

UiO : InterMedia
University of Oslo

INF5790 – Spring 2013

Lecture 4 – Instructional scaffolding for problem solving and design

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INF5790 – Technology-Enhanced Learning, lecture 4, April 3rd, 2013

Outline

- Scaffolding
- Three articles on aspects of scaffolding
 - Idea and key principles
 - Empirical study of advice-giving
 - Operationalization into computer-based critiquing systems
- Exercise



Basic idea put forth in this lecture

- Scaffolding is a refinement (concretization) of the more general idea (theory) proposed by Vygotsky, referred to as zone of proximal development (ZPD)
- Scaffolding was proposed in the 1970s to explain the behavior of human tutors based on empirical studies of interacting with children, and has influenced the work on intelligent tutoring systems (ITS), intelligent user interfaces, and help-, critiquing- and advisory (HCA) systems in the 1980s and 1990s
- Early work on empirical studies of help seeking and advice-giving interactions when using computer applications (early and mid 1980s) provide another source of empirical findings

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.
- McKendree, J. & Carroll, J.M. (1986). Advising roles of a computer consultant. *SIGCHI Bull.* 17, 4 (April 1986), 35-40.
- Fischer, G., Lemke, A.C., Mastaglio, T.W., and Mørch, A.I. (1991). The role of critiquing in cooperative problem solving. *ACM Transactions of Information Systems*, 9(2), pp.123-151.

Scaffold, dictionary def

scaf.fold  [skaf-uhld, -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)

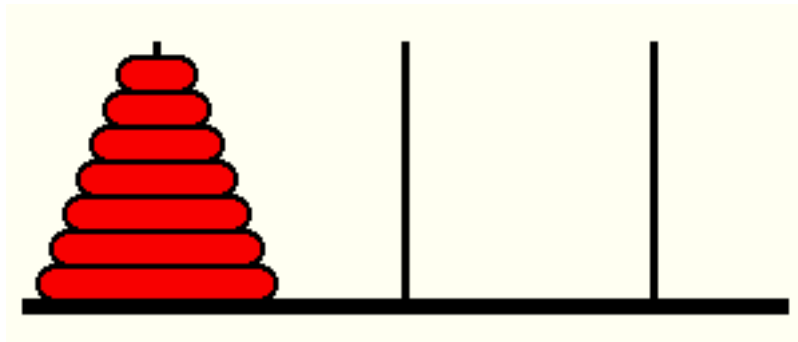
8. to furnish with a scaffold or scaffolding.
9. to support by or place on a scaffold.

Origin:

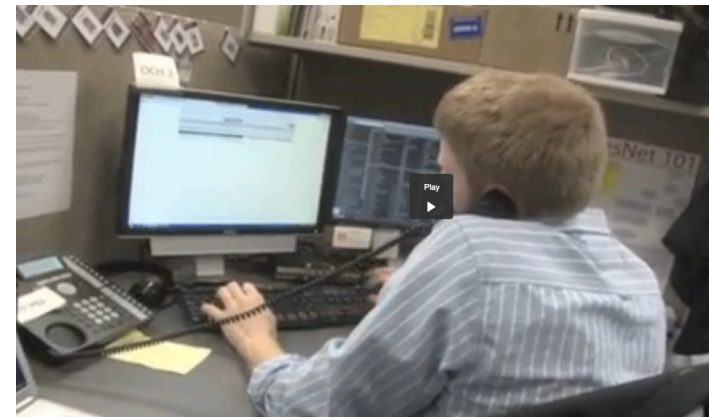
1300–50; ME *scaffot*, *skaffaut*, *scaffalde* < OF *escadafaut*; akin to [CATAFALQUE](#)

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

What range of tasks do the authors talk about in terms of ‘scaffolding?’



From problem solving ..

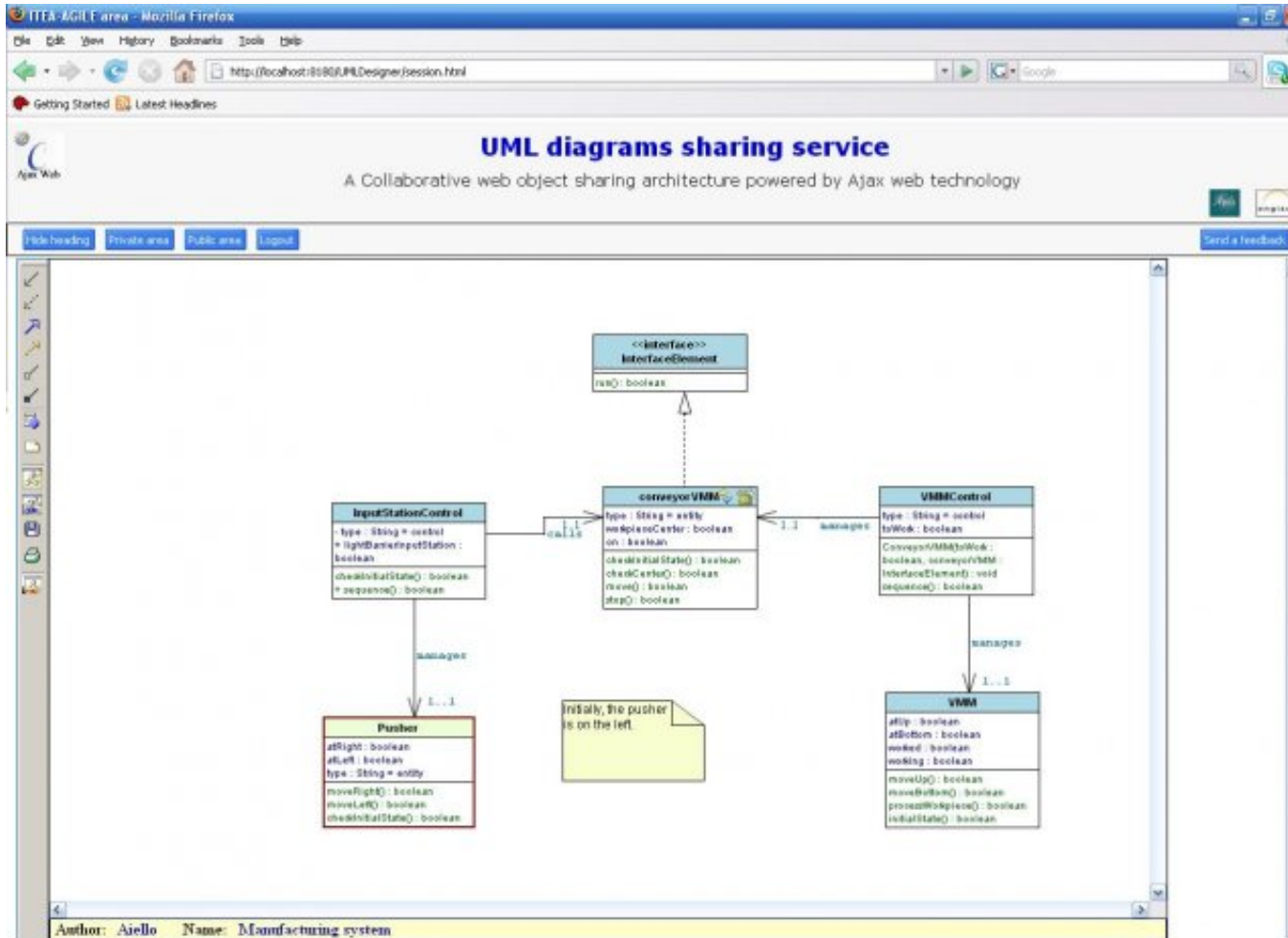


.. to help and error recovery



.. and design and modeling

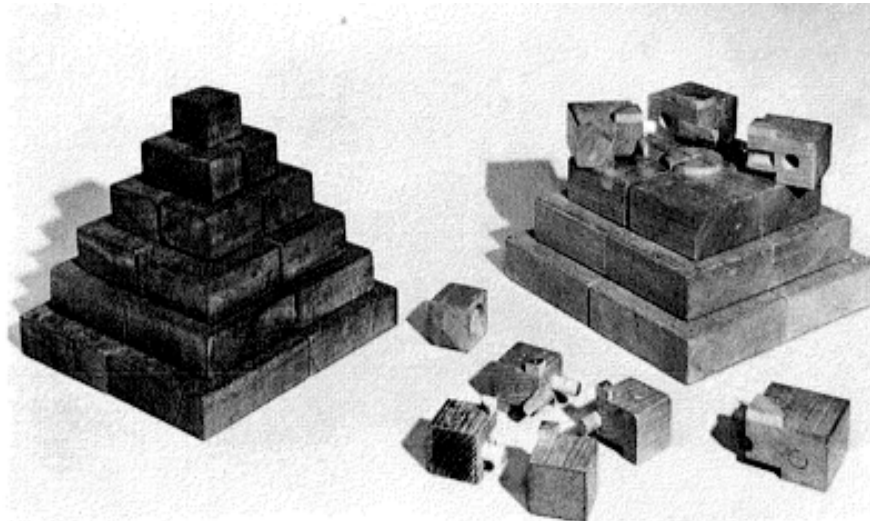
Information systems design tasks



Object-oriented design with Unified Modeling language (UML)

Discrepancies

The need for scaffolding tends to vary depending on the complexity of the task



Building block kit for 3-5 yr olds

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



..and scaffolds for children may not work as scaffolds for adults and vice versa

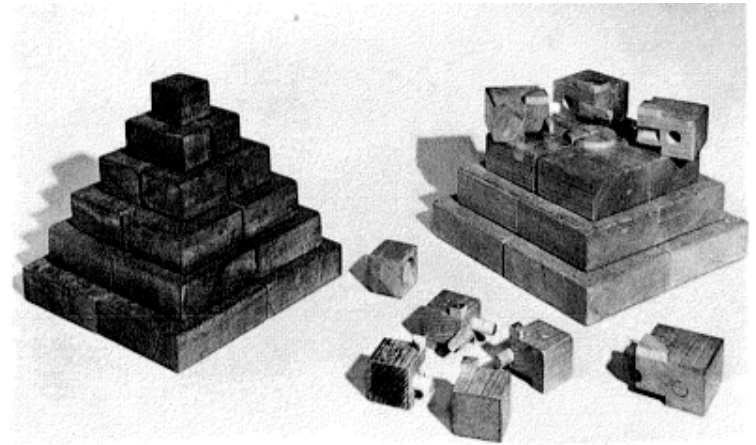
Zone of proximal development

- This is one of the inspirations for the notion of tutoring as scaffolding, namely Vygotsky's ZPD:
“The gap between what a given child can achieve alone, their potential development as determined by independent problem solving, and what the child can achieve through problem solving under adult guidance or in collaboration with more capable peers”
- This was discussed in lecture 1 (F1 slides)

Instructional scaffolding

- Wood, Bruner & Ross (1976):
- “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 in article 1



- 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
 - Verbal correction (telling)
 - General verbal directions (reminder, checking)

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 to build a pyramid out of the basic building blocks (shown in foil 11)
- Data is categorized according to the three types of scaffolds (direct intervention, verbal corrections, general verbal directions), 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 (praise) or checking of constructions

Author proposal: scaffolding process

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

Open issues for computer support

- How to further operationalize the scaffolding principles, e.g. what does ‘showing’ and ‘telling’ mean for a computer-based tutor?
- A scaffold implies a temporary support structure, to be removed once a task has been solved or a skill mastered to a certain level of proficiency, should it be taken literally for a computer-based tutor?
- Depending on the answers to the above questions (there are multiple answers) different directions for computer-based tutoring has been pursued

Early computer tutors

- 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” for it to perform at the level of a human tutor
- This has stimulated research on intelligent tutoring systems (ITS), critiquing systems (Fischer et al.), and collaborative learning environments (Soller et al.)

Empirical study of advice-giving

- An early study of a computer consultant (help desk) by McKendree and Carroll (1986)
- Identifying patterns of advice giving and the roles taken by the advisor
- Method used by researchers is protocol analysis, collecting verbal data of spoken interactions between help seekers and advisor and analyzing patterns of interaction
- This is similar to what we call interaction analysis (Jordan & Henderson, 1995)

Patterns of advice giving interactions

- Question-answer (8.8%)
- Statement-statement (8%)
- The rest of the utterances are not accounted for and/or not relevant

Role types of advisors

- Informing
 - Answering to a well defined question
- Defining
 - Reformulating a problem to guide help seeker
- Indexing
 - Helps to formulate the problem
- Structuring
 - The user don't understand the problem and needs help identifying it

Computer-based critiquing system

- Critiquing systems are a special type of intelligent tutoring system for design domains and inquiry processes
- Design and inquiry do not aim at optimal solutions but satisficing (good enough) solutions, except for simple (toy) design problems where optimal solutions is possible
- Individualized feedback is important to both computer tutors and critics in order to support gradual development and learning

TEL agency/scaffolding continuum



ITS: Intelligent tutoring systems

CS: Critiquing systems

DL: Discovery learning

MW: Micro worlds

Critiquing

- Critiquing is the presentation of a reasoned opinion about a product, item or action
- Supports both critique and praise
 - Critique: What can be improved
 - Praise: What is good about a design
- Modeled after how design critics in design studios observe and provide feedback to students by “looking over their shoulder”
- Automated critiquing systems have been built to support novice designers in many domains

Janus demonstration prototype

Janus-Argumentation

Answer (Refrigerator, Sink, Stove)
The distance between sink, stove and refrigerator, the work triangle, should be less than 23 feet.

$d_1 + d_2 + d_3 < 23 \text{ feet}$

Figure 10: the work triangle

Argument (Walking Distance)
The work triangle is an important concept in kitchen design. The work triangle denotes the distance between the three main appliances: sink, stove, and refrigerator. The length of the work triangle should be less than 23 feet to ensure an efficient work flow.

Argument (Small Room)
In small kitchens where the work triangle is not possible, alternative layouts should be used.

Viewer: Default Viewer

Commands

- Show Example: "Answer (Refrigerator, Sink, Stove) Section"
- Show Example Answer (Refrigerator, Sink, Stove) Section

Argumentative hypertext

Janus-Construction

Appliance Palette

walls

doors

windows

sinks

stoves

Design units

Catalog

L-Shaped-Kitchen

Janus-Work Area

Clear Work Area
Load Catalog

Critique All
Save In Catalog

Edit Global Descriptions
Select Context

Work area

Messages

- The length of the work triangle (Double-Bowl-Sink-1, Four-Element-Stove-1, Single-Door-Refrigerator-1) is greater than 23 feet.
- Single-Door-Refrigerator-1 is not near Four-Element-Stove-1.

Commands

- Critique All

Critic messages

Aspects of scaffolding in critiquing

- Critiquing process
 - Action-breakdown-reflection (Schön, 1983)
- Condition-action rules
 - Automated feedback to point out designs that can be improved, not following design rules (telling)
- Catalog examples
 - Examples of good and bad designs (showing)
- Argumentation
 - Dynamic form of explanation-giving (new aspect)
- Intervention techniques
 - Timing of feedback: proactive, reactive, passive

Critiquing cont'd

- Critiquing is related to learning by a method called “learning on demand” (Fischer, 1995):
 - Learning by doing, making mistakes, and being informed
- Three stages of being informed (from shallow to deep)
 - 1) Hint, prompt, feedback message
 - 2) Examples, counterexamples
 - 3) Argumentation
- Developed for design activities, originally for individual design, later for cooperative design

Critiquing and learning (learning by doing, making mistakes, and getting feedback)

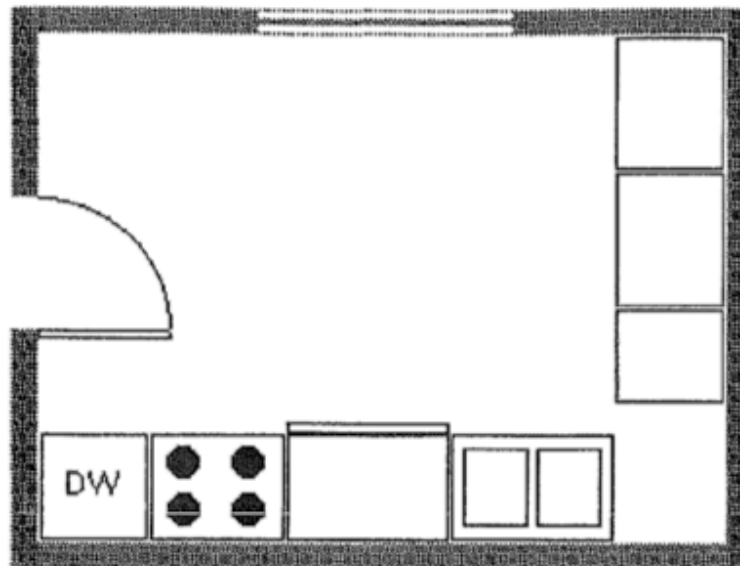
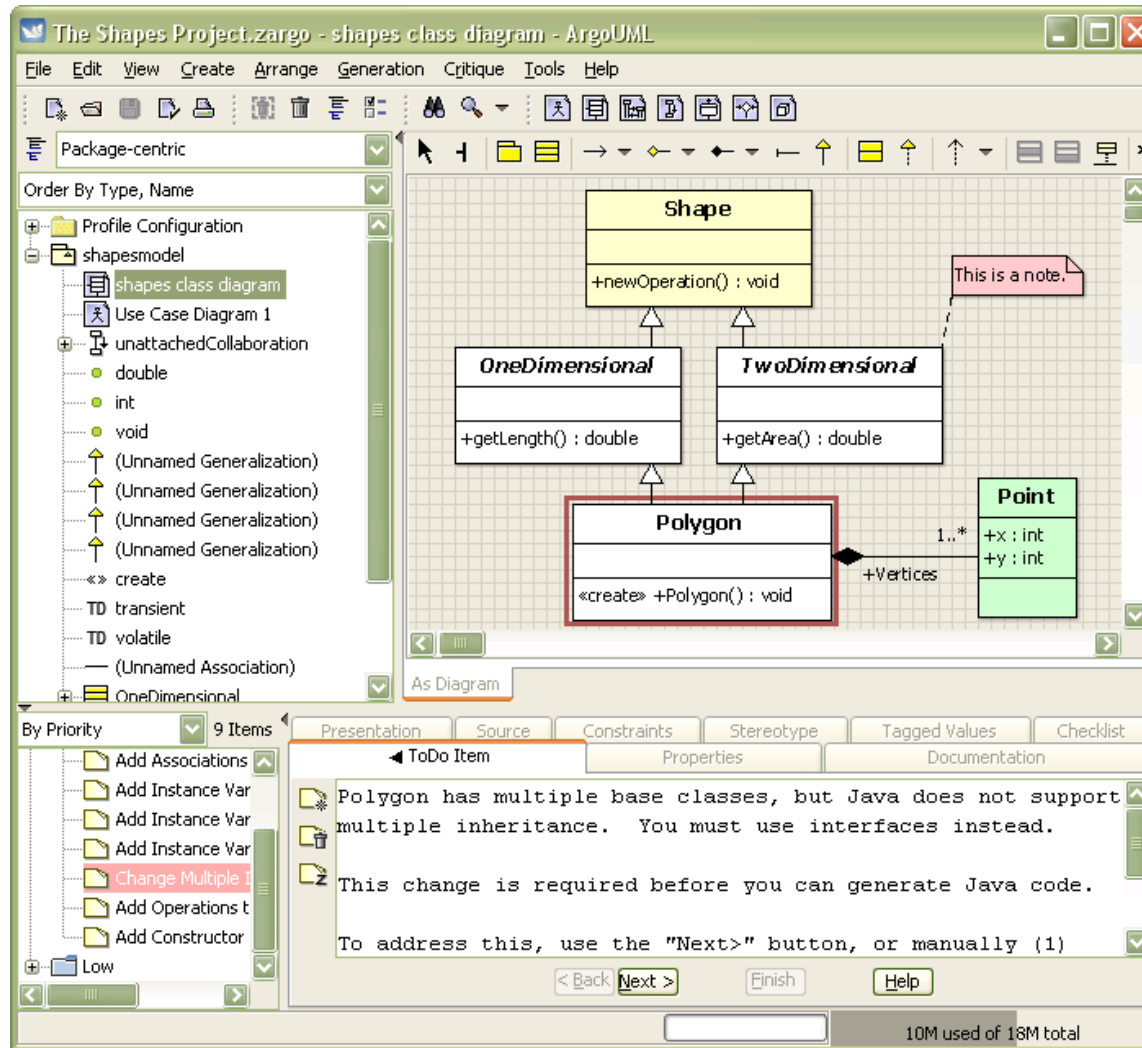


Figure 5: JANUS-CRACK: A learning example from the Catalog

The critics in JANUS detect the following suboptimal features of the kitchen shown in this figure: The width of the door is less than 36 inches, the dishwasher is not next to a sink, the stove is next to a refrigerator, the refrigerator is next to a sink, and the sink is not in front of a window.

From Fischer et al., 1991

Critiquing for information systems design



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

Group exercise

ZPD → scaffolding

- To what extent can it be said that Wood et al.'s notion of scaffolding: 1) provides an specialization of Vygotsky's ZPD concept, and 2) fail to provide such a refinement

Scaffolding → critiquing

- To what extent can it be said that computer-based critiquing: 1) operationalizes the idea of scaffolding proposed by Wood et al., and 2) fails to operationalize the idea