ED23F-1074 Do sandbox models help students to visualise geologic structures and deformation?

Christopher J. Rowan
Department of Geology,
Kent State University,
e-mail: crowan5@kent.edu
Twitter: @Allochthonous

Bridget K. Mulvey
School of Teaching, Learning and Curriculum Studies
Kent State University

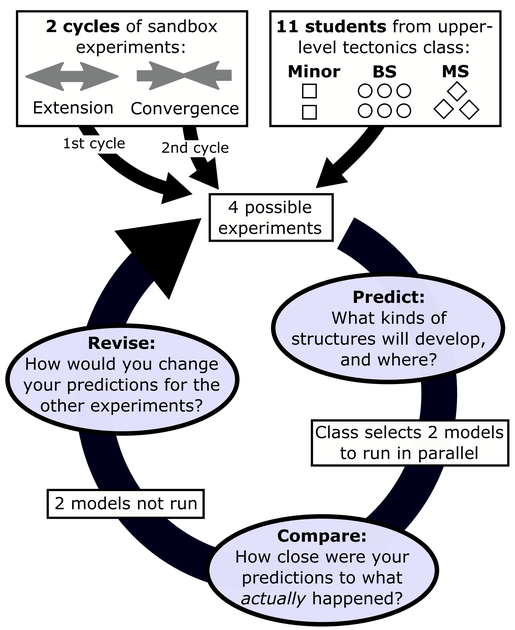
With thanks to:
- Joe Wislocki
  for significant contributions to sandbox model design, construction and testing.
- Jennifer Marcinkiewicz
  for advice on study design.

Analogue sandbox models are cool, but can we demonstrate that they actually aid learning?

- Does seeing structures developing in a 3D volume improve core spatial reasoning skills?
- Can students use their observations to make more geologically realistic predictions of deformation?

CYCLE-BASED LEARNING

"A cycle of prediction, comparison, and feedback supports spatial learning in geoscience."
- Davatzez et al. (2018)



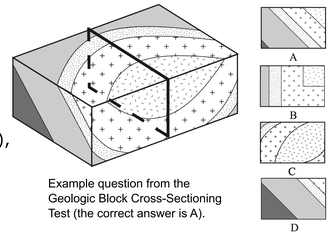
REFERENCES

DAVATZES A., GAGNIER K., RESNICK I. & SHIPLEY T. 2018. Learning to form accurate mental models. Eos 99, doi: 10.1029/2018EO091643.

ORMAND C.J., MANDUCA C., SHIPLEY T.F., TIKOFF B., HARWOOD C.L., ATIT K. & BOONE A.P. 2014. Evaluating geoscience students' spatial thinking skills in a multi-institutional classroom study. Journal of Geoscience Education 62: 146-154.

BLOCK MODEL TEST SUGGESTS IMPROVEMENTS IN SPATIAL REASONING...

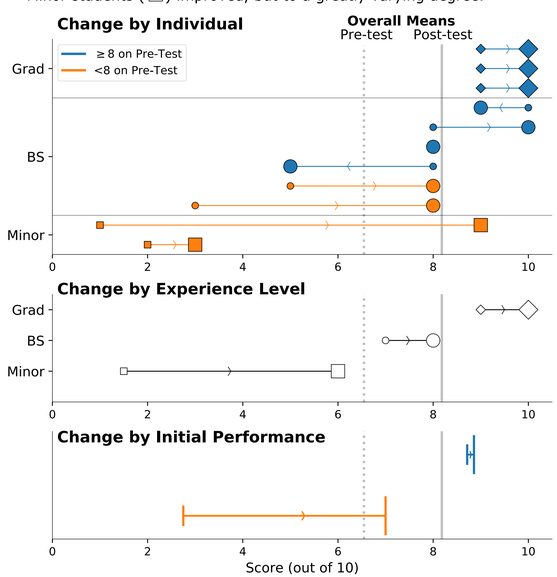
Spational reasoning skills were assessed using a shortened, 10-question version of the Geologic Block Cross-Sectioning Test (Ormand et al. 2014), administered before and after the sandbox experiments.



Example question from the Geologic Block Cross-Sectioning Test (the correct answer is A).

Pre-test scores can be divided into **high-scoring (≥8/10)** and **low scoring (<8/10)** groups. More experienced students were more likely to have better scores.

The average score increased in the post-test, **but improvements were not evenly distributed:**
- Graduate students (◇) showed a small but consistent improvement;
- BS students (○) improved on average, but degree and direction varied;
- Minor students (□) improved, but to a greatly varying degree.



The clearest result: **most of the students in the low-scoring group markedly improved their score in the post-test.**

Caveat: difficult for students in the high-scoring group to show much improvement!

...PARTICULARLY FOR LESS EXPERIENCED STUDENTS.

DURING EXPERIMENTS PREDICTIVE SKETCHES BECOME MORE REALISTIC DUE TO TRANSFER OF RELEVANT OBSERVATIONS.

Predictive sketches for stronger base layer of confectioner's sugar overlain by sand (not run in either experimental session):

Low Score on Pre-test, high Score on Post-test vs **High Score on Pre-test, more experience**

Extension - Initial Predictions

- Homogenous bulk thinning of layers.

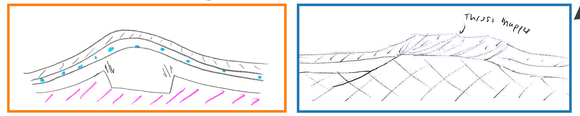
vs

- More realistic structures (graben/faults).
- Clear (but inaccurate) contrast in mechanical behaviour.

Extension - Revised Predictions

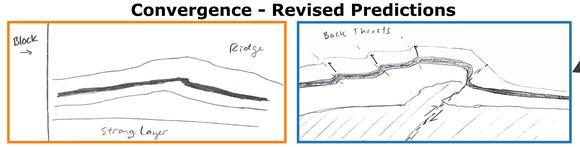
- **Both students** accurately applied observations of different behaviour in sugar (steep fracture) vs sand (collapse into rift).
- **Neither** transferred observations of rift symmetry and folding of the sand layers.

Convergence - Initial Predictions



- **Both students continued to transfer observations** about behaviour of sugar layer; but only more experienced student predicted faulting rather than buckling in sand.
- **Both students challenged by change in deformation type**: faults in the sugar are drawn with normal displacements!

Convergence - Revised Predictions



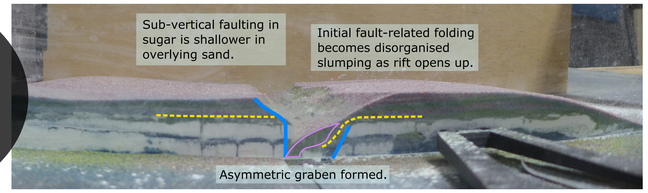
- Improves prediction of overall form of the deformation, but **much less detail**.

vs

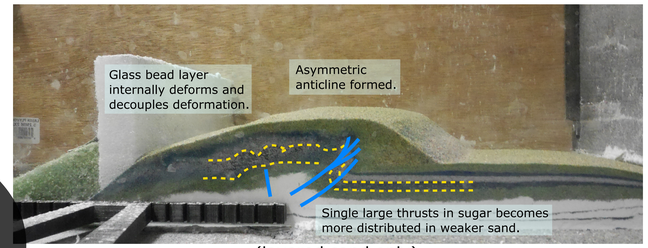
- **Combines observations from both models** to improve prediction.

More experienced students clearly drew on their prior geological knowledge in their initial sketches, but all students used relevant observations of the experiments that were run to reassess and improve their predictions for the experiments that were not.

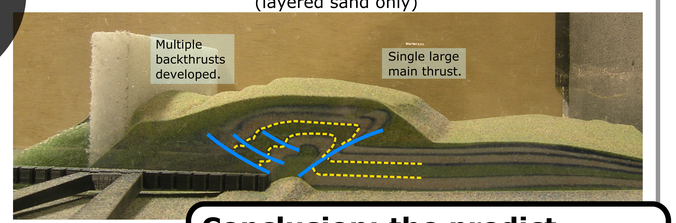
Class Experiment - Extension
(basal sugar layer with oblique cuts)



Class Experiments - Convergence
(basal sugar layer and mid-level glass bead layer)

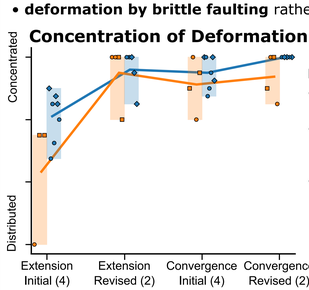


(layered sand only)



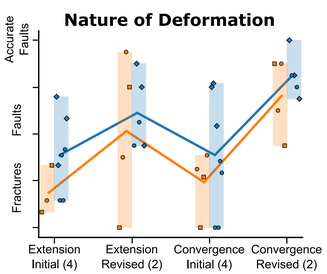
All students' sketches were scored for how well they predicted:
- **concentration of deformation** at the edge of the fixed base plate;
- **deformation by brittle faulting** rather than buckling of layers.

Concentration of Deformation



During study:
- General **improvement** in quality.
- **Quality gap** between low- and high-scorers on the pre-test largely **closes.**
- **More difficult concepts do not transfer as easily** between different sets of experiments.

Nature of Deformation



Conclusion: the predict-compare-revise cycle is an effective framework for using sandbox models to develop spatial reasoning and geological understanding.

- Unlike the block model test, sketches suggest improvements at all experience levels. A more demanding test is needed for expert students.
- A lesson plan that specifically directs students towards relevant observations may further increase effectiveness of this intervention.