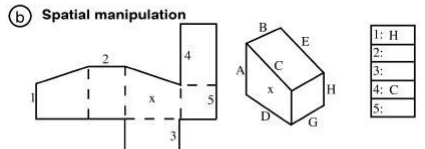
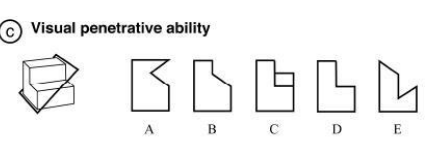


## Can students think (geologically) in 3-D?

Earth, ocean and atmospheric scientists and professionals (i.e. our students now and soon!) all need to think in three dimensions. Are these types of skills somehow “special”? Or, are there “generic” 3D skills that could help predict abilities to succeed in EOAS courses? What learning opportunities can help students improve their 3-D thinking? This edition of EOS-SEI Times summarizes relevant information about what our geology students can do, based on Carrie Wong’s undergraduate honors thesis (2011), and introduces **Visible Geology**, a new, freely available, online tool for building, manipulating and exploring 3D geological scenarios.

### What are general 3D “skills”?

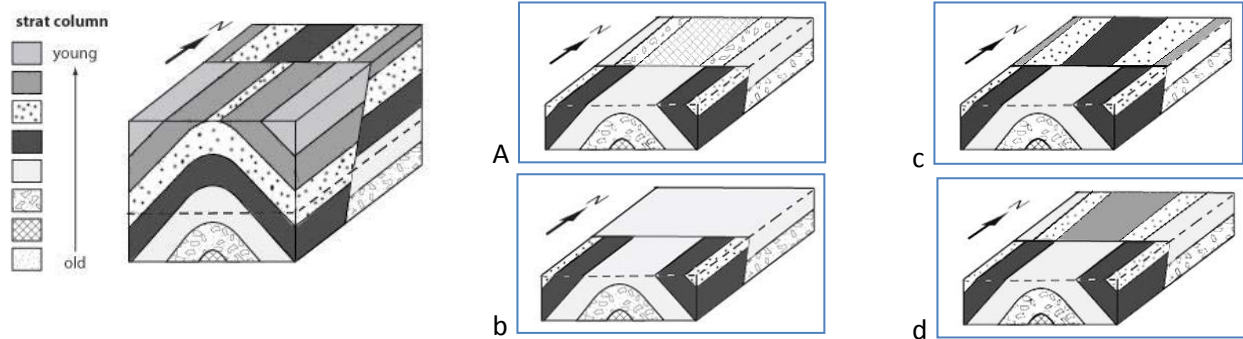
Carrie studied three types of three-dimensional thinking skills identified by psychologists and educators. She used well-established tests to determine individual abilities at these three skills. Here are examples of tasks associated with these three skill types. Can you get these? Answers are at the end.

<p>(a) <b>Spatial relations</b></p>  <p style="text-align: center;"><i>Spatial relations</i> abilities.</p>	<p>(b) <b>Spatial manipulation</b></p>  <p style="text-align: center;"><i>Spatial manipulation</i> abilities (match numbers to letters in the table).</p>	<p>(c) <b>Visual penetrative ability</b></p>  <p style="text-align: center;"><i>Visual penetrative</i> abilities</p>
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### Are those skills related to geologic skills?

Carrie then built a new set of questions involving geological tasks that correspond to the generic 3-D skill types. These questions were carefully validated with a cycle of interviews with volunteer students and experts, then both the generic and the geologic questions were administered to one second year class (EOSC 223, n=62) and to two classes for upper level students (EOSC 332 and 328, combined n=31). Seven multiple choice questions and four questions involving sketching were developed. Here is one example. What is the answer, and which of the three generic skill types does one have to use to find the answer? Answers are at the end.

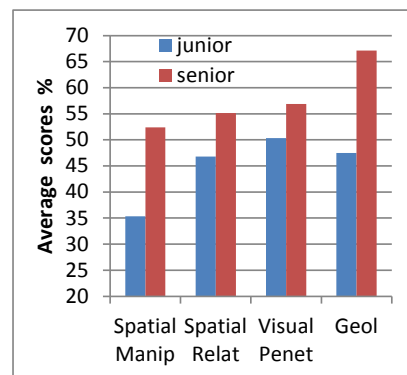
4.



This block shows folded stratigraphy that has been faulted. The fold hinge is horizontal (i.e. not plunging). The area’s stratigraphy is shown in the stratigraphic column. There has been some movement along the fault shown on the block. If you were to slice this block through the plane indicated by the dotted line, and remove the top half, what would the surface look like?

### Scores: How did our students do?

- On overall geology questions, students in eosc332 & 328 scored significantly higher than students in eosc223 (two tailed  $p < 0.001$ ; right-most paired columns in the figure) & on overall spatial questions (two tailed  $p = 0.002$ ; sum of the 3 left-most paired columns in the figure).
- Eosc332 / 328 Students scored significantly higher than those in eosc223 on *spatial manipulations* ( $p < 0.0001$ ,  $p = 0.8$ ,  $p = 0.1$ ), but not on *spatial relations* or *visual penetration*. See the three left-most paired columns are in the figure.



### Are spatial skills predictors of geologic skills?

- *Spatial manipulations* scores were most well correlated with geology scores.
- *Spatial relations* scores were least well correlated to geology score.
- Spatial scores of eosc223 students predicted their geology results better than those of eosc332/328 students.
- *Spatial manipulation* abilities generally improve the most in education (from literature).
- There were no gender differences except for slightly better scores from men in *spatial relations* tests.

Details of results are given in the thesis, which is online at <https://circle.ubc.ca/handle/2429/34237>.

### Can such data contribute toward improving 3-D thinking abilities of EOAS students?

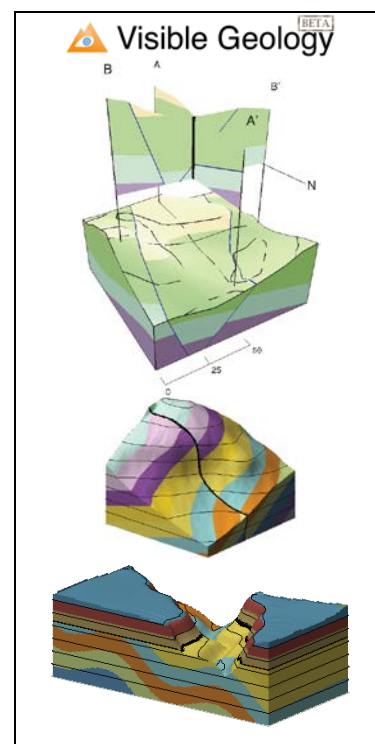
Concept tests such as Carrie's question set can be useful for *diagnosing* student abilities at the start of a course or module, and for *measuring* knowledge gains by testing before and after a course or module. It is not trivial to produce rigorous concept tests, but once built and tested, they are a resource that instructors will find useful if the questions are not changed and the test is used appropriately. Some further questions worth considering are:

- Does studying geology (or other EOAS disciplines) improve spatial skills and vice versa? What helps?
- Unexpectedly, scores for *specific* skill types were reasonable predictors of *overall* scores on the geology-based 3D thinking questions, but poor predictors of scores on corresponding *specific, related* geology tasks. The tasks and questions have been carefully validated, however perhaps the relation between *generic* 3D skills and *specific* geologic tasks needs to be investigated in more detail.
- Can our field schools (eosc223 and 328) and structures courses (eosc323 and 422) *pre-test* students so they have some idea about their own 3D abilities? If this was done, we could *post-test* them after each course, and see if there are improvements as a cohort of students goes through our system! Please contact Brett, Francis or Sara Harris for help, either in these or other courses.

### Practicing and assessing 3D geological thinking (including stereonet).

Consider incorporating **Visible Geology**, into your teaching, student labs, homework, and/ or testing. **Visible Geology** is a web-based program developed by Rowan Cockett, an EOAS student pursuing an MSc. in hydrogeophysics. This (currently free) facility can help introduce students to many geologic concepts and spatial skills in a virtual environment. It is in use at several colleges in North America, and there is a growing list of *assignments*, ideas for *activities*, and *premade models*, which allow students to engage with three dimensional thinking while learning geologic concepts.

- See a two page [colour flyer](#) outlining **Visible Geology's** features and purposes.
- A features list is at <http://app.visiblegeology.com/features.html>.
- Examples are at <http://visiblegeology.com/wiki/index.php?title=Assignments>.



### Further information

- Contact STLFs (Brett and Francis) to discuss options for incorporating 3D thinking skills tests as diagnostics or assessments of progress in any course, or to incorporate **Visible Geology** (or other approaches!) into class demonstrations, activities, assignments / labs, and assessments.
- We can also ask Rowan Cockett if he is able to visit and answer questions or offer demonstrations of **Visible Geology**.