

Sketch Worksheets go to their first class

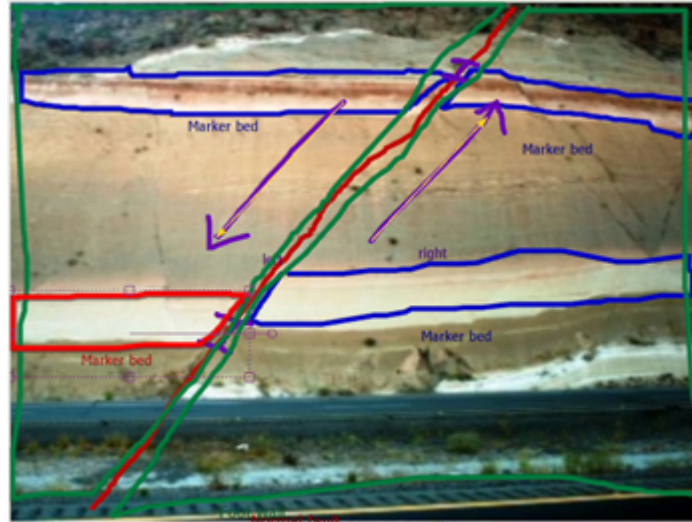
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Pencil and paper worksheets are a staple of education. But drawings are hard to grade, and pencil and paper worksheets cannot provide feedback based on what a student is doing. A new technology developed by SILC researchers, *sketch worksheets*, uses artificial intelligence software to provide immediate feedback to students and help instructors with grading. For the first time Fall quarter, sketch worksheets were used as part of student work in a real course. This pilot experiment is a first step towards making sketch worksheets broadly available in education.

Why make sketch worksheets? Results from artificial intelligence in education research indicate that software tutors can provide significant benefits for students, in part by providing immediate feedback. Unfortunately, intelligent educational software has rarely been built for spatial domains. A major barrier is that the software needs to be able to see a student's sketch the way a teacher would. SILC research is tackling this problem head-on, by creating *CogSketch*, a new kind of sketch understanding system. *CogSketch* incorporates models of human visual processing and spatial reasoning, based on cognitive science research in AI, cognitive psychology, and vision science. (For an example of *CogSketch*'s visual processing abilities in action, please see the April 2009 showcase.)

Understanding the sketch is half of the problem. The other half is providing feedback to students, and assessment information to instructors. Sketch worksheets incorporate a hidden sketch, made by an instructor, providing a kind of "answer key" for the worksheet. This sketch is compared against the student's work. The similarities and differences between them provide the basis for feedback. The comparison process itself is based on a cognitive model of human analogical matching, also developed by SILC researchers. Worksheet authors can specify what feedback *CogSketch* should provide to students based on this comparison, as well as provide grading rubrics for assessment.

To refine the software, the *CogSketch* team worked with Prof. Brad Sageman, Professor of Earth and Planetary Sciences of Northwestern University, to create sketch worksheets for his Physical Geology course. The first assignment was for extra credit, involving worksheets where students identified faults and their properties in photographs of geological sections, and reconstructed a sequence of geological processes based on a diagram. The first assignment went sufficiently well that a second assignment, this time required, was developed, where students sketched the reservoirs and flows of the carbon cycle, annotating it with the magnitudes of the flows. Students were able to use sketch worksheets with only minimal training, and the *CogSketch* team got valuable feedback that has helped them refine the software to make it better for future users.



Fault Worksheet Sketch

This is the first step on a long journey: Many further studies will be required to improve the software and the cognitive models it relies on, to find out how we can best improve student learning. We hope that this journey leads to sketch-based educational software that helps students learn spatially.

To find out more:

CogSketch is publicly available from SILC's web site (www.spatiallearning.org). The download contains sample worksheets and the full worksheet authoring environment.

A paper on sketch worksheets will be presented at the Innovative Applications of Artificial Intelligence conference in July.

- Yin, P., Forbus, K., Usher, J. Sageman, B., and Jee, B. 2010. Sketch Worksheets: A Sketch-based Educational Software System. 22nd Annual Conference on Innovative Applications of Artificial Intelligence, July, Atlanta.

To find out more about CogSketch, please see

- Forbus, K., Usher, J., Lovett, A., Lockwood, K., & Wetzel, J. (2008). [CogSketch: Open-domain sketch understanding for cognitive science research and for education](#). In the *Proceedings of the Fifth Eurographics Workshop on Sketch-Based Interfaces and Modeling*. Annecy, France.