Instructional scaffolding for problem solving and design

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TOOL 5100

University of Oslo, 17.09.2009

Two articles

- Wood, D., Bruner, J.S. & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 17, 89-100.
- Oh, Y., Gross, M.D. & Do, E. Y.-L. (2008). Computer-aided critiquing systems: Lessons learned and new research directions. *Proceedings Computer Aided Architectural Design and Research in Asia* (CAADRIA). Chiang Mai, Thailand, pp. 161-167.

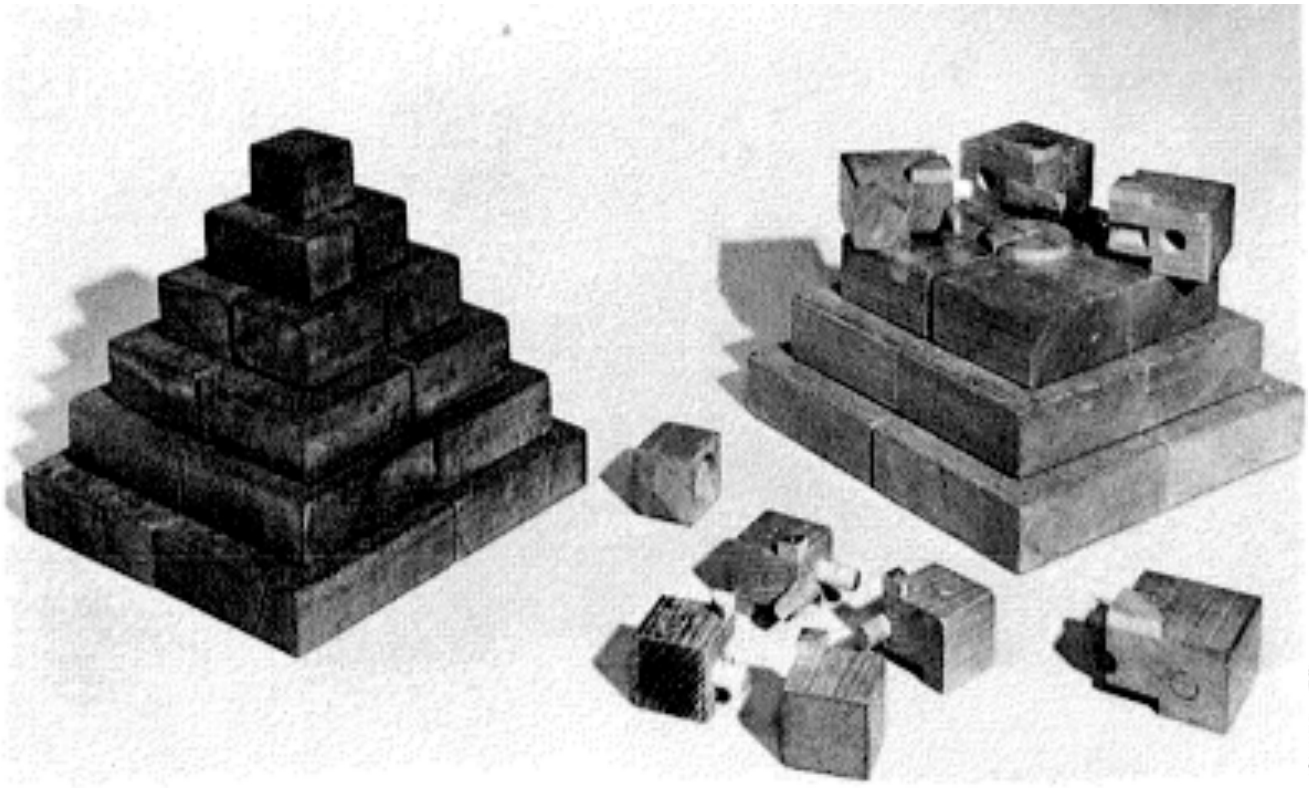
What they have in common

- One article about human tutoring as an extension of Vygotsky ZPD and with implications for computer support
- The other article is about computer-aided critiquing systems modeled after how expert designers critique novice designers' work in progress
- Both develop notions of "scaffolding," the second by constructive feedback / critique

Differences

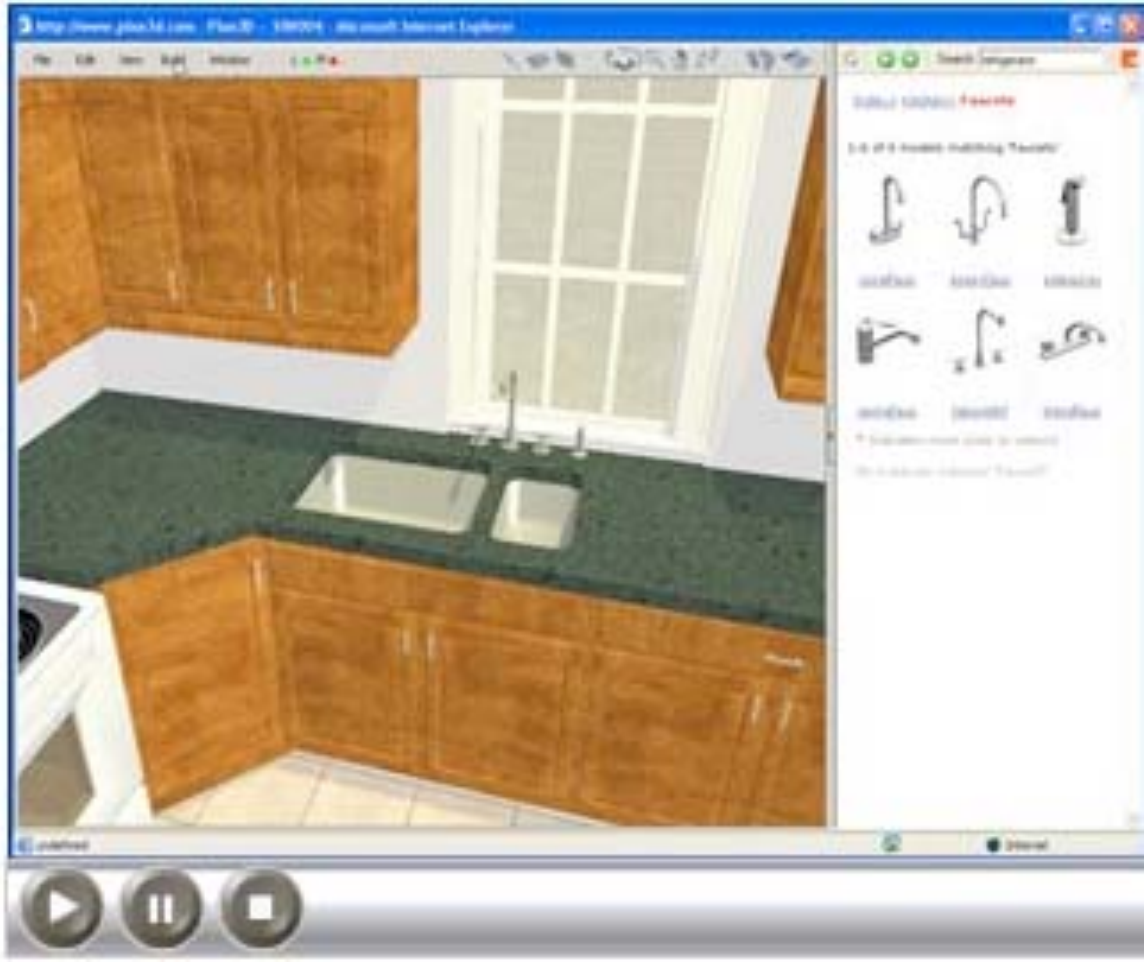
- Associated with the difference between problem solving and design
  - Problem solving is goal-oriented with tasks that define sub-goals, often one best solution/goal
  - Design is “open ended” problem solving, with multiple alternative solutions that are “better or worse” with respect to some reference criteria, rather than well defined goals
  - They converge in children's construction kits with one right solution for assembly (like the building block kit used in the first paper)

Building block kit for 3-5 yr olds

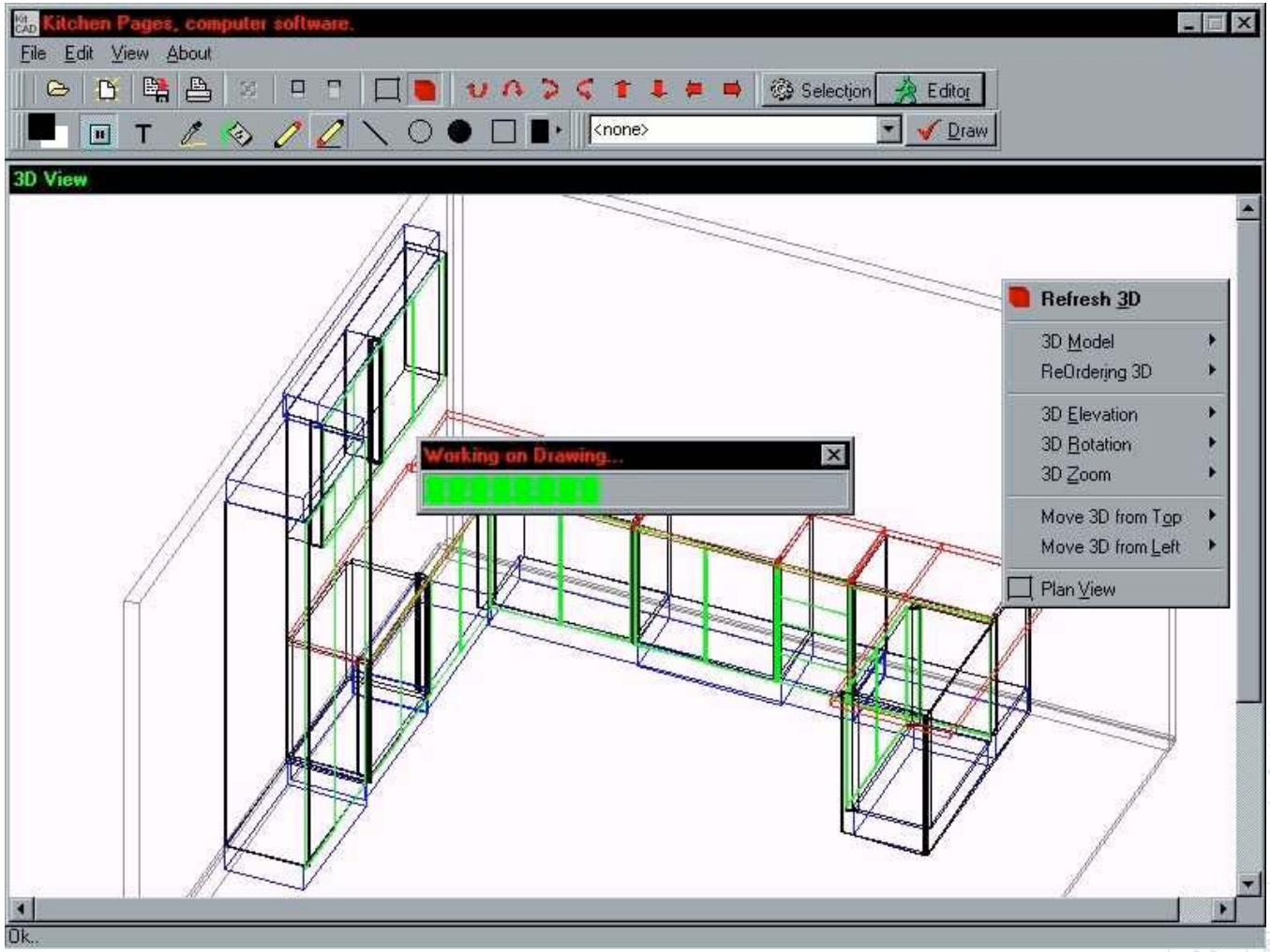


Construction kit

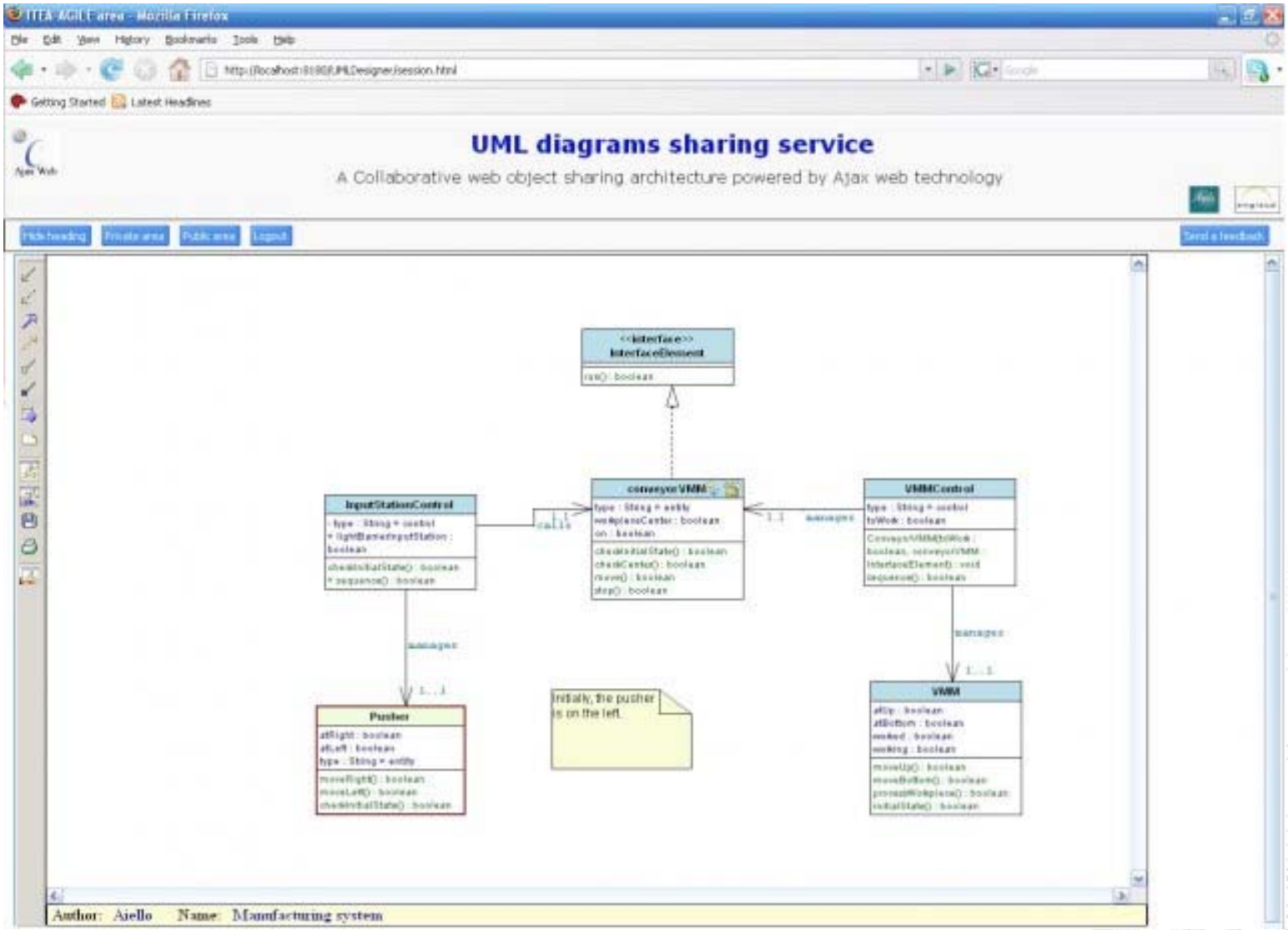
Design environment



3D design environment



Collaborative design of UML diagrams



Scaffold, dictionary def

scaf·fold [**skaf**-*uh* ld, -ohld] Show IPA

–noun

1. a temporary structure for holding workers and materials during the erection, repair, or decoration of a building.
2. an elevated platform on which a criminal is executed, usually by hanging.
3. a raised platform or stage for exhibiting spectacles, seating spectators, etc.
4. any raised framework.
5. a suspended platform that is used by painters, window washers, and others for working on a tall structure, as a skyscraper.
6. *Metallurgy*. any piling or fusion of materials in a blast furnace, obstructing the flow of gases and preventing the uniform descent of the charge.
7. a system of raised frameworks; scaffolding.

–verb (used with object)

8. to furnish with a scaffold or scaffolding.
9. to support by or place on a scaffold.

Origin:
1300–50; ME *scaffot, skaffaut, scaffalde* < OF *escadafaut;* akin to CATAFALQUE

Example usage: The scaffolding must be removed once the house is built.

Instructional scaffolding

- Bruner et al:
- "To enable a child or novice to solve a problem, carry out a task or achieve a goal that would be beyond his unaided performance"
- "*Scaffolding* is accomplished by an adult or more capable peer controlling those elements of the task that are initially beyond the learner's capacity"
- It acts like individualized feedback from the environment, supporting the learner to progress

Task

- Discovery learning with a a collection of wooden building blocks
- Need to take into account both “blind” (serendipitous) action and the more rigid instruction rules followed by the tutor
- The tutor provides scaffolding during the building and learning processes, sometimes being there and sometimes fading away to support the learner’s gradual development

Types of feedback by tutor

- Showing
  - Direct intervention (giving example)
- Telling
  - A verbal error prompt (correction, critiquing)
  - Verbal attempt to make child to make more constructions (direction and reminder)

Experiment with children

- The paper describes an experiment with children aged 3, 4, and 5 years
- They interact with a human tutor (adult) who helps them build a pyramid out of the basic building blocks (shown in foil 5)
- Data is categorized according to the three types of scaffolds and compared across age groups

Results

TABLE 2. RELATIVE SUCCESSES OF EACH AGE GROUP WITH "SHOWING" AND "TELLING"

	Age 3	4	5
Showing succeeds	40%	63%	80%
Telling succeeds	18%	40%	57%

TABLE 3. RELATIVE FREQUENCY OF INTERVENTIONS BY THE TUTOR EXPRESSED AS INTERVENTIONS PER NUMBER OF CONSTRUCTION OPERATIONS (BOTH ASSISTED AND UNASSISTED) PERFORMANCE BY EACH CHILD

	Age 3	4	5
Total construction operations	262	352	280
Total interventions	201	198	112
Operations per intervention	1·3	1·8	2·5

The 5-yr-olds performed significantly more operations per intervention than the 4-yr-olds ($U = 16, p < 0{\cdot}02$) who performed more than the 3-yr-olds ($U = 10, p < 0{\cdot}002$).

Results cont'd

- 3 year olds learn less from telling (ignore them) than from showing (demonstration), 4 years are more explorative and verbal and learns also from telling (verbal correction and direction), whereas 5 year olds are more independent and need less feedback, they learn from telling, especially confirmation or checking of constructions

Implications for computer support

- According to Bruner et al a, good tutor makes hypotheses about the learner's hypothesis
- This is a dynamic process, which is important for successful tutoring
- Bruner et al suggest a "task model" and a "learner model" to be part of a "computer tutor" to perform at the level of a human tutor
- More about "intelligent tutoring systems" in the lecture on 08.10.2009. ITS is a type of educational technology using AI techniques

The scaffolding process

- Recruitment (engagement, motivation)
- Reduction in degrees of freedom
- Direction maintenance
- Marking critical features (identify ZPD)
- Frustration control
- Demonstration (showing)

Computer-aided critiquing

- Critiquing systems are less stringent compared to “computer tutors”, regarding modeling tasks and students’ progress
- The “goal” is to design something, which is characterized by open-ended, “good enough,” solutions, except for simple design problems
- Individualized feedback are important to computer tutors and critics to both motivate the learner and to fill the ZPD with right chunk

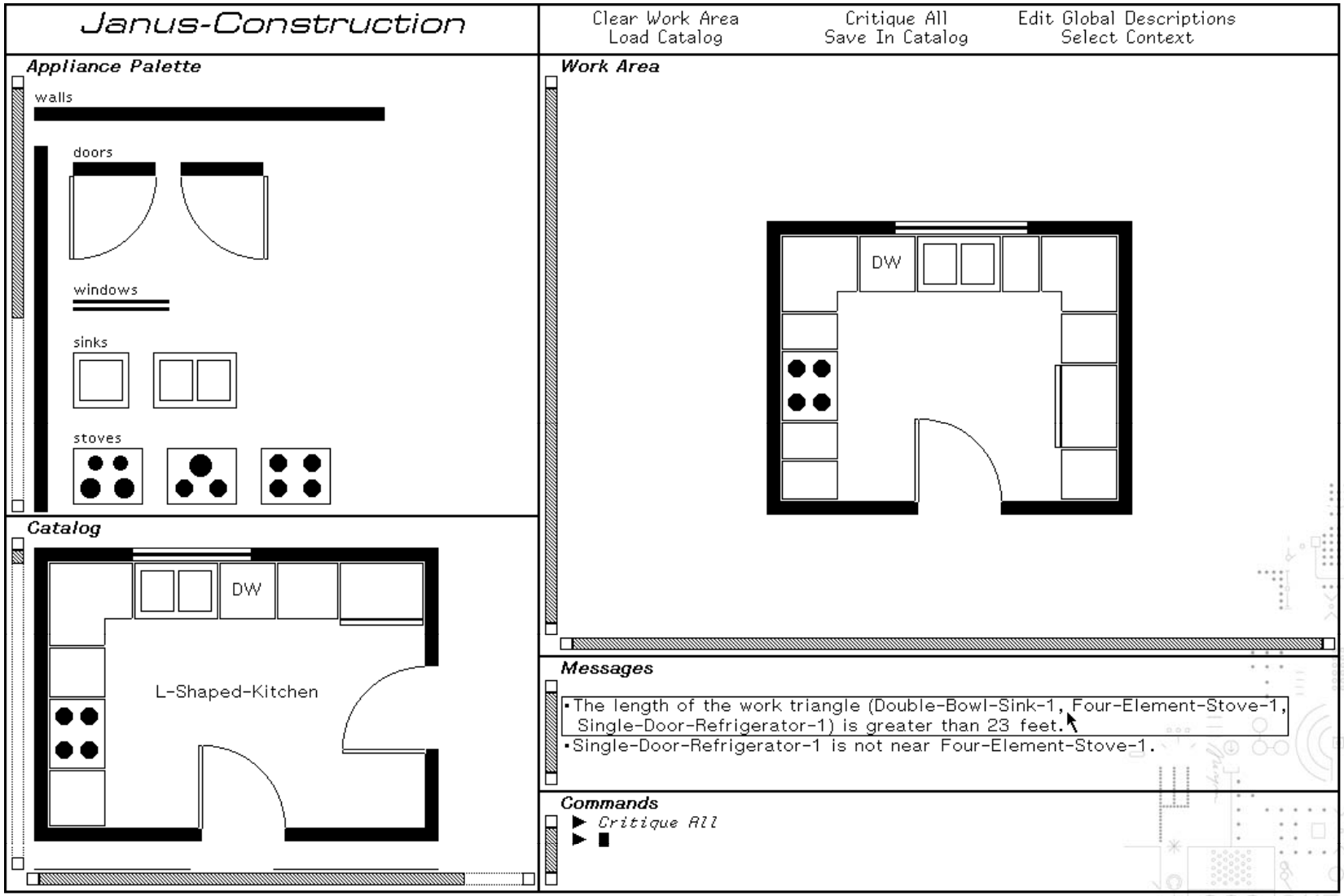
Critiquing systems

- A computer aided critiquing system analyzes intermediate design solutions and provides feedback on the design, according to Oh et al.
- Modeled after how a design studio “teacher observes students’ progress by looking at their drawings and listening to their descriptions of their design”
- Automated critiquing systems have been built to support novice designers in many domains

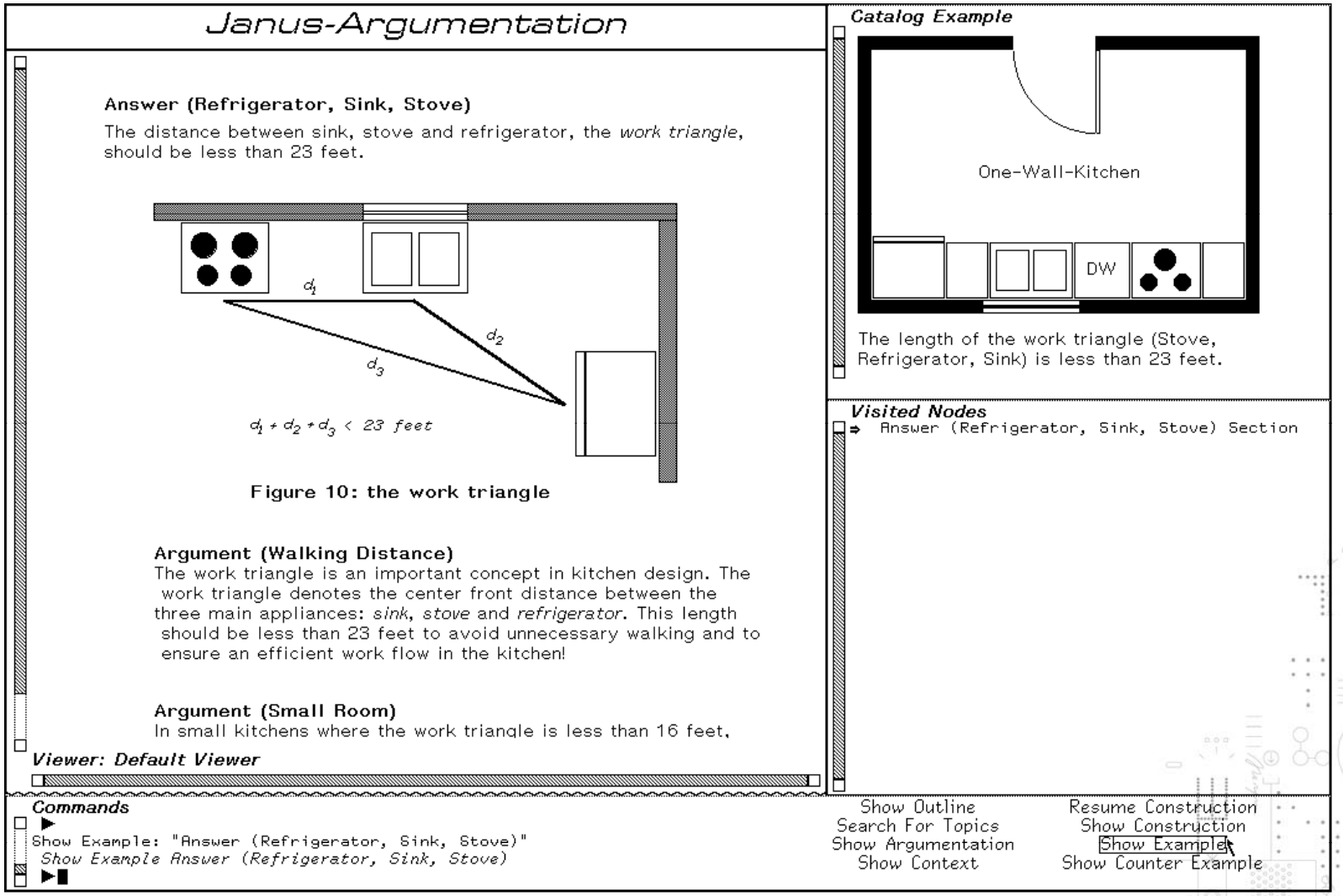
Aspects of critiquing

- Critiquing process
  - Action-breakdown-repair (Schön, 1983; Fischer et al. 1991)
  - Advice-improve (Robbins, 1998)
  - Construct-parse-check-critique-maintain (Oh et al., 2004)
- Critiquing rules
  - Condition-action rules to identify suboptimal designs
- Intervention techniques
  - Timing of feedback: proactive, reactive, and latent

Janus construction: A critic for kitchen design



Janus-viewpoints: Argumentation



Open issues for discussion

- In what ways will a computer-based tutor/critic fall short of being a human-like tutor (e.g. during what kind of tutoring will the system reveal itself)?
- In what ways will a computer-based tutor/critic compare to (or even outperform) a human tutor?
- How is the scaffolding process similar to (or different from) instructional scaffolding when the learners are not children (*ref. F4 lecture*)?