



Design Buddy: Sketch Understanding in Design Education

Jon Wetzel and Kenneth Forbus

Qualitative Reasoning Group, Northwestern University



Motivation

Design Buddy is an educational software program that will help us achieve several goals:

- Improve the ability for engineering and design students to communicate their ideas through sketching.
- Improve CogSketch as a tool for cognitive modeling and as a platform for educational software.
- Generate sketch data for use in developing cognitive models of sketching and design.

Qualitative Mechanics

Qualitative Mechanics will allow Design Buddy to understand and solve problems in physics dealing with systems of objects and forces.

- Based on previous research: Nielsen, P. (1988,1991) Kim, H. (1990,1993)
- Systems modeled using this previous work include linkages, clockworks, pumps, and engines.
- Implemented as a set of concepts and logical statements for reasoning in FIRE.

CogSketch, a SILC Initiative

Design Buddy will be built on CogSketch, an open-domain sketch understanding system which features:

- Conceptual labeling from the contents of the OpenCyc knowledge base, consisting of over 58,438 concepts constrained by 1.8 million facts. (Cycorp, <http://www.cyc.com>)
- FIRE inference engine capable of reasoning over large knowledge bases.
- Analogical reasoning and inference via the Structure Mapping Engine (Falkenhainer, B., Forbus, K. & Gentner, D. 1989).

Spatial relationships are computed for sketches labeled by concepts in the knowledge base. FIRE and SME can then reason over these to infer meaning behind the sketch.

CogSketch can provide a basis for cognitive simulation of spatial learning and reasoning, and for creating educational software that understands sketches in a human-like way. Learn more at: http://spatiallearning.org/projects/cogsketch_index.html

Next Steps

- Implement QM theory in CogSketch
- Develop Design Buddy intent interface for communicating desired outcomes, understanding and suggestion in CogSketch.
- Perform formative evaluation with students in Northwestern University's Engineering Design and Communication program. (EDC)

ACKNOWLEDGEMENTS

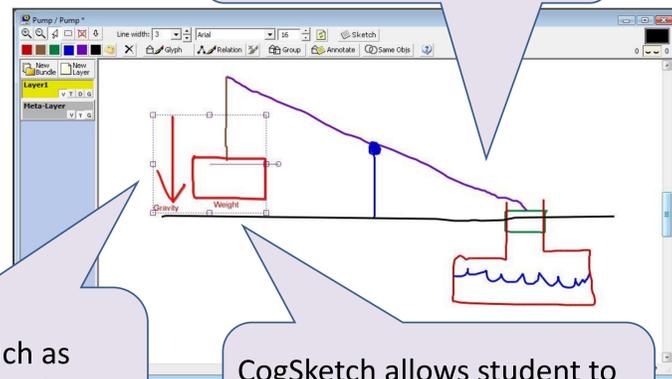
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A design or engineering student will draw a sketch of their design using Design Buddy.

In this example the student has drawn a lever-operated pump with a weight tied to one end.

External forces such as gravity are expressed as annotations to the glyphs.

Individual parts are represented as "glyphs".



CogSketch allows student to conceptually label the glyphs in their sketch.

Next the student will inform Design Buddy of the desired outcome.

In this example, the position of the weight and water level are specified.

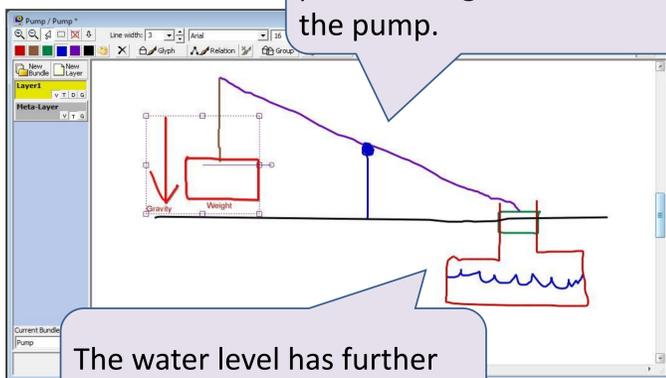
Student's Intended Outcome

This pump is designed to move water out of a well.
The weight will fall to the ground, lifting water out of the well so it can be reached by people at the surface.

Student will use specialized interfaces, including natural language, to express how their design is intended to work.

This information will act as a test for Design Buddy's reading of the sketch.

Design Buddy will use Qualitative Mechanics to analyze the set of objects and spatial relationships in the sketch to infer how the system will operate.



The water level has further to move than the weight.

Inference is made about the possible range of motion of the pump.

Design Buddy will compare its reasoning with the student's desired outcome and points out the source of any differences.

Design Buddy's reasoning reveals violations of the user's expectation.

Design Buddy's Understanding of Outcome

Glyph	Constraint	Glyph
Weight	Below	Pivot
Bottom-of Weight	Touching	Ground
Water	Below	Ground

Design Buddy will suggest changes to the student that might help improve the design.

Design Buddy's Suggestions

- Change location of weight.
- Change water level.
- Change size of weight.