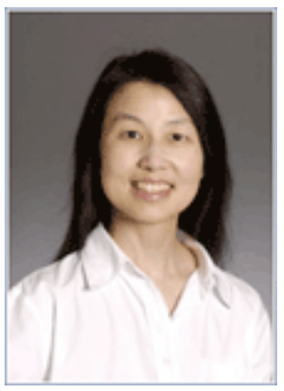
design thinking IS computational thinking

mark d gross
cmu school of architecture
(computational design lab)

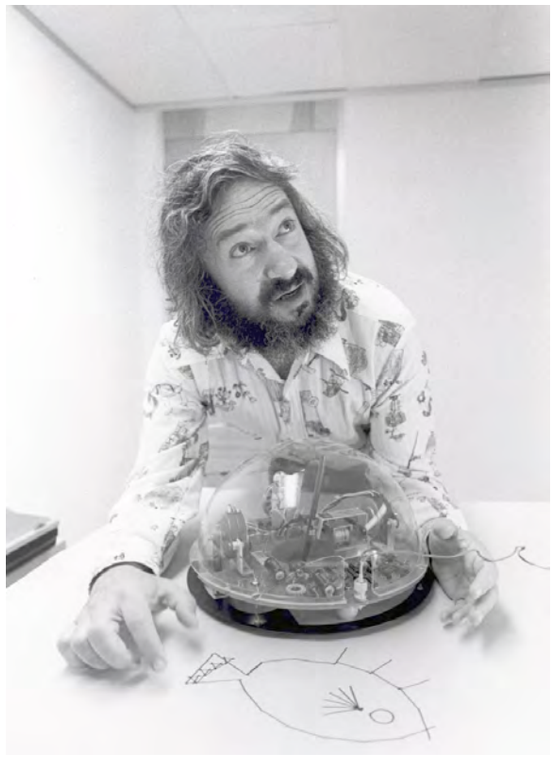
Computational thinking is a way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to computer science. ... thinking in terms of abstractions, invariably multiple layers of abstraction at once. ... the automation of these abstractions.



CMU Computational Thinking website manifesto

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
A.I. LABORATORY

Artificial Intelligence
Memo No. 247



October 1971

LOGO
Memo No. 2

TEACHING CHILDREN THINKING[1,2]

Seymour Papert*

... in its embodiment as the physical computer, computation opens a vast universe of things to do. But the real magic comes when this is combined with the conceptual power of theoretical ideas associated with computation.

Computation has had a profound impact by concretizing and elucidating many previously subtle concepts in psychology, linguistics, and the foundations of logic and mathematics. I shall try to show how this elucidation can be projected back to the initial teaching of these concepts.

CMU C-T says “computational thinking is not just programming”

I say,

programming language IS important

Complicated thoughts demand external notation,
the notation we use affects what we can think.
(Whorf hypothesis)

We should design our languages
to help us think better.

therefore:

... domain oriented, high-level languages
so end users can build their own ideas ...

out, forward

out, off

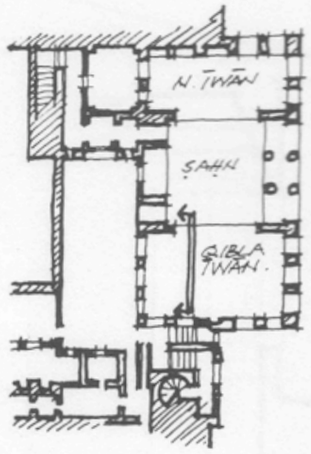
pro.gram == de.sign

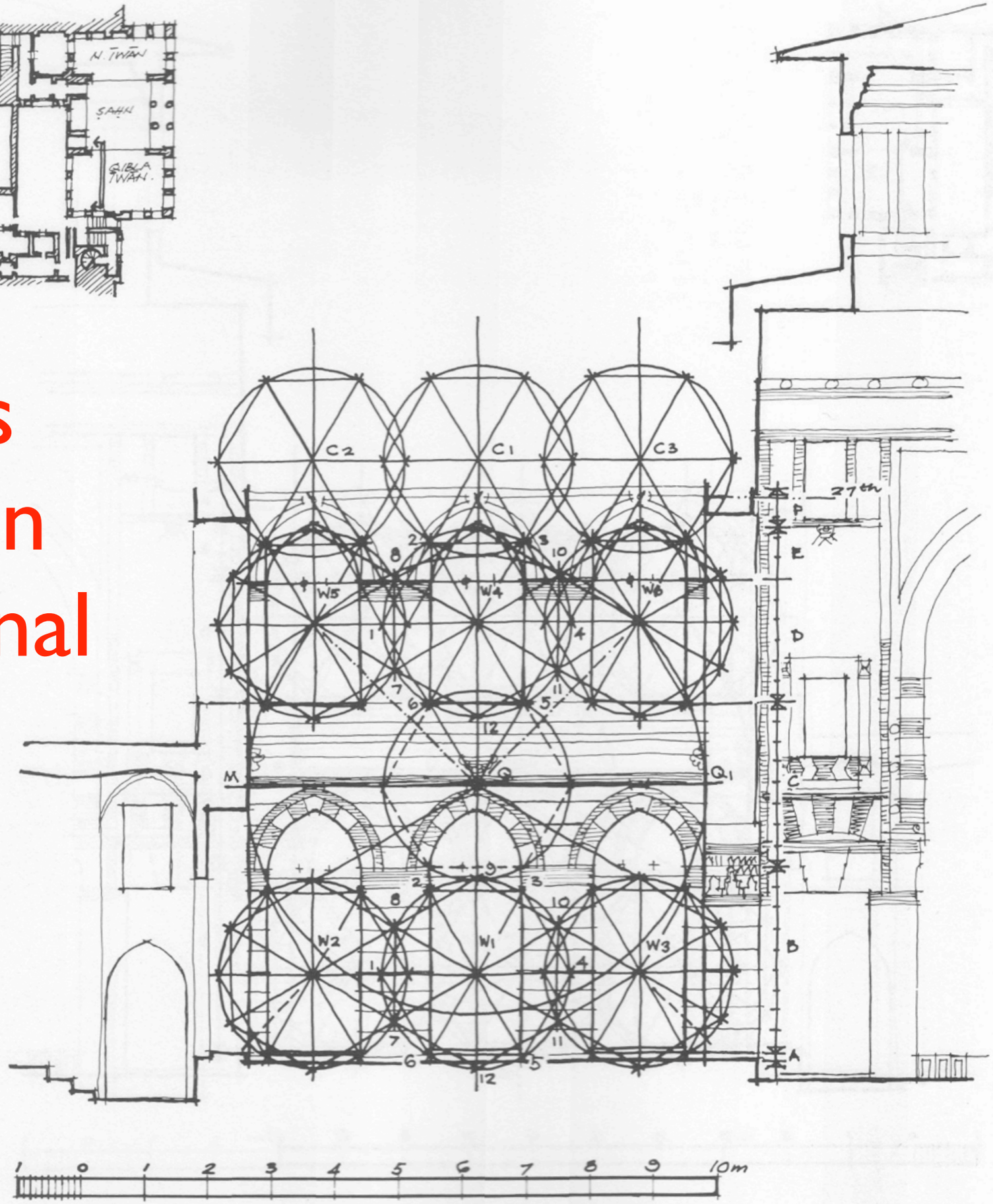
something written, a mark

mark

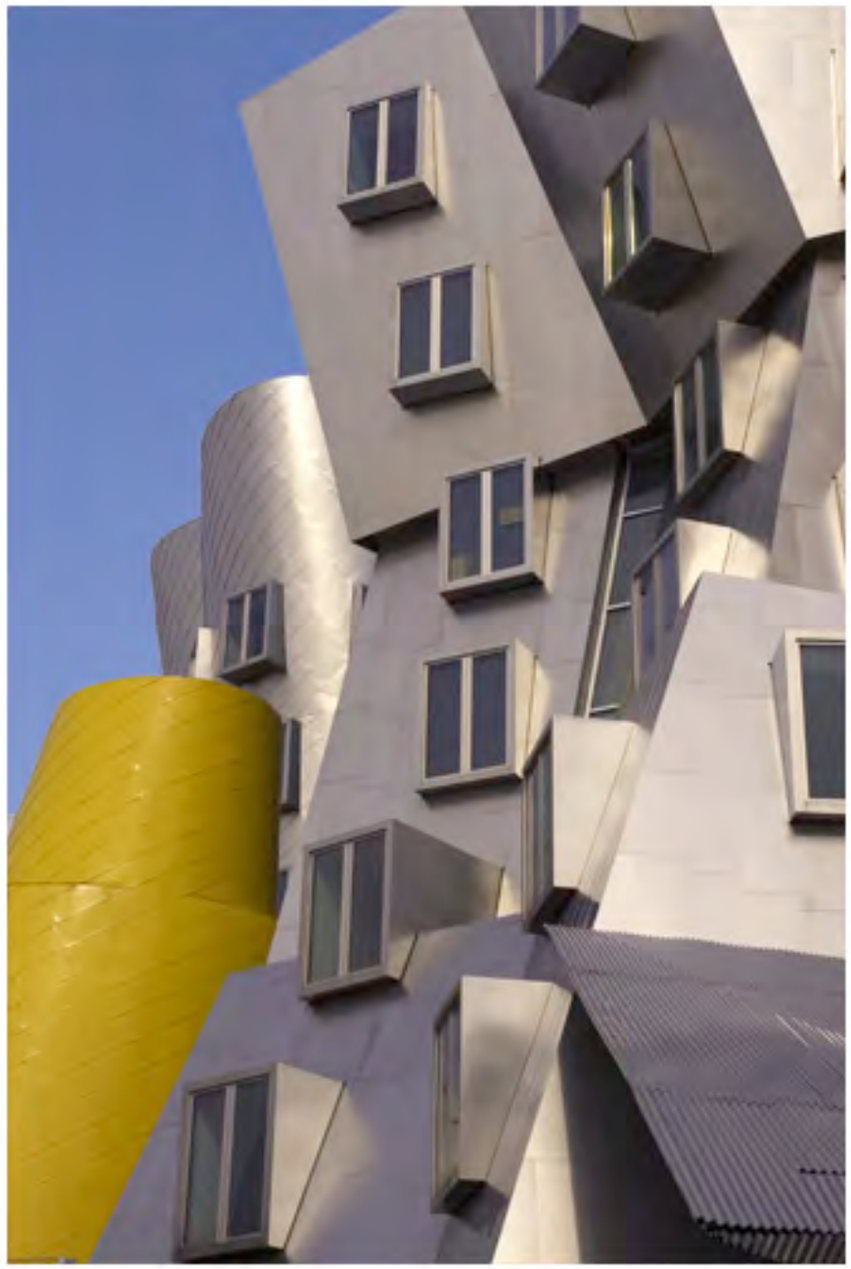
source: Oxford English Dictionary, thanks: Martin Brynskov

design has
<u>always</u> been
computational





so what's the big deal?



architecture

What has the design of the Gates building in common with the design of Windows Vista™ ?

- large complex project
- accommodate legacy users
- support change over time
- hard to keep on schedule
- designers work concurrently at different levels™
- multiple stakeholders, conflicting requirements

How to design?

How does designing work?

Mass Housing

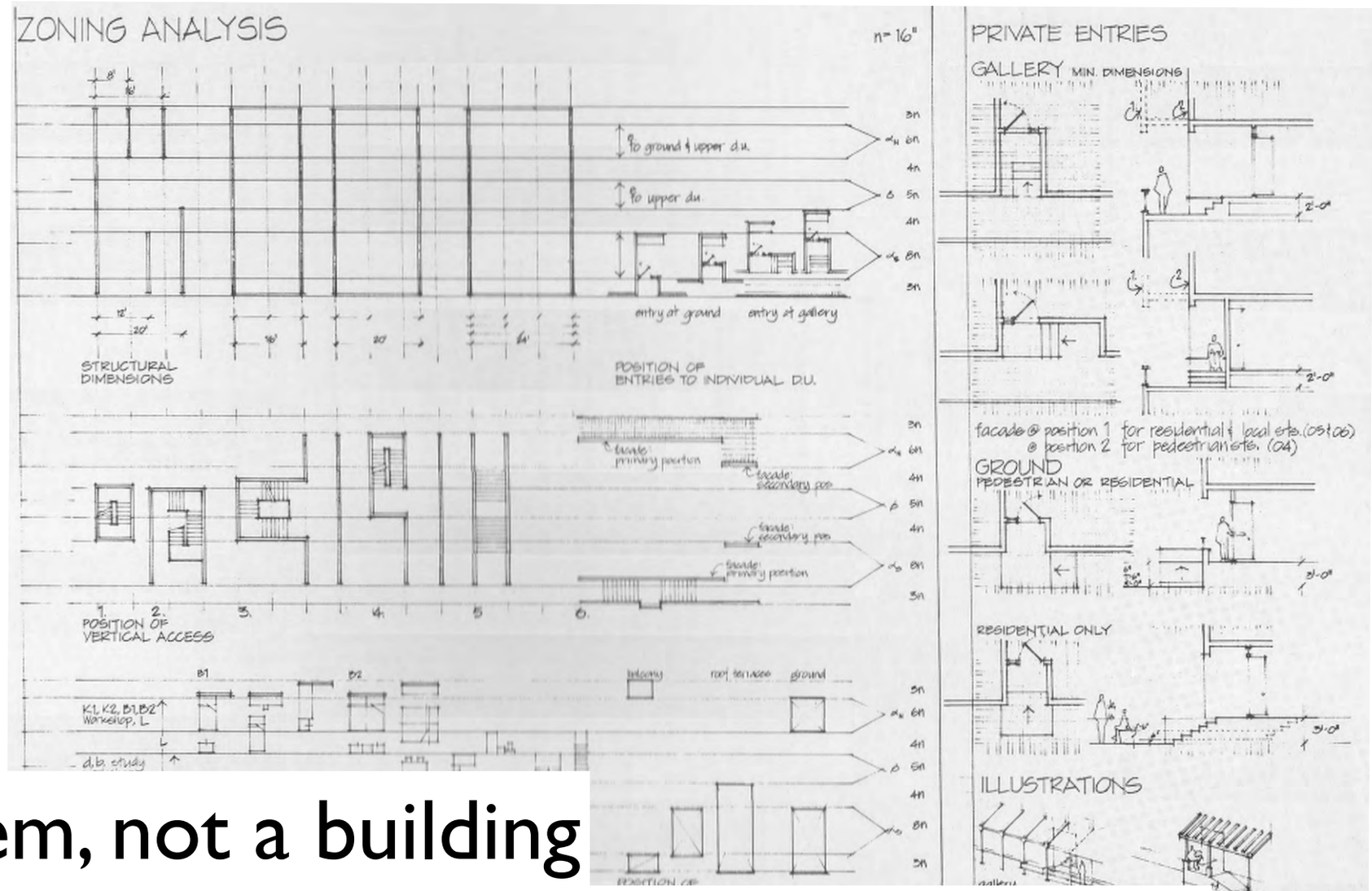
"Supports" — how to design for:

variability?
flexibility?
change?

Recognize:

- dependency, control hierarchies
  - (gravity, enclosure, supply)
- scope of action (who can act where?)
- protocol layers

N.J. Habraken, "SAR 65"



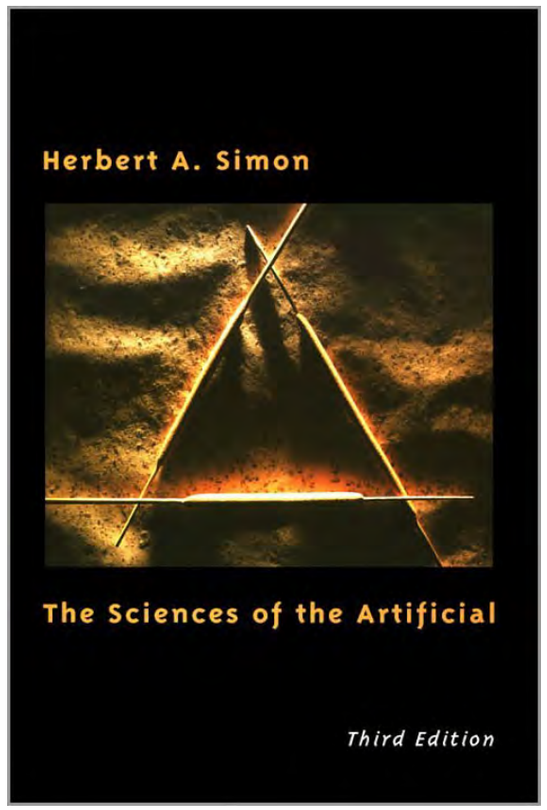
design a system, not a building

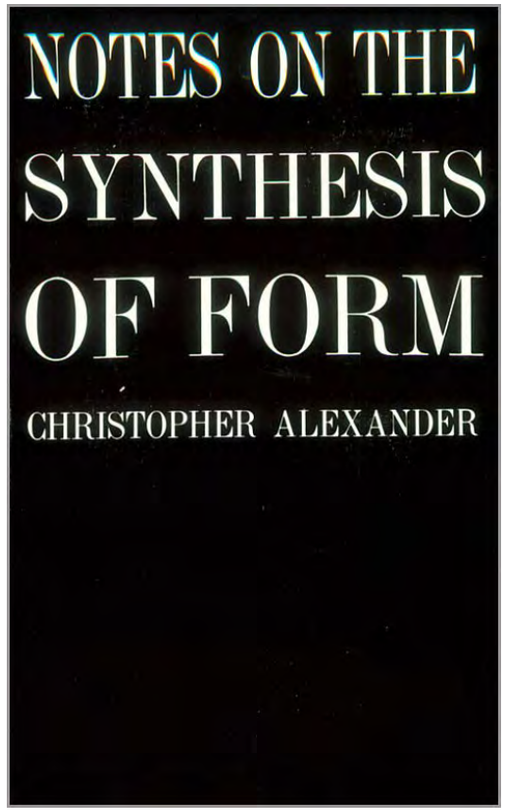
evaluate a system differently than a single design

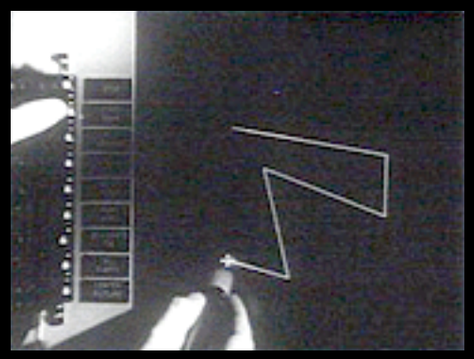
example: capacity to support lower level variation

all this leads inevitably to:

design spaces, search, optimizing and satisficing,
minimal spanning trees, clustering, &tc



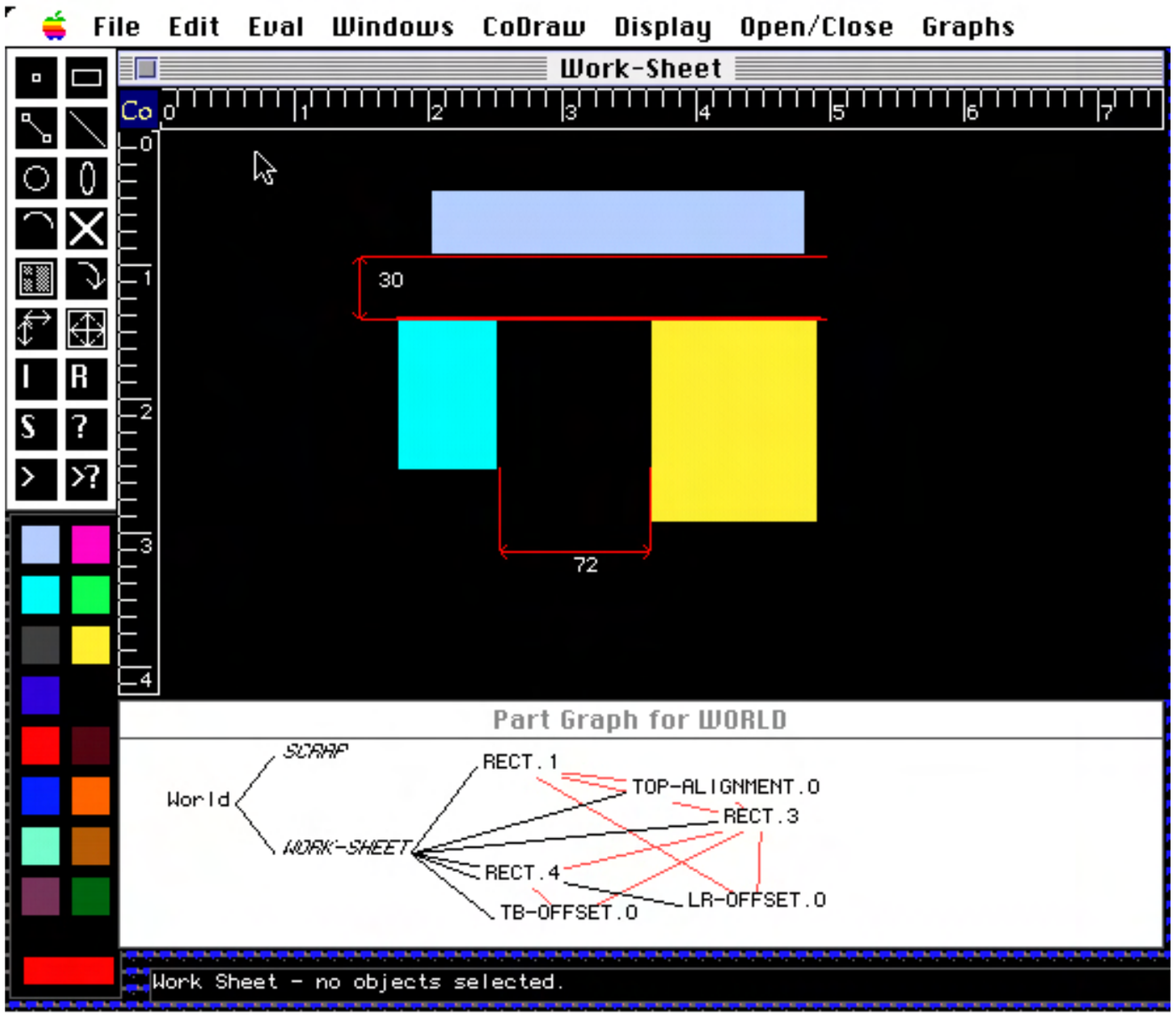




constraints

design as exploring constraints

designers define a space of alternatives
by adopting and inventing constraints
because problem and solution "co-evolve"
so: constraint programming languages for design
designers (end users) use constraints to define abstractions



* object oriented
* constraint based
- relations first class objects
- interval math
- simultaneous, nonlinear
- multiple inheritance
- part lattice (not tree)

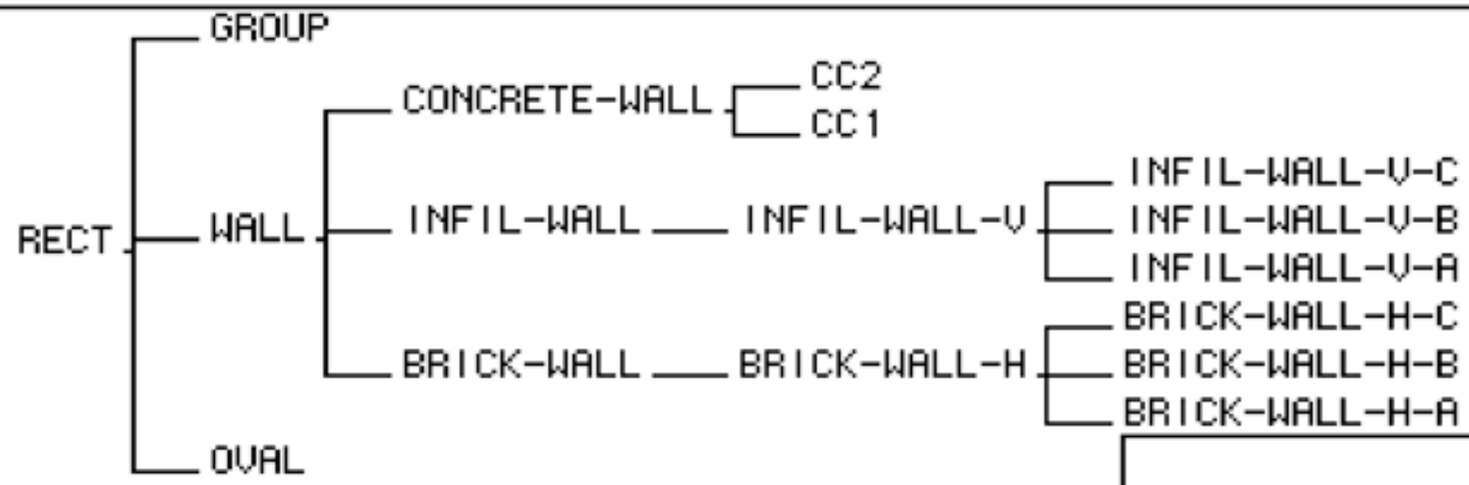
* end users program it

CoDraw (constraint language and draw program)

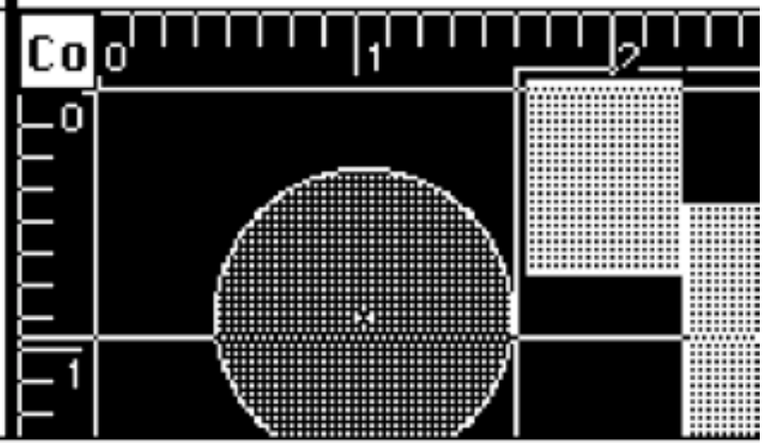
~1990

File Edit Eval Windows CoDraw Display Open/Close Graphs Library 8:07:09

Subclasses of RECT



Work-Sheet



Relations of RECT.1

[RECT.1 COLOR] EQ [4096 LIST 65280]	R-156
TOP] = 48	R-155
LEFT] = 166	R-152
HEIGHT] = 92	R-107
WIDTH] = 47	R-105

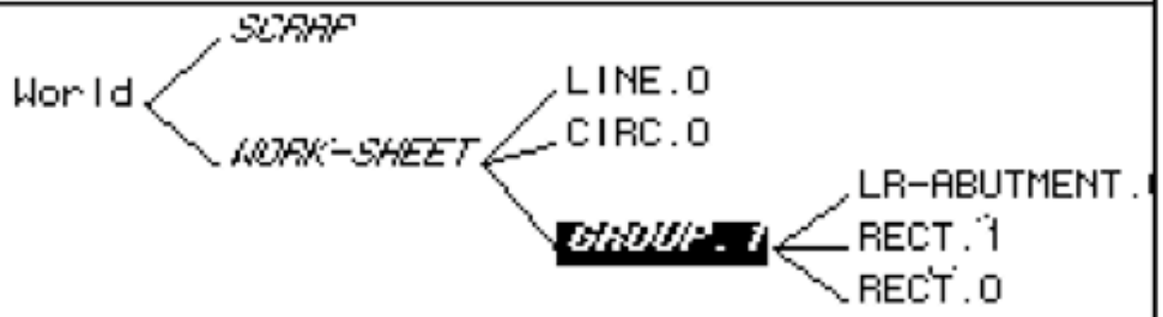
SQUARE Class Variables

Fix | Add Var | Rel's Card | SubClass | ☒ all
Retract | Del Var | Inits Card | Instance

super
inspect
terms
why?
graph

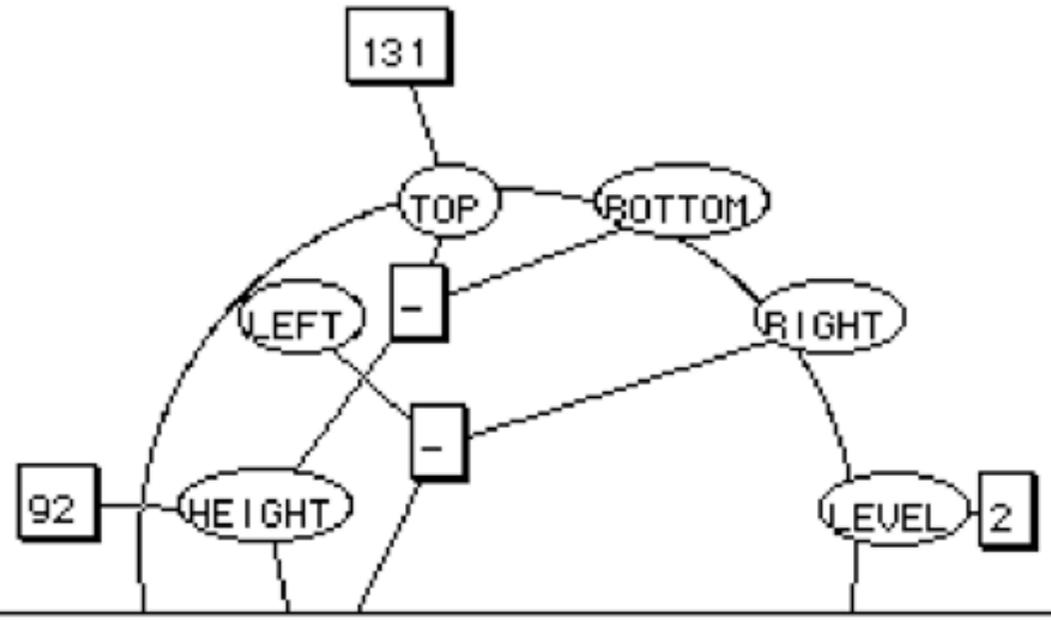
AREA	4324
BOTTOM	223
COLOR	(4096 65280 21248
HEIGHT	92
LEFT	200
LEVEL	2
RIGHT	247
SP-GROUP	GROUP.1, a GROUP
TOP	131

Part Graph for WORLD

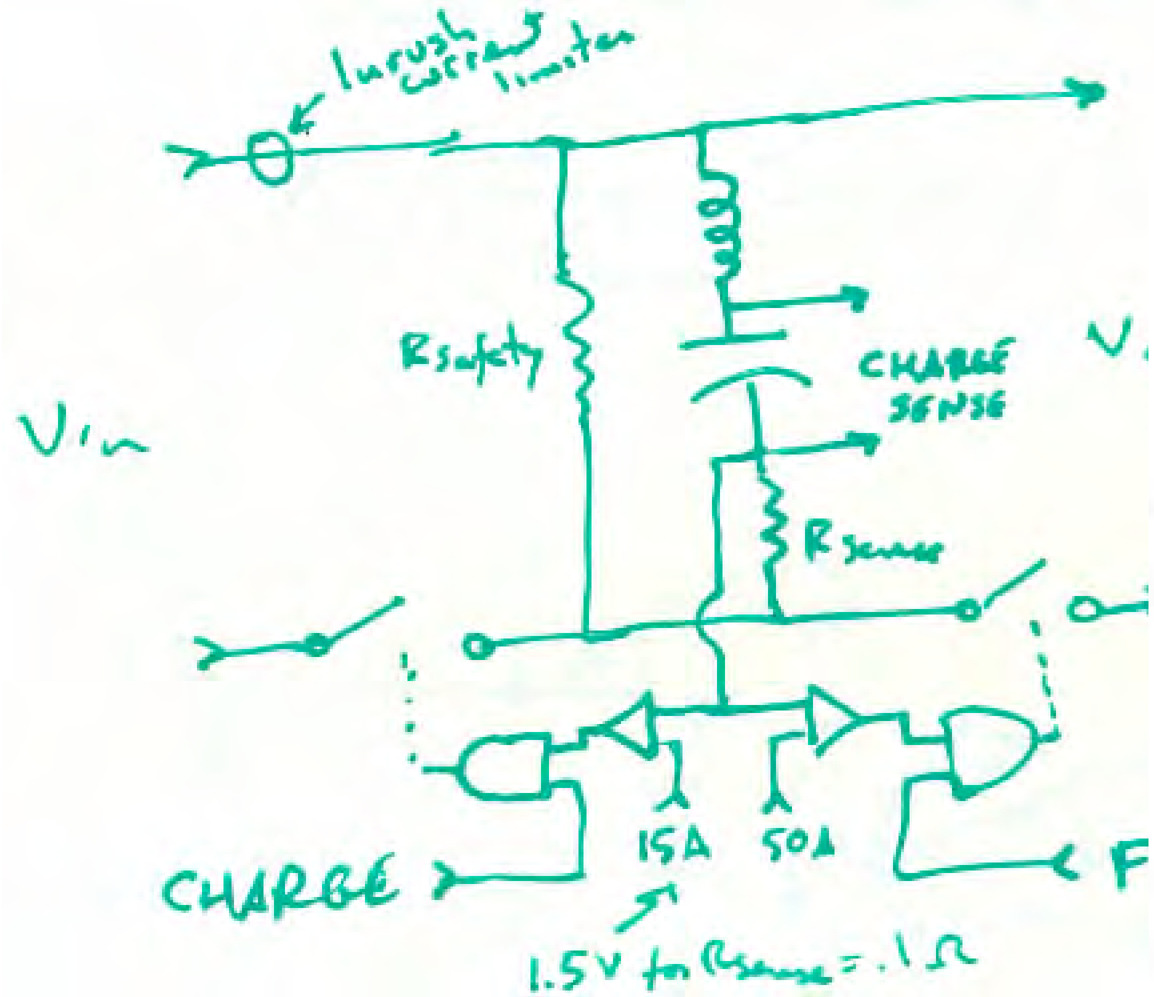


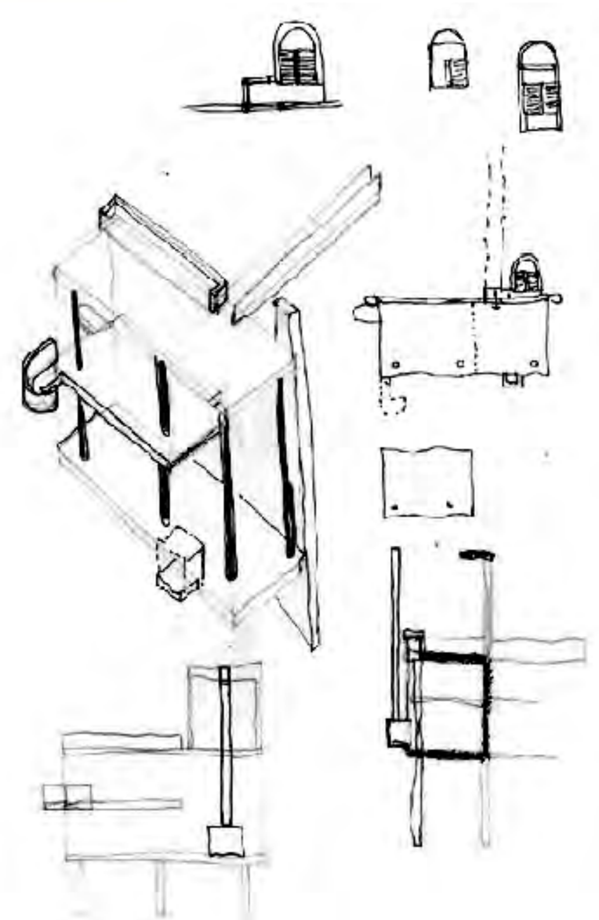
GROUP.1 selected in Work-Sheet.

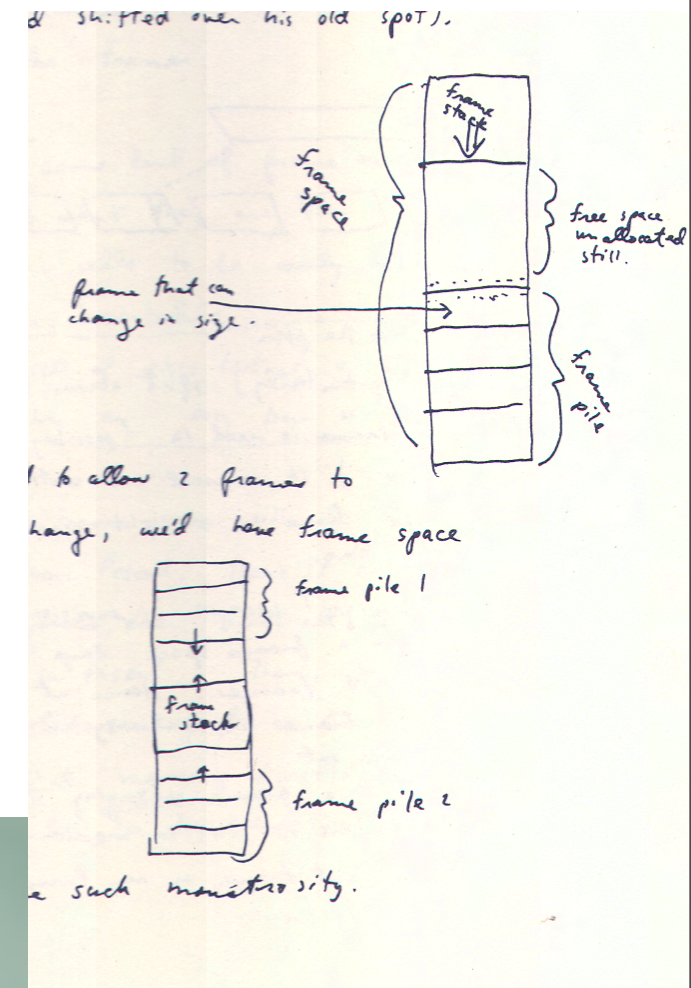
Constraint graph RECT.1

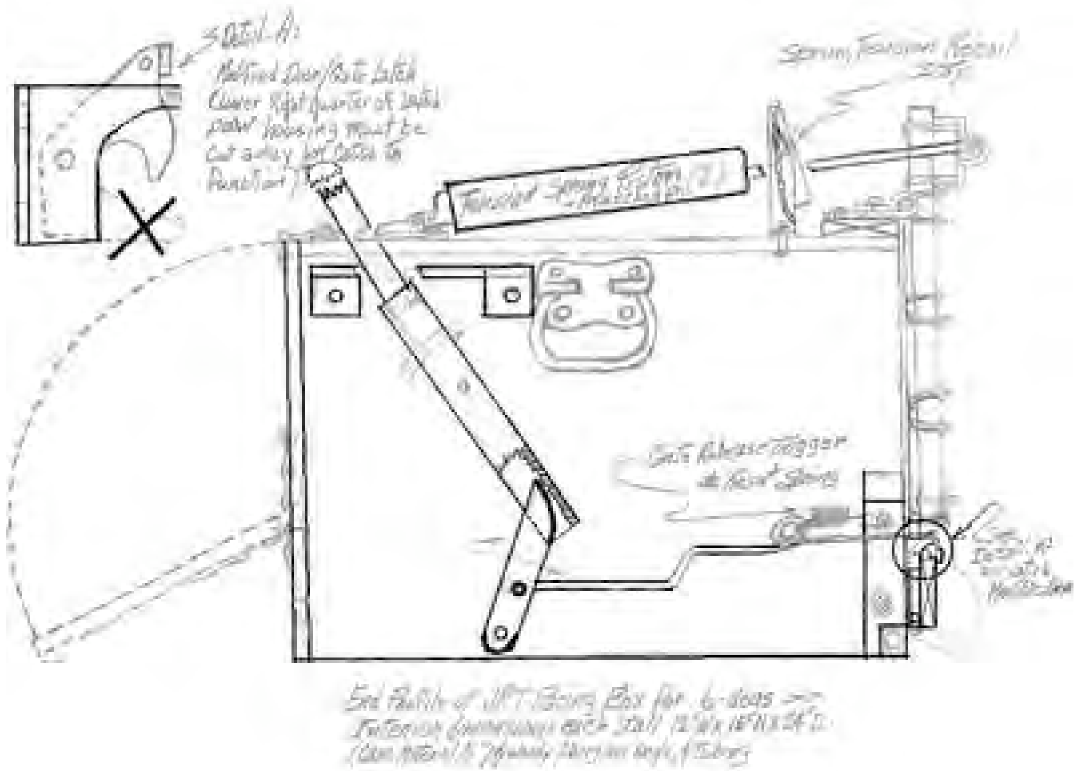


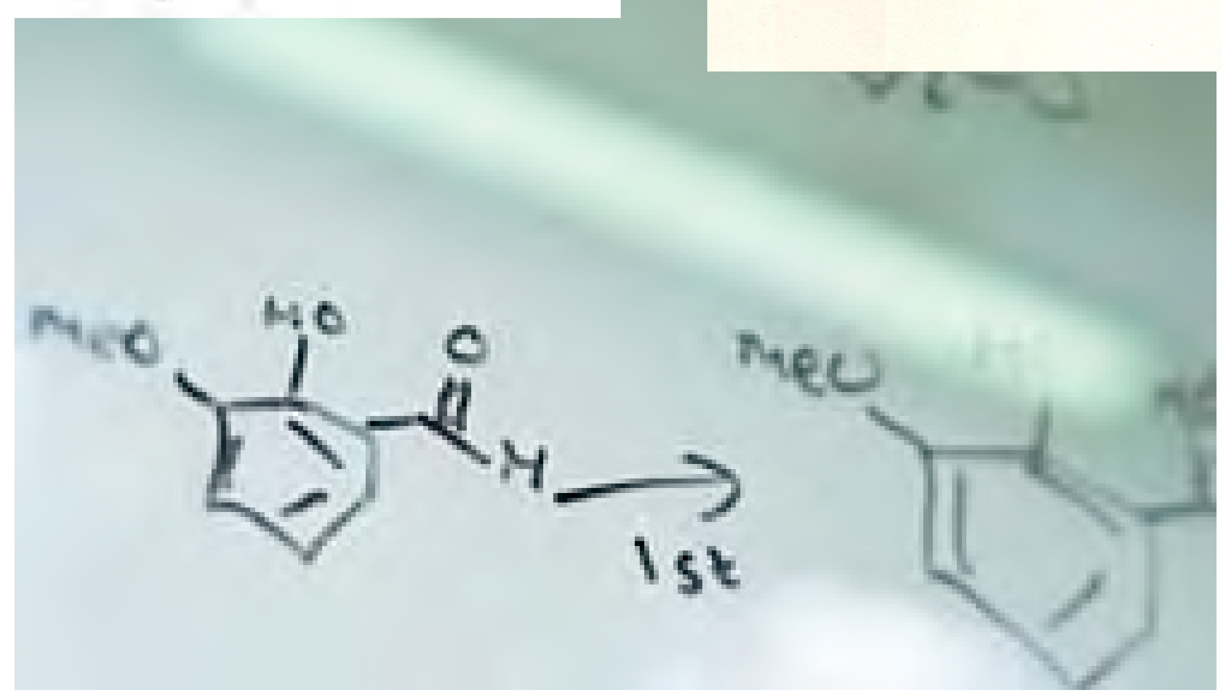
drawing


Inrush current limiter
Rsafety
CHARGE SENSE
Vin
Rsense
CHARGE
15A
50A
1.5V for Rsense = .1Ω




shifted over his old spot).
frame stack
frame space
free space unallocated still.
frame that can change in size.
frame pile
to allow 2 frames to
change, we'd have frame space
frame pile 1
frame stack
frame pile 2
such monstrosity.




MeO
HO
O
H
1st
MeO

visual languages

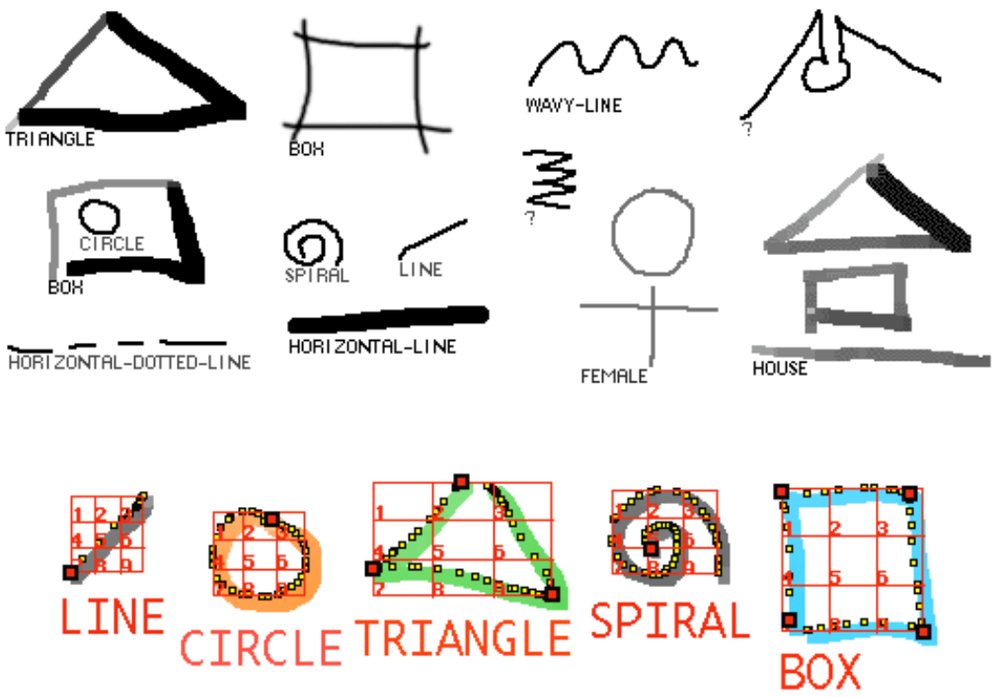
how do design drawings mean?

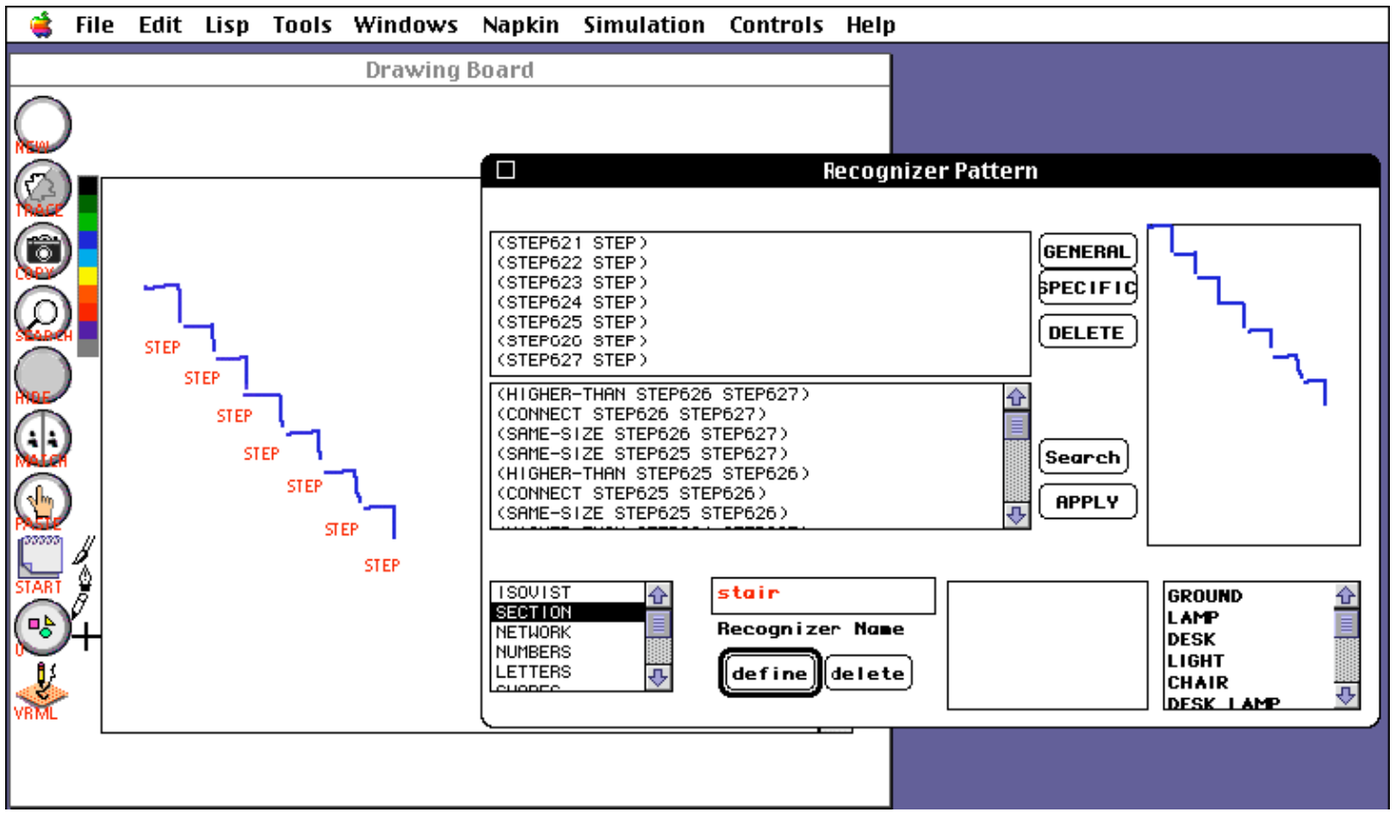
drawing is a notation for reasoning

recognizing and interpreting diagrams

drawing as a front end to knowledge based systems

electronic cocktail napkin





Sketches:

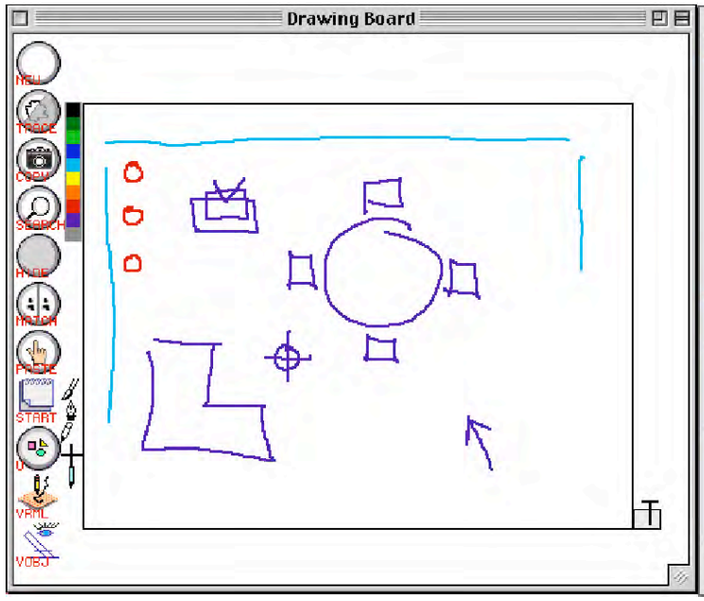
Quick
Imprecise
Vague, suggestive
Incrementally formal
Symbolic
Meaningful

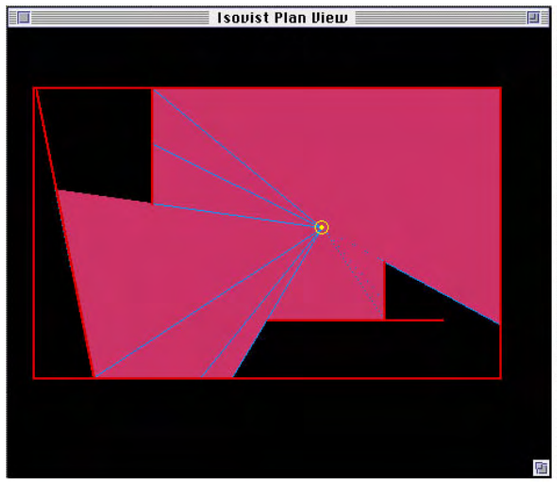
Cocktail Napkin recognizer:

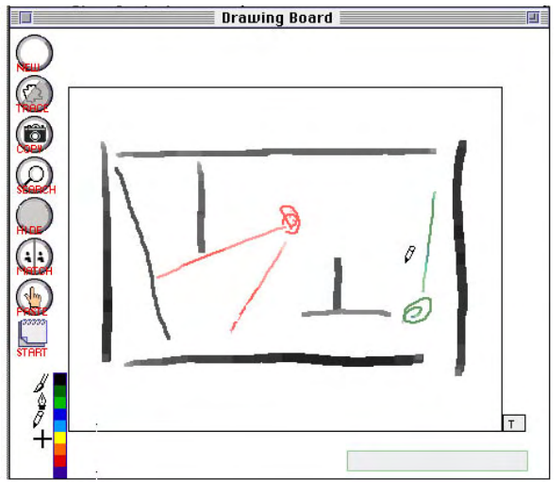
2 levels end user defined recognizer
- Ledeen (augmented) for symbols
- Higher-level grammar for configs

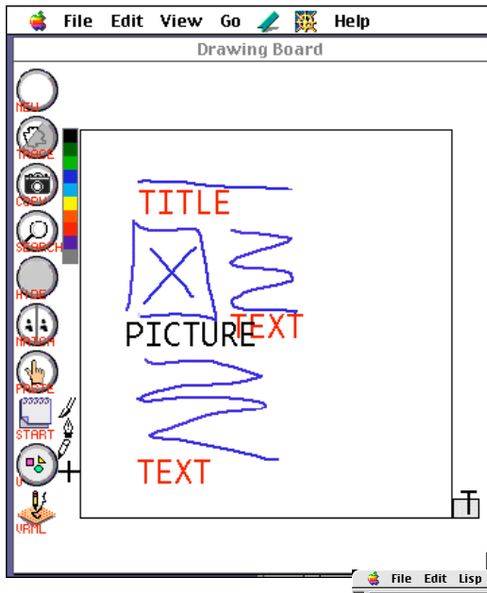
Lazy, context-driven, context inferring
On-the-fly training
Maintains ambiguity

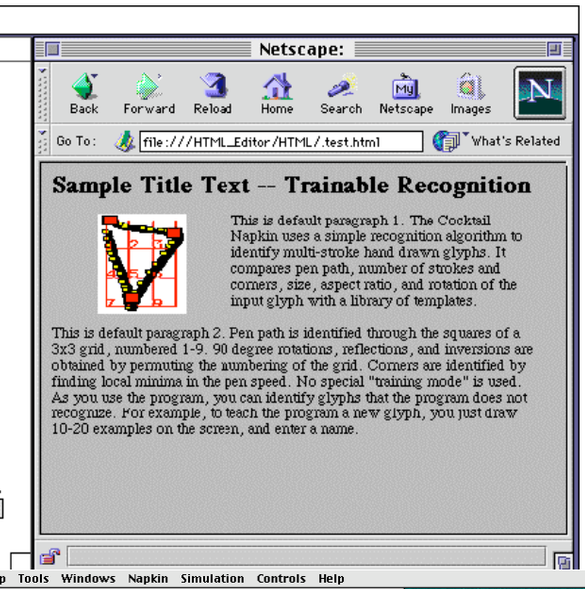
Beautification considered harmful

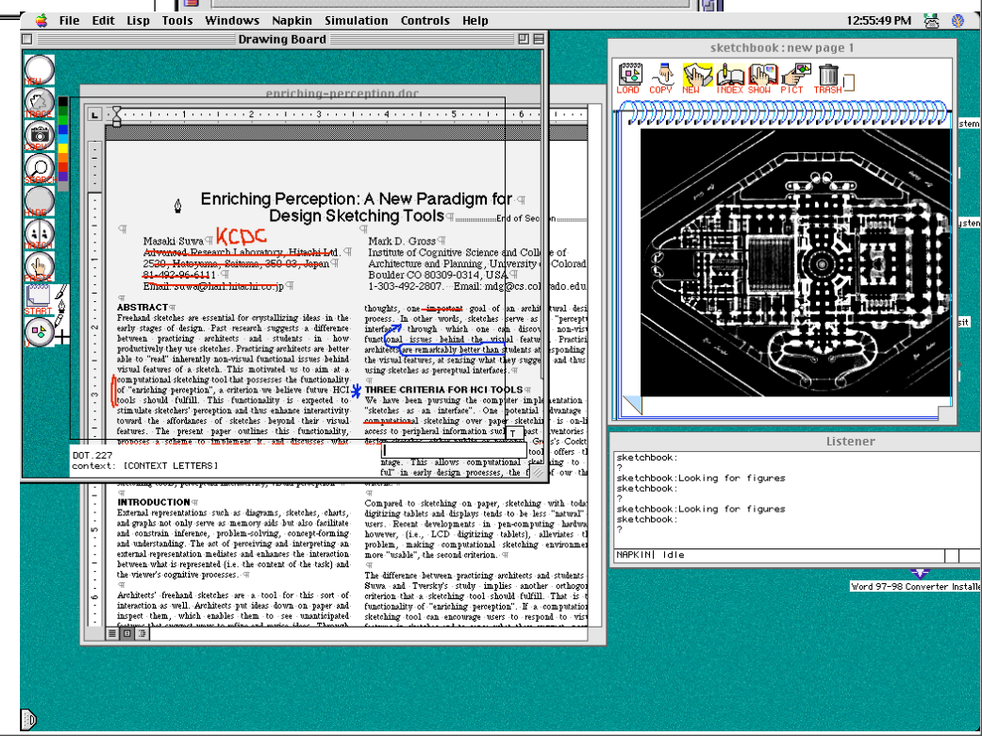










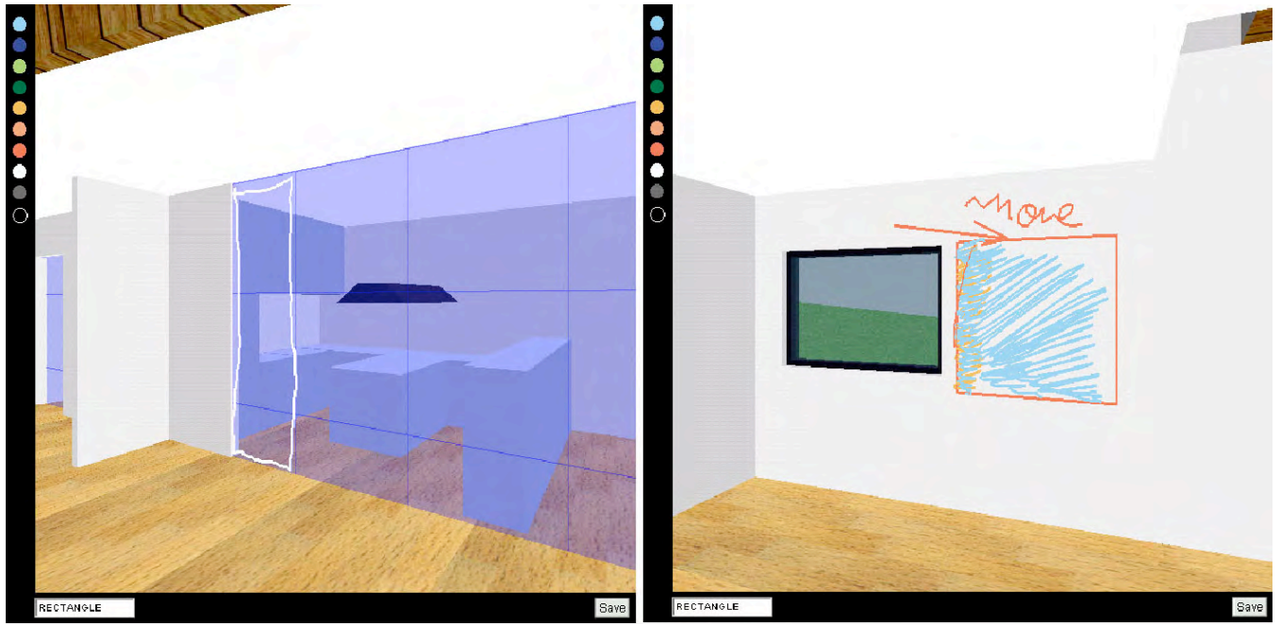


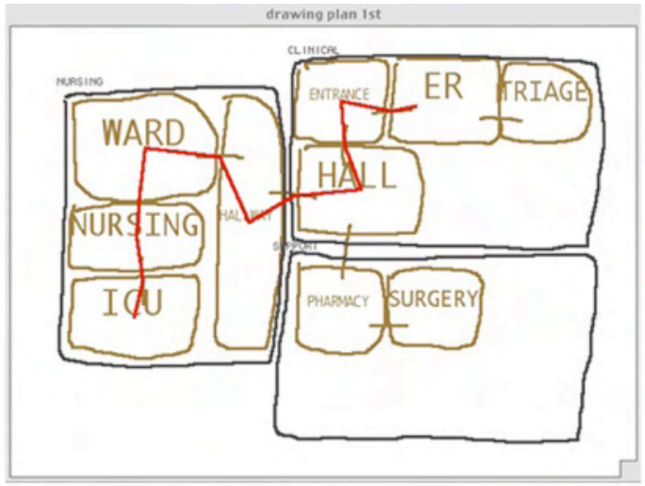
drawing for:

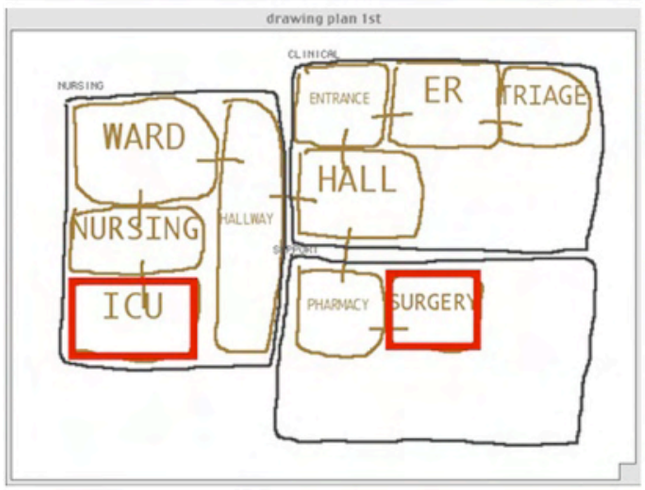
- retrieving information
- back-of-envelope simulation
- modeling & construction
- editing

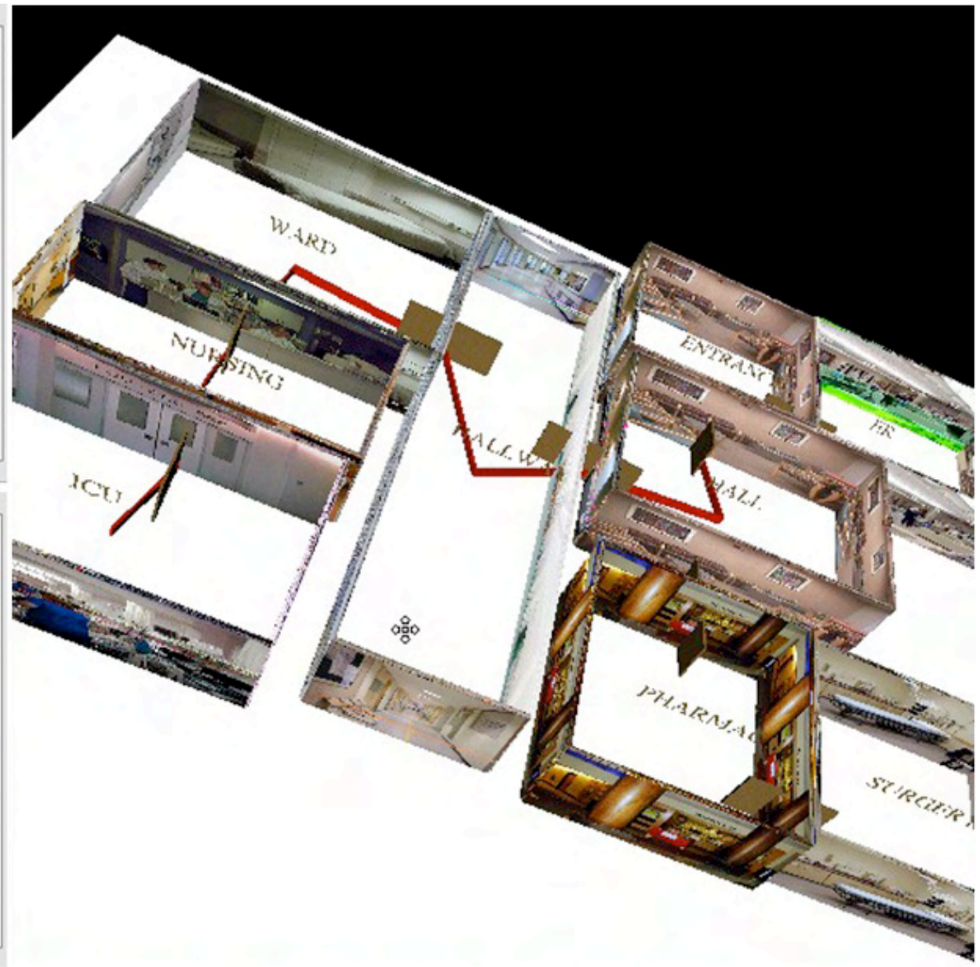
drawing to
annotate, model

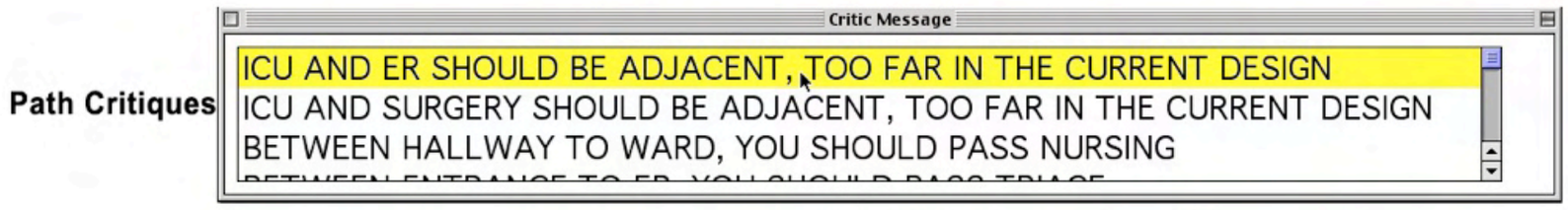
as interface to
expert lighting
design advisor

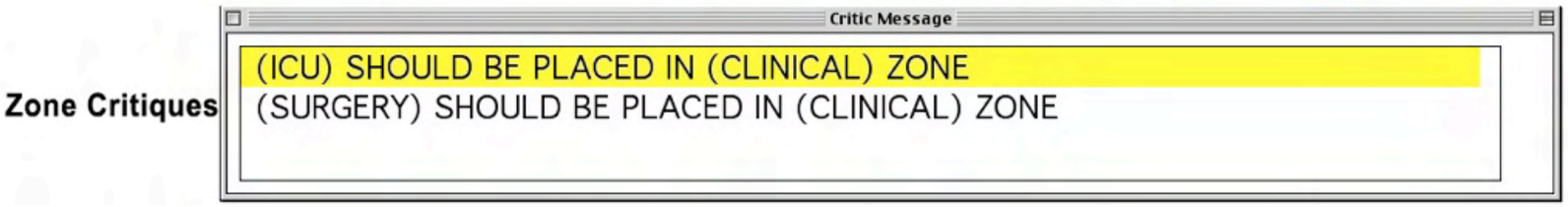








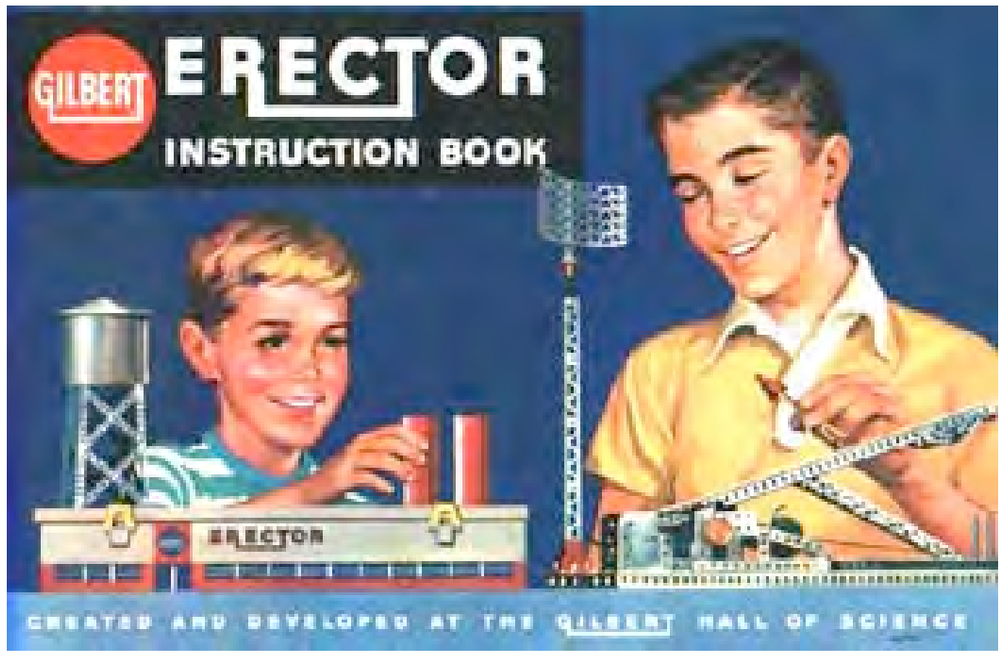


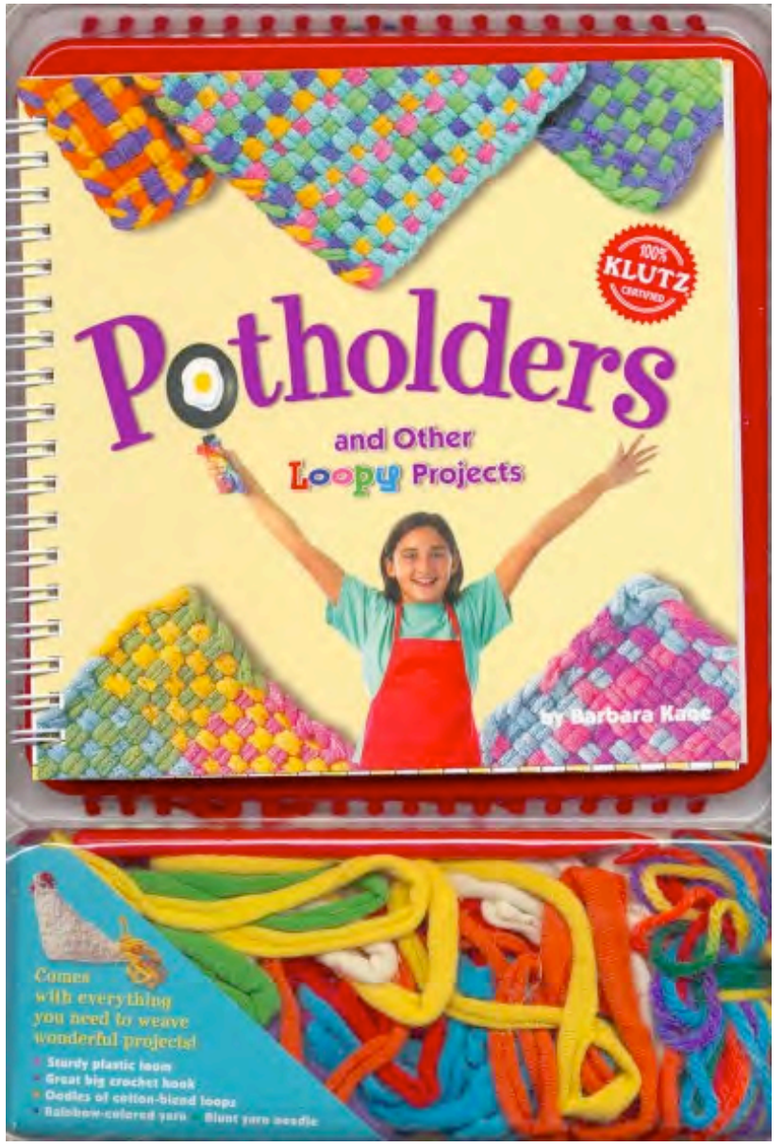


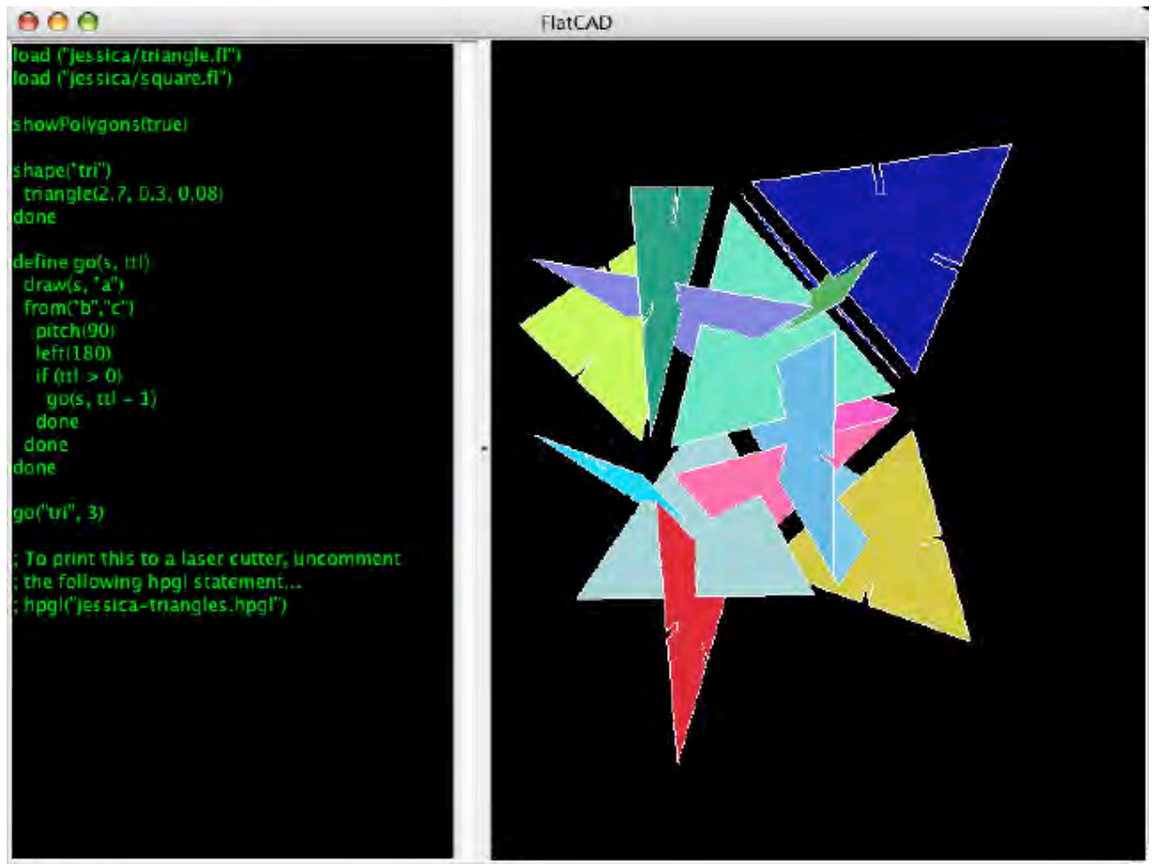
critiquing design drawings

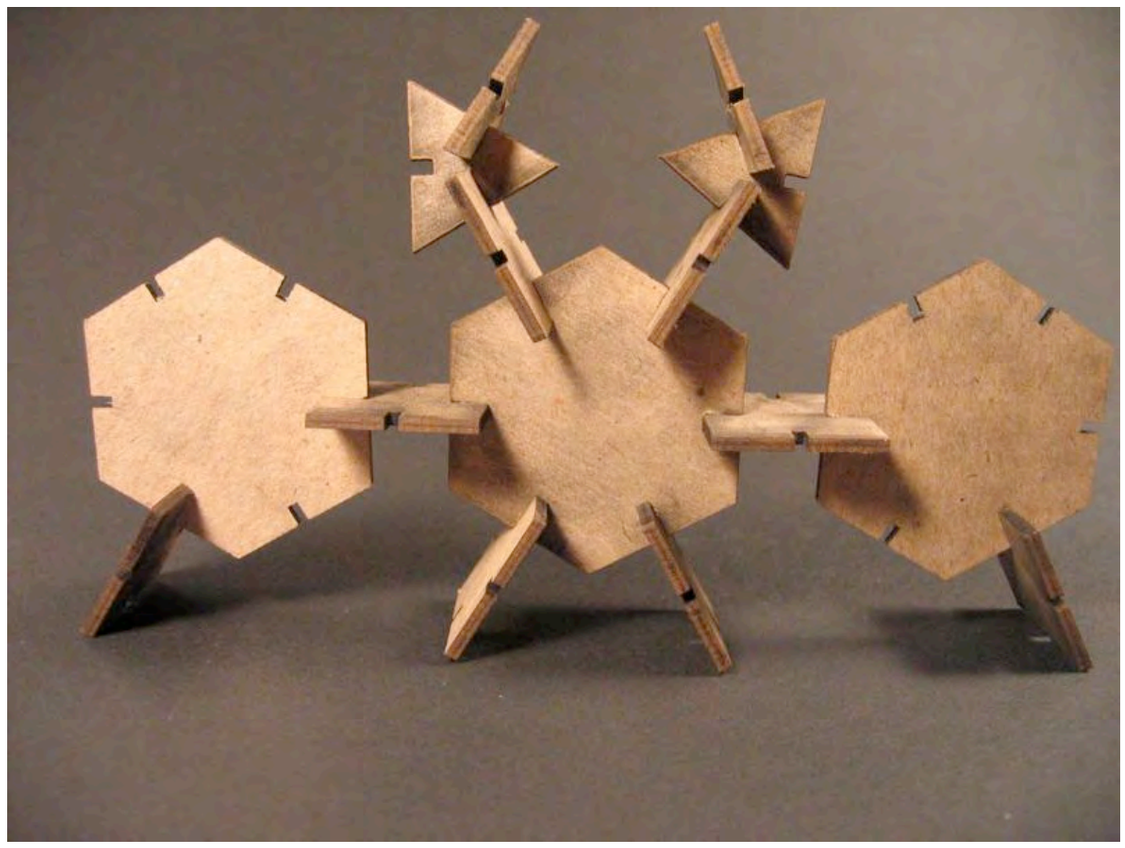
construction

construction kits & craft

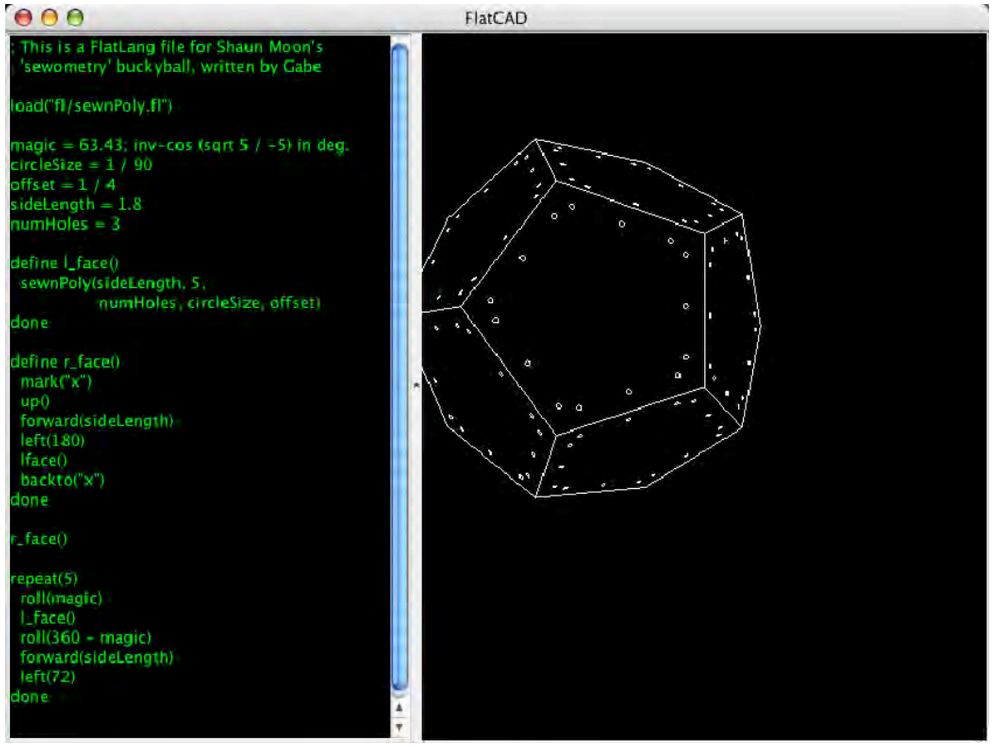


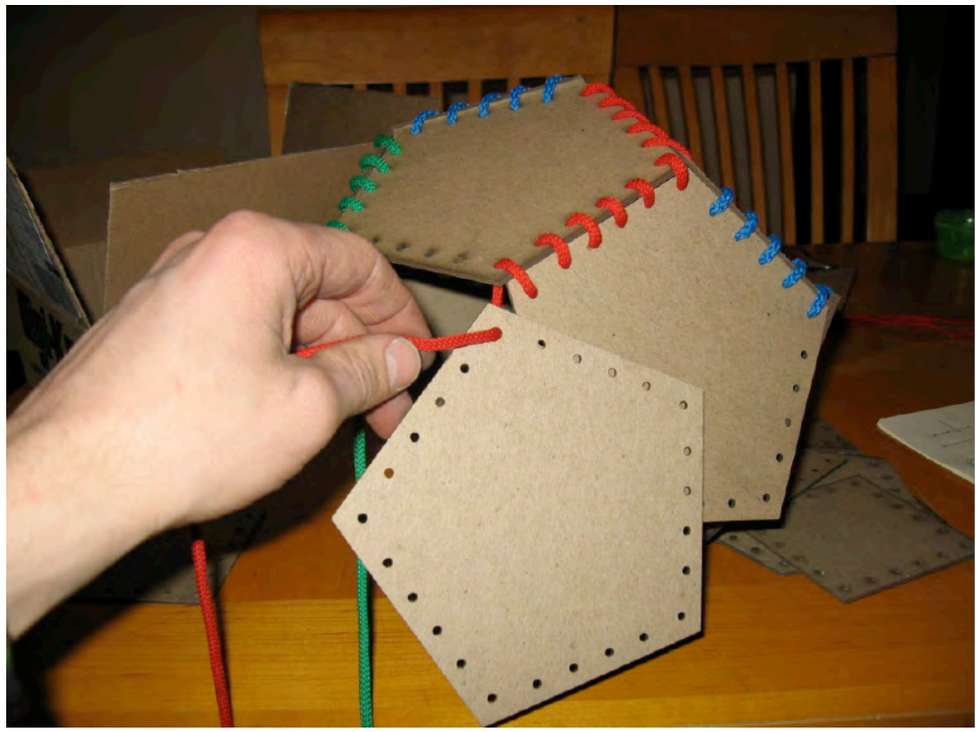




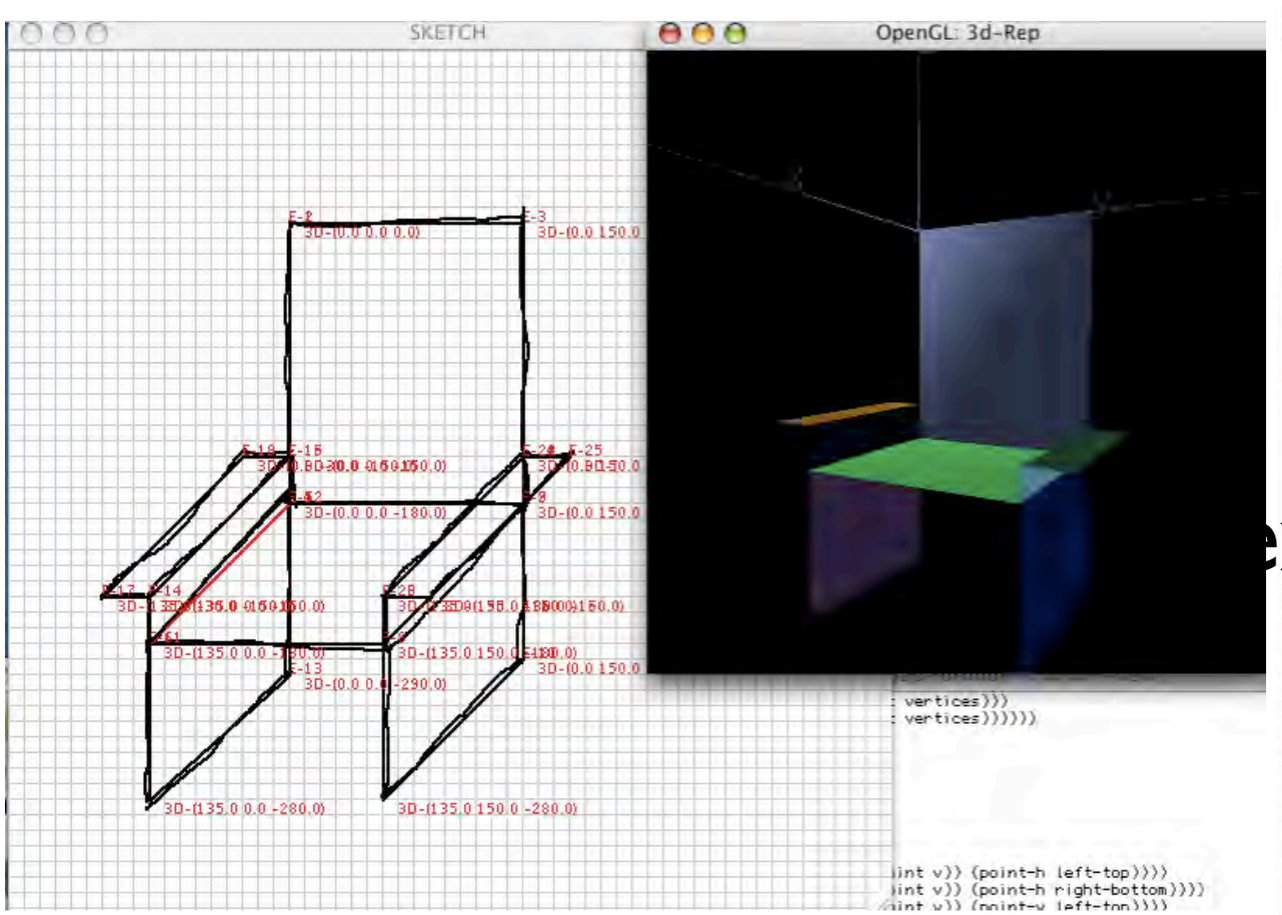


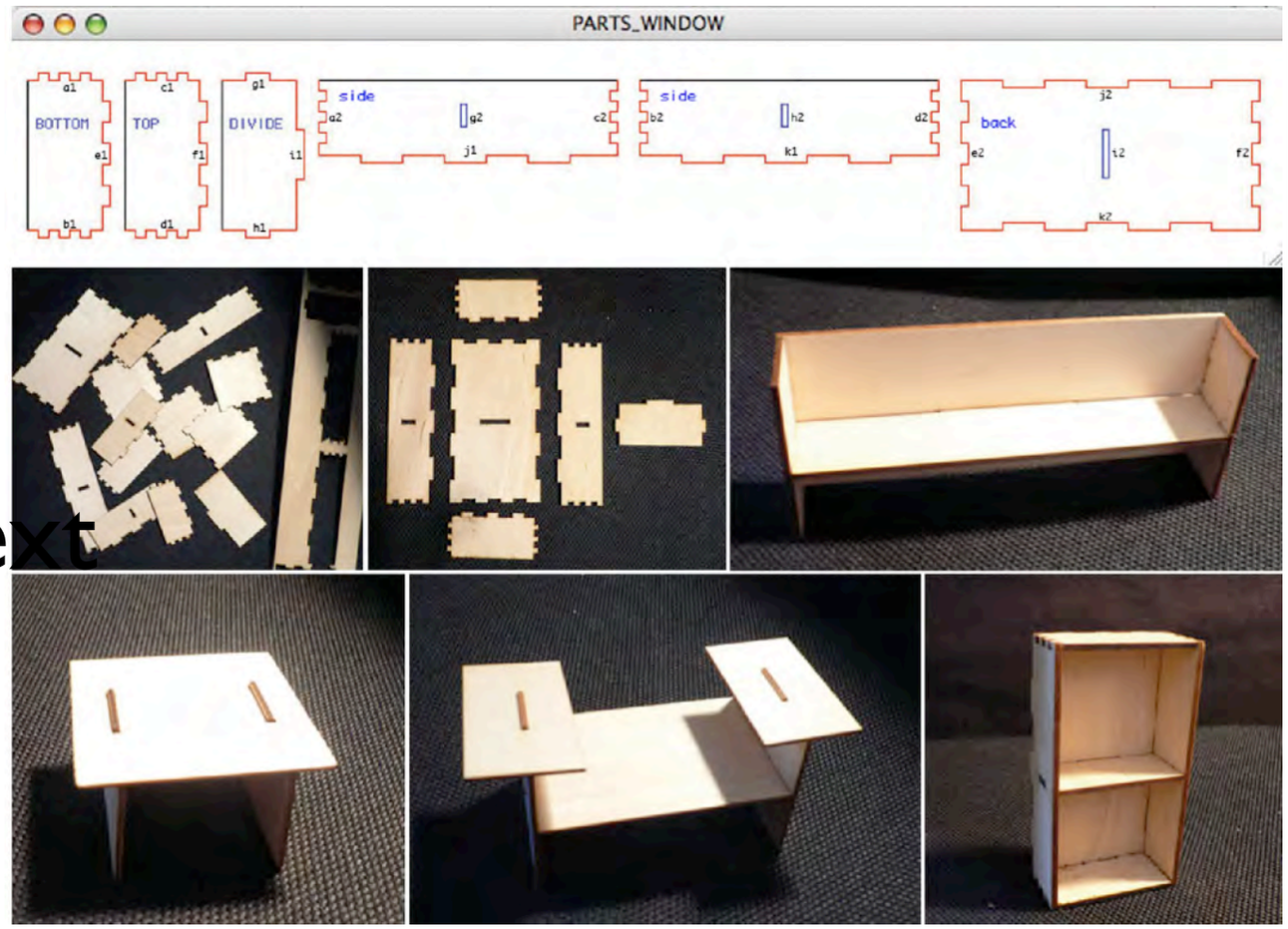
FlatCAD: using 3D turtle geometry to design and manufacture wood models





SewOmetry - using FlatCAD to make construction kits

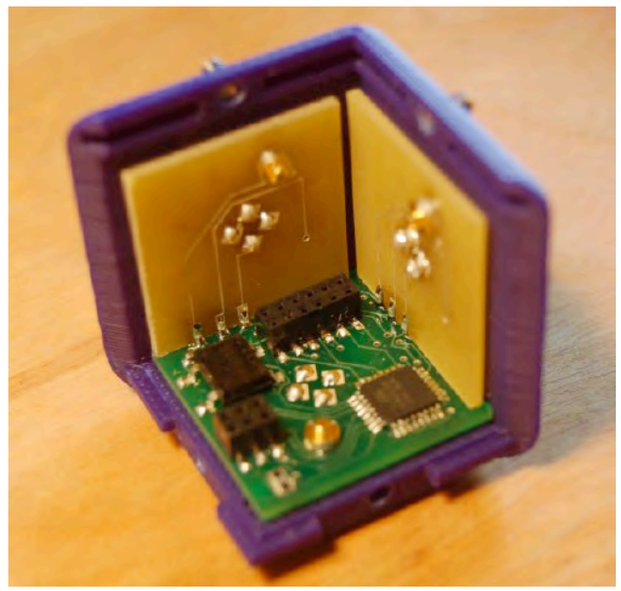




Furniture Factory - sketch to 3D for rapid manufacture

roBlocks

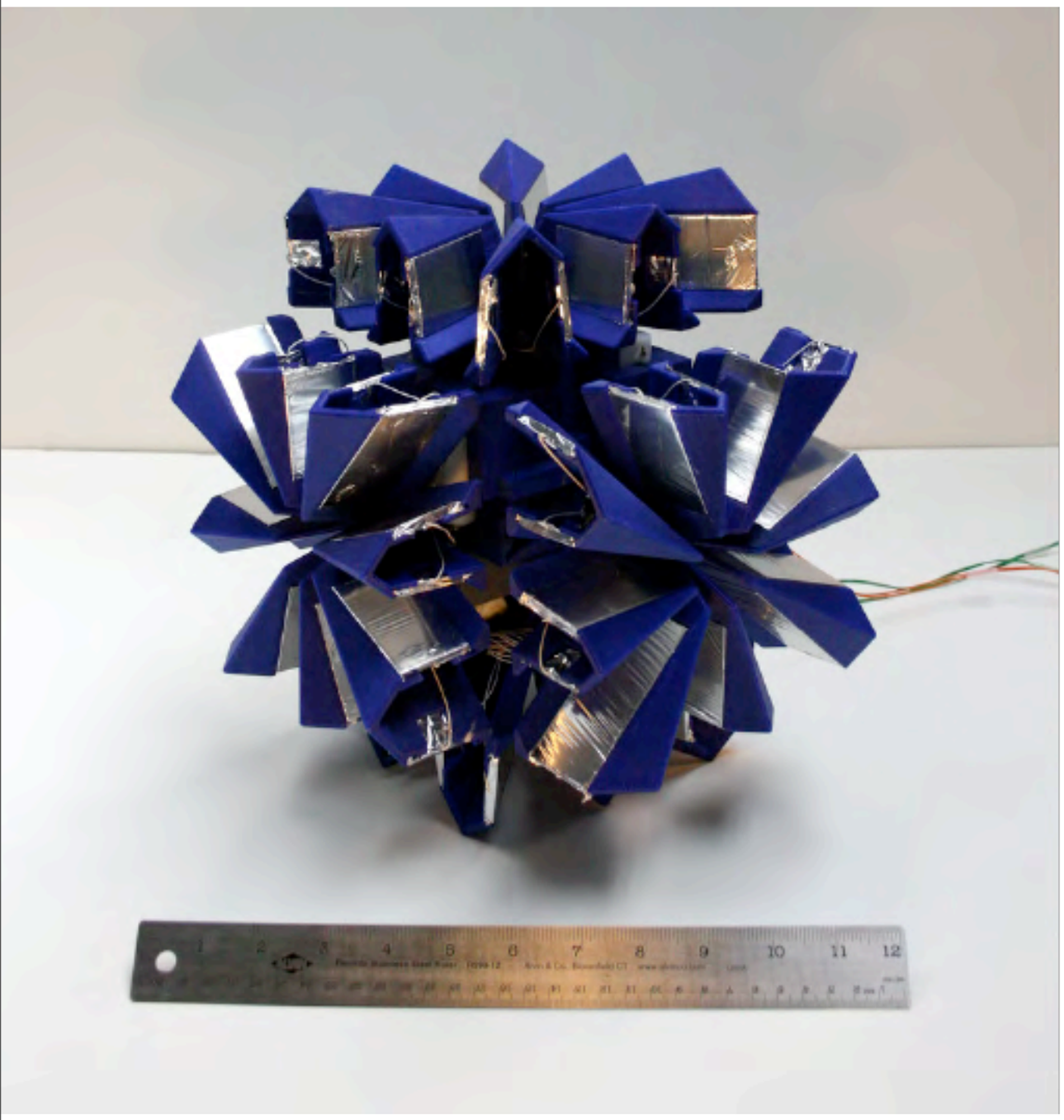
a toy for distributed computational thinking

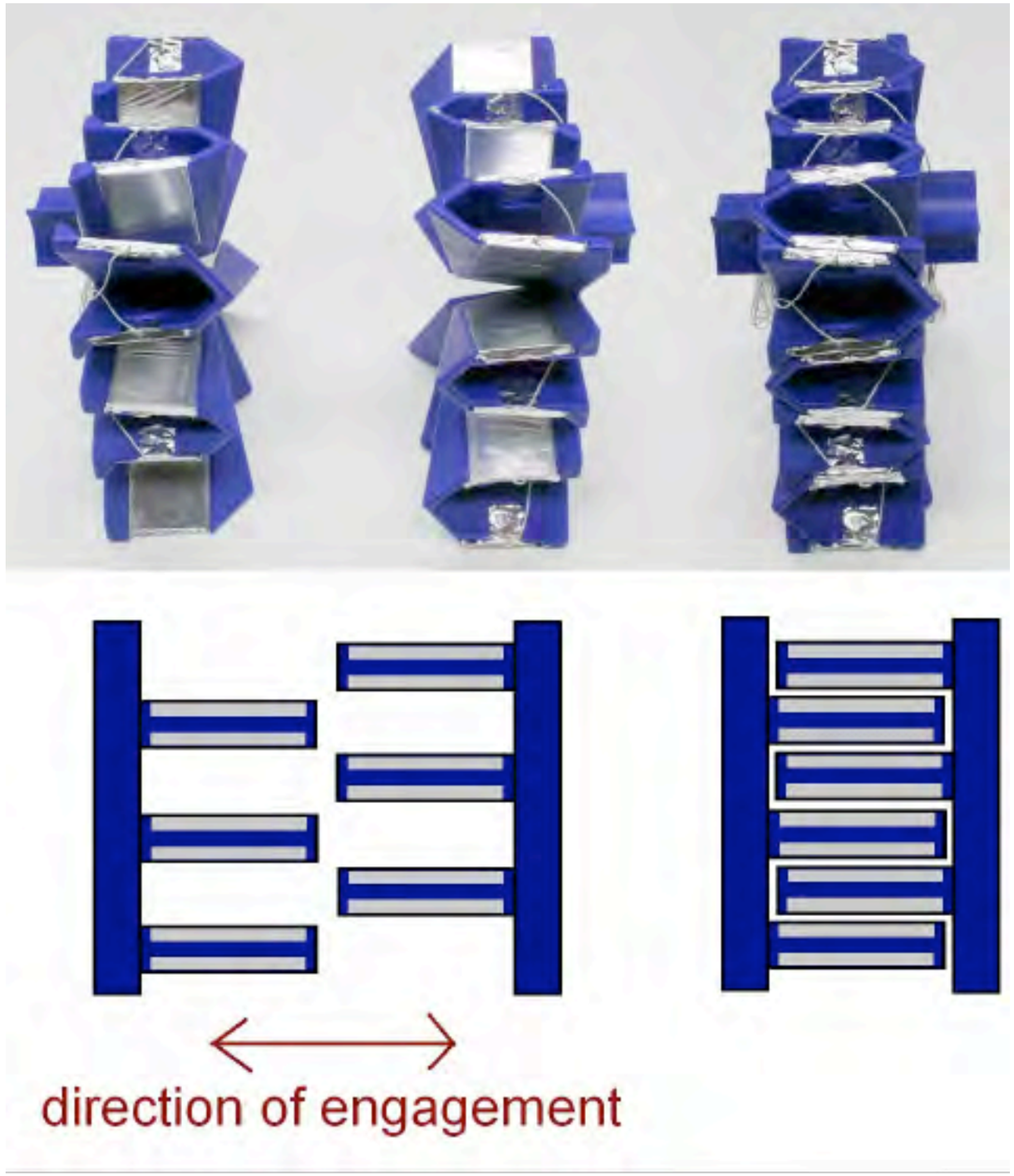


black sensors
white actuators
colored operators
compute locally to produce“emergent” behavior

www.roBlocks.org

cube robots (with Seth Goldstein's Claytronics group)





Posey !


digital
EQUIPMENT
CORPORATION
Certified for PDP-5/8
2702g Blocks
201g 12 bit words/block
Certified for PDP-1
4, 6, 7, 9, 10, 15
1102g Blocks
400g 18 bit words/block
by _____ date _____

dectape

future work

design as debugging
design compilers (e.g., for mechatronics)
design by analogy
critiquing

IS Design Thinking Computational Thinking?

Design is important (everything is designed).
We don't know a lot about how design works.
Computational thinking will help.

If it's not, it should be.

thanks!

Ellen Yi-Luen Do - Electronic Cocktail Napkin
Gabe Johnson - FlatCAD
Shaun Moon - SewOmetry
Thomas Jung - 3D sketch annotation
Yeonjoo Oh - Furniture Factory, Critiquing
Eric Schweikardt - roBlocks
Mike Weller - Posey, cube 'bots

NSF ITR 0326054 : Construction Kits (w. Eisenberg)
NSF CCF 0613822: Science of Design (w. Shaw, Finger, Herbsleb)
PITA '04-'05 "Thinking With Your Hands" (w. Do, Finger)

http://code.arc.cmu.edu

end

since we know you're free Tuesday afternoons ...

research in design @ CMU

dr-lab@mailman.srv.cs.cmu.edu

oct 16: suguru ishizaki

A Model of Rhetorical Design Strategies

computational thinking?

MONSIEUR JOURDAIN: Oh, really? So when I say: "Nicole bring me my slippers and fetch my nightcap," is that prose?

PHILOSOPHY MASTER: Most clearly.

MONSIEUR JOURDAIN: Well, what do you know about that! These forty years now, I've been speaking in prose without knowing it! How grateful am I to you for teaching me that!

Moliere: Le Bourgeois Gentilhomme