Instructional scaffolding for problem solving and design

Anders Mørch

INF5790 Lecture 3, UiO, Feb 18th, 2011

Three 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.
- Fischer, G., Lemke, A.C., Mastaglio, T.W., & Mørch, A.I. (1991). The Role of Critiquing in Cooperative Problem Solving. *ACM Transactions of Information Systems*, 9(2), pp.123-151.
- Soller, A., Martinez, A., Jermann, P. & Muehlenbrock, M. (2005). From mirroring to guiding: A review of state of the art technology for supporting collaborative learning. *International Journal of Artificial Intelligence in Education*, 15, 261-290.

What they have in common

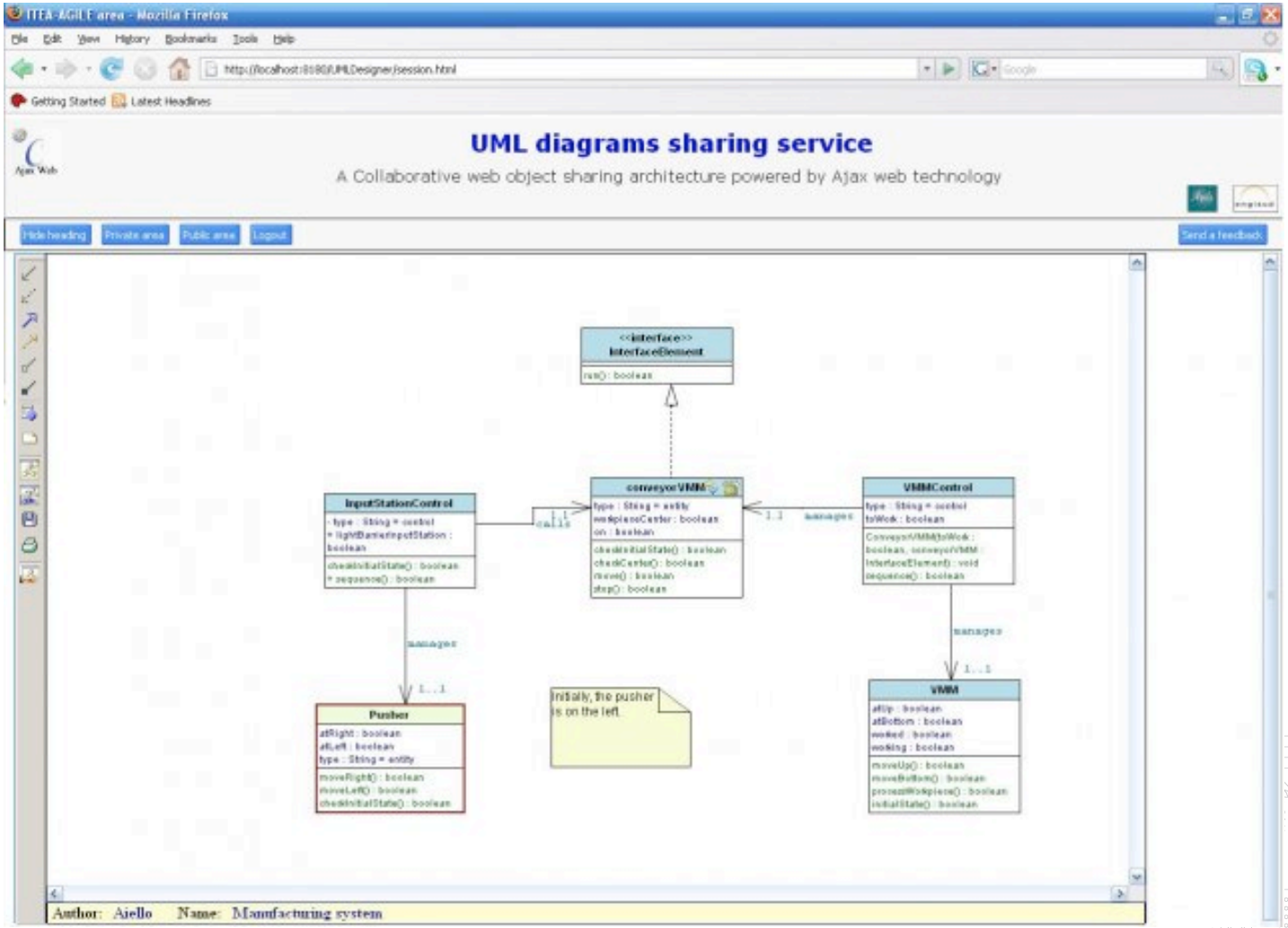
- The first article is about human tutoring, which ca be seen as extension of Vygotsky's ZPD concept with implications for computer support
- The 2nd article is about computer-based critiquing systems modeled after how expert designers critique novice designers' drawings
- The third article is about automated feedback strategies in collaborative learning environments

Differences

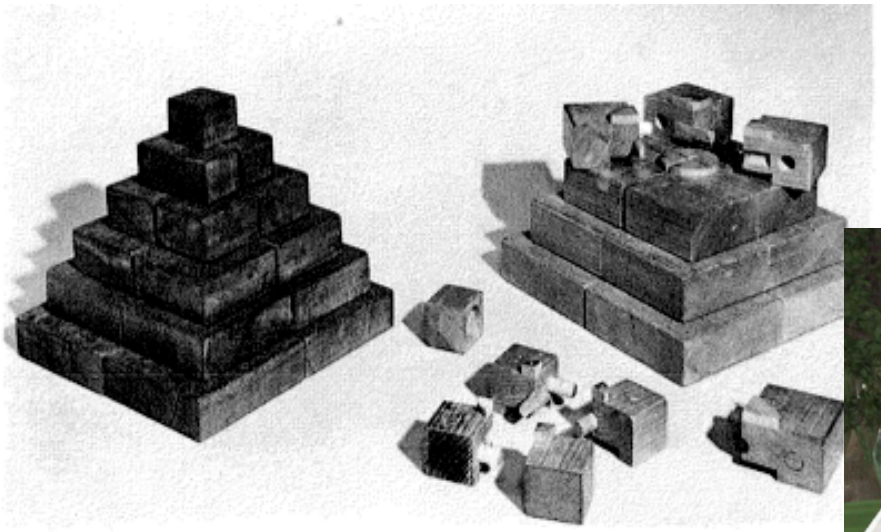
- Problem solving vs. design
  - Design is “open ended” aiming at “good enough” solutions among a set of alternatives, whereas problem solving aims at optimal solutions
- Individual vs. collaborative design
  - Collaborative design has a social dimension
- Children vs. adults
  - Can we make use findings from studies of small children to inform studies of adults?

Problem solving vs. design

Individual vs. collaborative design



Children vs. adults



Building block kit for 3-5 yr olds

Reproduction of Mies van der Rohe's Farnsworth House in Second Life

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

- Wood 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

- 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 Wood et al., a good tutor makes hypotheses about the learner's hypothesis
- This is a dynamic process among tutor and tutee, which is important for successful tutoring
- They suggest a "task model" and a "learner model" to be part of a "computer tutor" to perform at the level of a human tutor
- This has stimulated research on intelligent tutoring systems (ITS), critiquing systems, and collaborative learning environments

The scaffolding process

- Recruitment (engagement, motivation)
- Reduction in degrees of freedom
- Direction maintenance
- Marking critical features (identify ZPD)
- Frustration control
- Demonstration (showing)
- *Two intersecting dynamic planes*: 1) gradual structuring/regulating, and 2) role changing

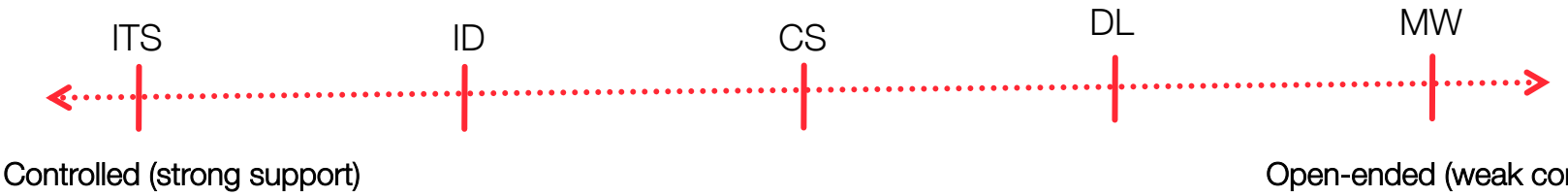
Computer-based critiquing

- Critiquing systems are a type of computer tutor that support design rather as a cooperative problem solving between human and computer
- Design is characterized by making “good enough” solutions, except for simple design problems where optimization is attainable
- Individualized feedback are important to computer tutors and critics in order to support stages of the scaffolding process

Agency in critiquing systems

- TEL systems can be positioned along a continuum depicting locus of control between predefined instructional sequences and self motivated doings
- *On one side*: Intelligent tutoring systems
- *On the other*: Model-based microworlds
- *In between*: instructional design, critiquing and discovery learning

TEL agency continuum



ITS: Intelligent tutoring systems
ID: Instructional design
CS: Critiquing systems
DL: Discovery learning
MW: Micro worlds

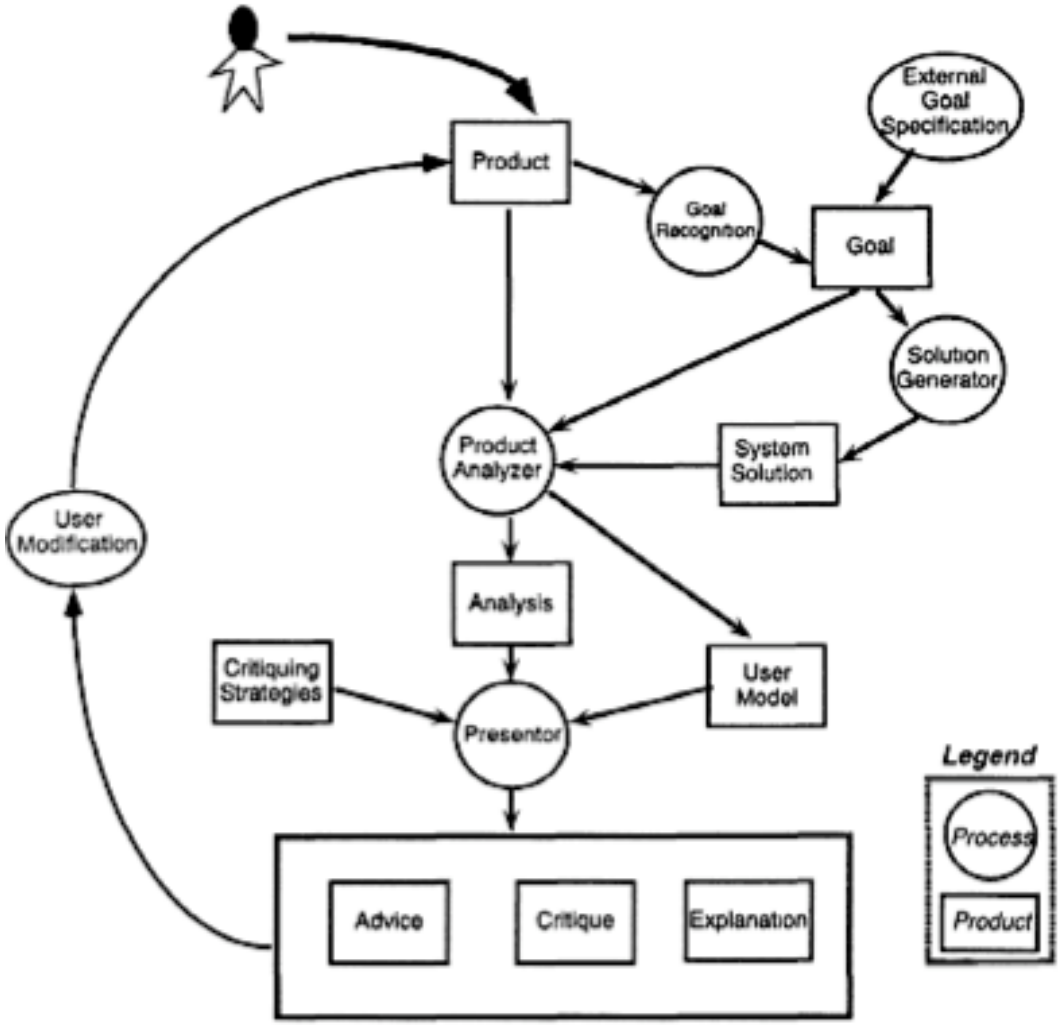
Critiquing systems

- Critiquing is the presentation of a reasoned opinion about a product or action
- A computer based critiquing system analyzes intermediate designs and provides feedback
- Modeled after how a design studio teacher observes students progress by looking at their drawings and providing advice for next steps
- Automated critiquing systems have been built to support novice designers in many domains

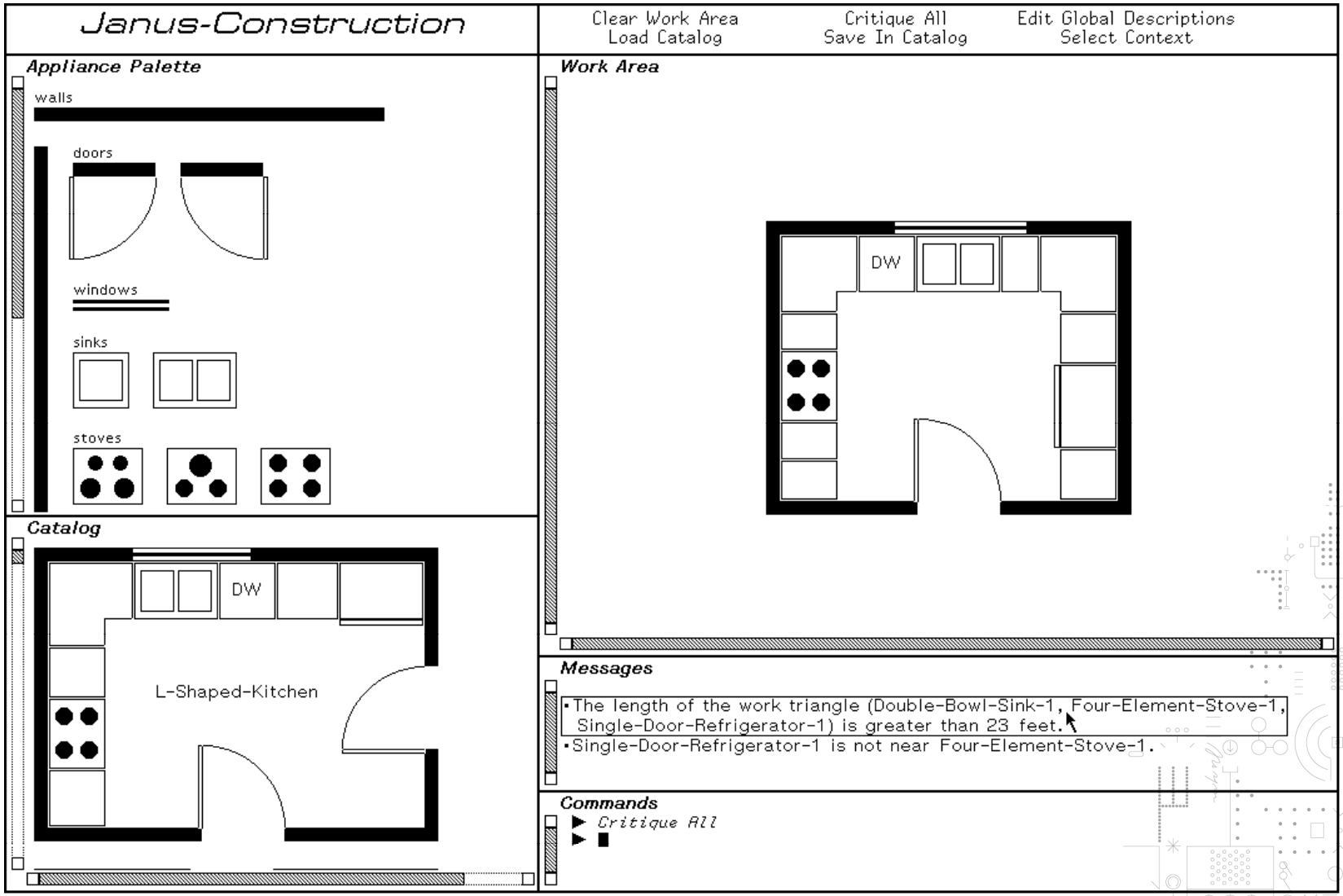
Aspects of critiquing

- 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, on-request

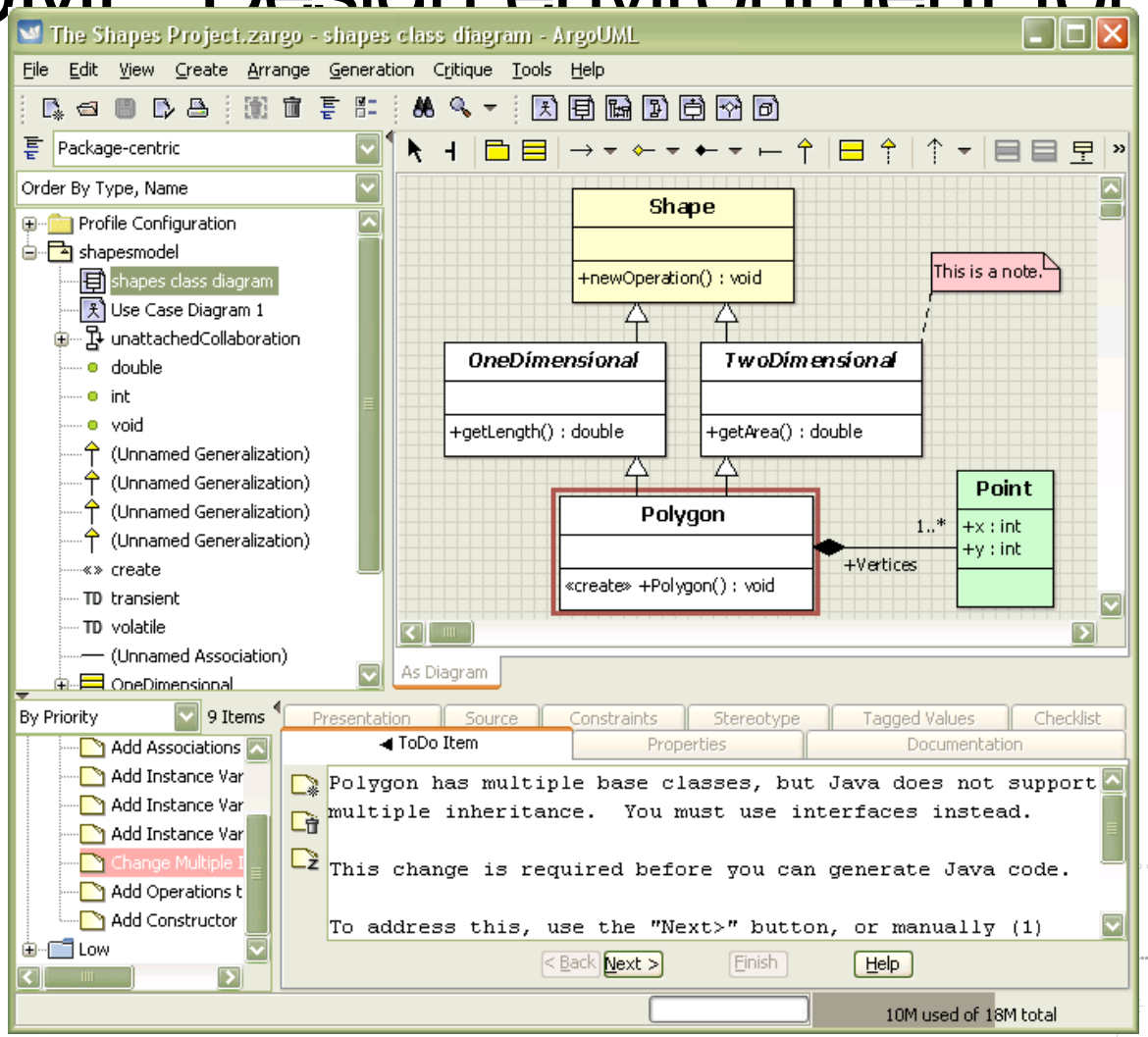
The critiquing process (Fischer et al., 1991)



Janus: A critiquing system for kitchen design



ArgoUML : Design environment for UML



Retrieved from: http://argouml.tigris.org/

Strategies of critiquing in collaboration environments

- Soller et al (2005) propose a conceptual framework for organize different types of feedback in collaborative design
- A goal is to support group members meta-cognitive activities related to their interaction in the virtual environments
- By structuring and regulating student interaction in multiple stages

Collaborative management cycle

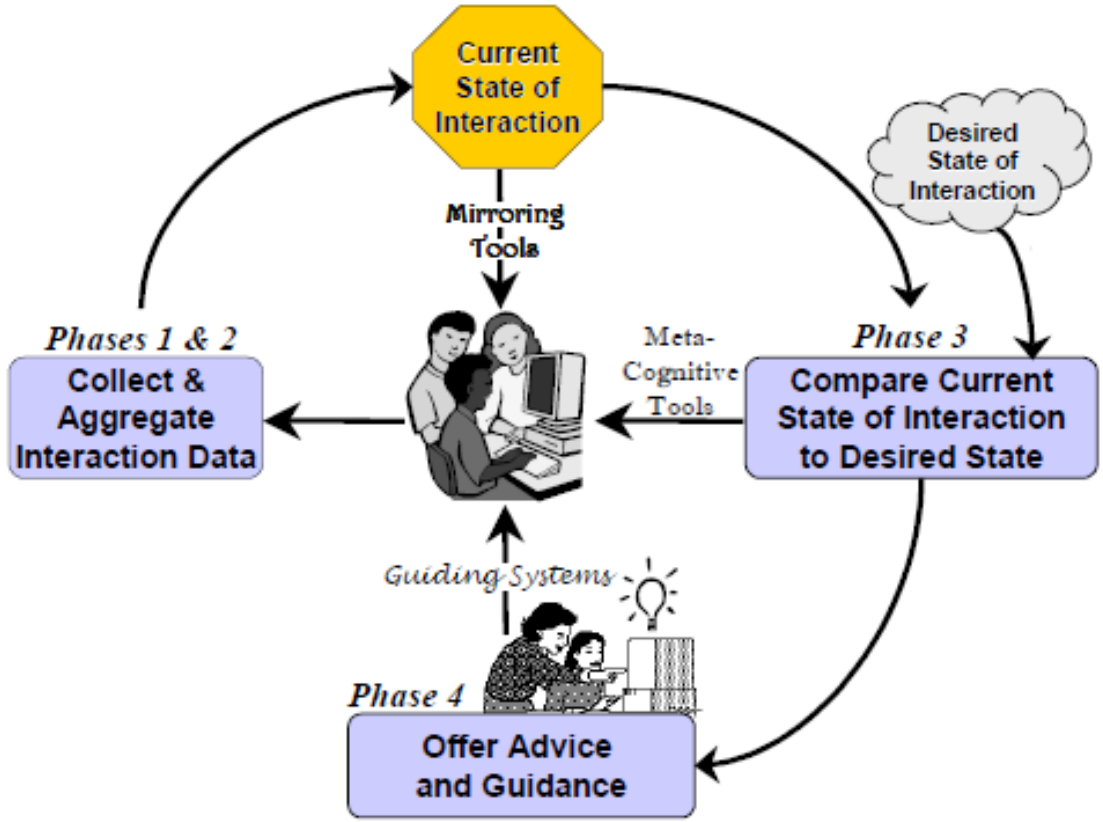
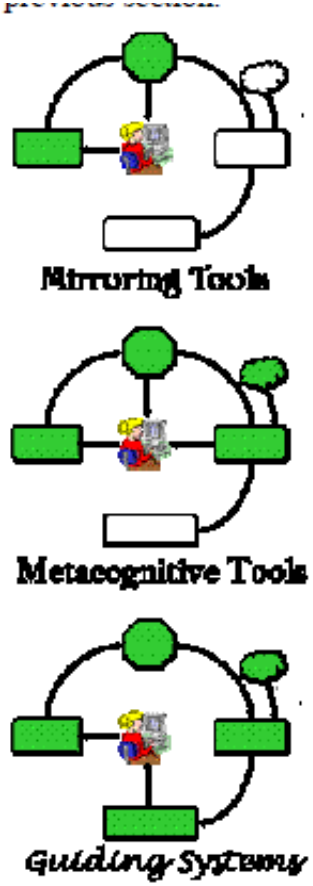


Figure 1. The Collaboration Management Cycle

Three strategies of computer support



- *Mirroring tools* are designed to make the students aware of their own actions and behaviour.
- *Meta-cognitive tools* show information about the desired and the current interaction, and provides referents
- *Guiding systems* proposes remedial actions

Open issues for discussion

- In what ways will a computer tutor/critic fail as a human-like tutor (e.g. during what kind of tutoring will the system reveal itself as such)?
- In what ways will a computer tutor/critic compare to (or even outperform) a human tutor?
- How are the computer-based scaffolding techniques in the last two papers similar to (or different from) Wood et al's 6 stage scaffolding process?