

Pedagogical Agent Design for Distributed Collaborative Learning

Anders Mørch
InterMedia, University of Oslo
Norway
anders.morch@intermedia.uio.no

Outline

- Background
- Perspective
 - CSCW, CSCL, knowledge building
- Gen-ethics pilot study
- Software agent systems
 - Student Assistant (SA) agent
 - Instructor Assistant (IA) agent
- Pedagogical agent design space

Collaborators

- Pedagogical design
 - Sten Ludvigsen (Univ Oslo)
 - Barbara Wasson (Univ Bergen)
- Systems building
 - Weiqin Chen (Univ Bergen)
 - Jan Dolonen (Univ Oslo)
 - Jan-Eirik Nævdal (Univ Oslo)

DoCTA NSS project

- Design and use Of Collaborative Telelearning Artefacts – Natural Science Studios
- Goal: Study social, cultural and pedagogical aspects of artefacts in distributed collaborative learning and apply the findings to the design of new learning environments
- Pilot study: Gen-ethics scenario

Perspective

- CSCW
- CSCL
- Knowledge building

CSCW

- Computer Supported Cooperative Work
- CS-part focus on groupware, knowledge management and communication systems
- Technical issues include: distributed systems, communication tools, document sharing, awareness mechanisms
- CW-part address social aspects of using the systems by empirical (usually field) studies
- Theoretical background in communication, coordination and activity theories

CSCW

- Computer Supported Collaborative Learning
- Educational CSCW applications for teaching and learning (school and workplace)
- Broad and multifaceted conceptual foundation, which includes:
 - Socio-cultural theories
 - Constructivism
 - Situated learning
 - Distributed cognition

Knowledge building

- A model for collaborative learning
- Students learn and interact by “talk” (reasoning aloud) with peers to develop explanations of scientific phenomena
- Formulate research questions, answering them independently, and finding arguments
- Supported by discussion forums with message categories modelled after scientific discourse
- Computer supported knowledge building
 - CSILE and Knowledge Forum
 - Fle3

Phases of knowledge building



Adopted from Hakkarainen, Lipponen, & Järvelä's (2002) progressive inquiry model

Research questions

- What meanings do students attribute to scientific categories?
- How to scaffold computer-supported knowledge building with software agents?

Our approach

- Empirical based design
 - Identify needs for computer support based on data from empirical studies
- Reuse existing systems (web-based, open-source) and adapt them to our specific local needs

Empirical study

- Two secondary school classes in Norway (10th grade)
- 3 week pilot; 4 week field trial (2001, 2002)
- Collaborative learning in small groups
- Discussing science problems
- Knowledge domain: Ethical aspects of biotechnology
- Web-based discussion forum (Fle)

Gen-ethics scenario (pilot)

- Task
 - Video to trigger engagement in knowledge domain
 - Group formation (by teachers)
 - Problem identification (by students)
- Scientific discourse
- Fle2 system
- Method

Co-located/distributed setting

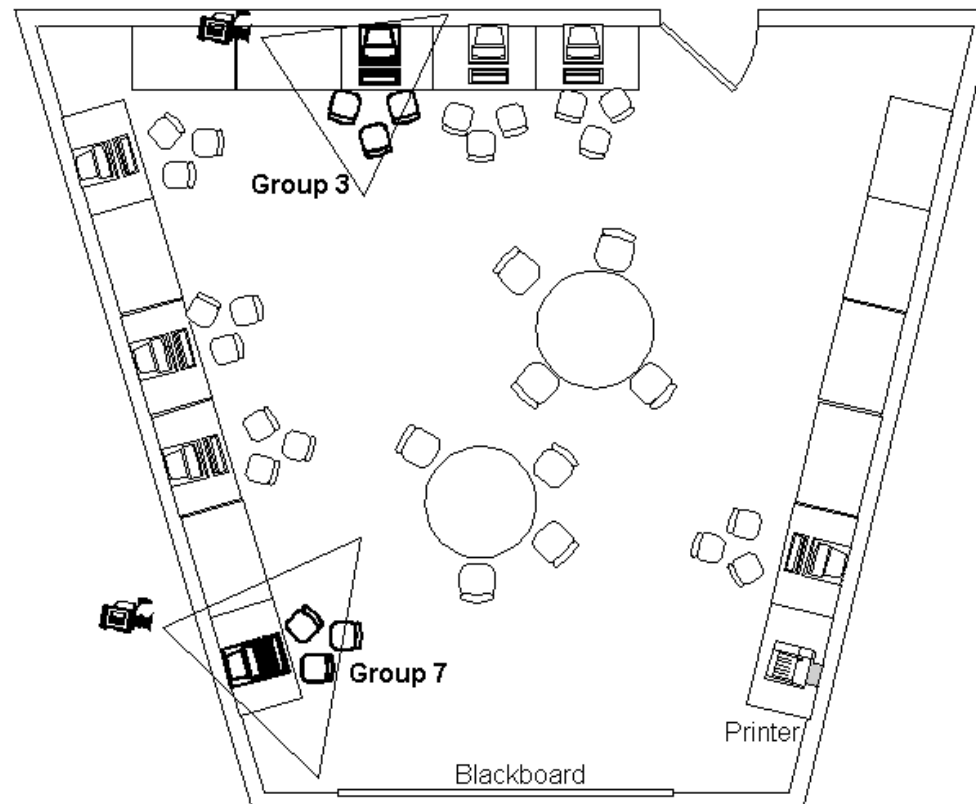


School A, 10th grade, Bergen

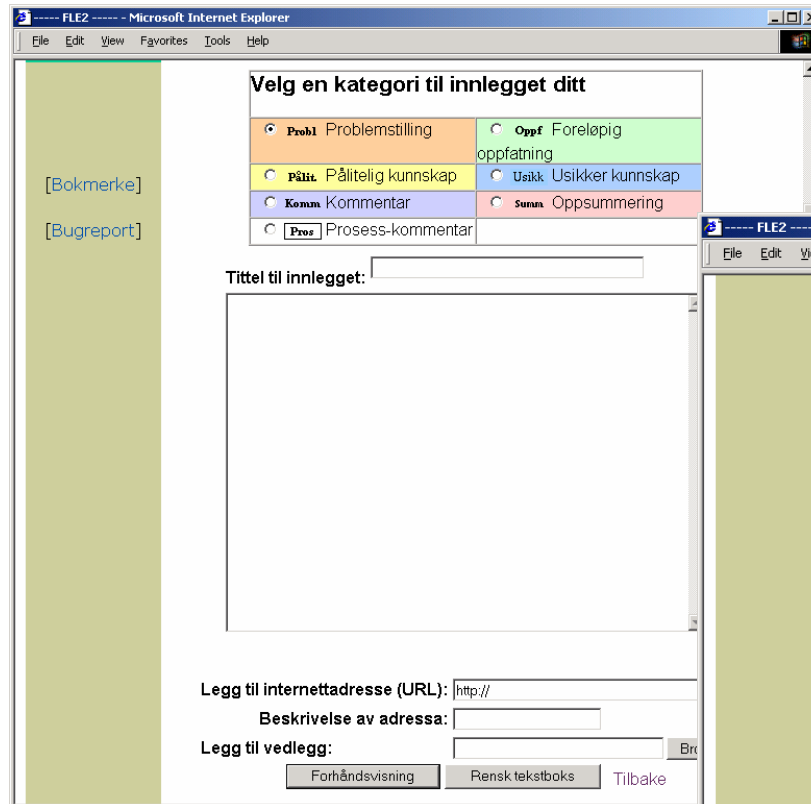
School B, 10th grade, Oslo



Physical set-up in school A

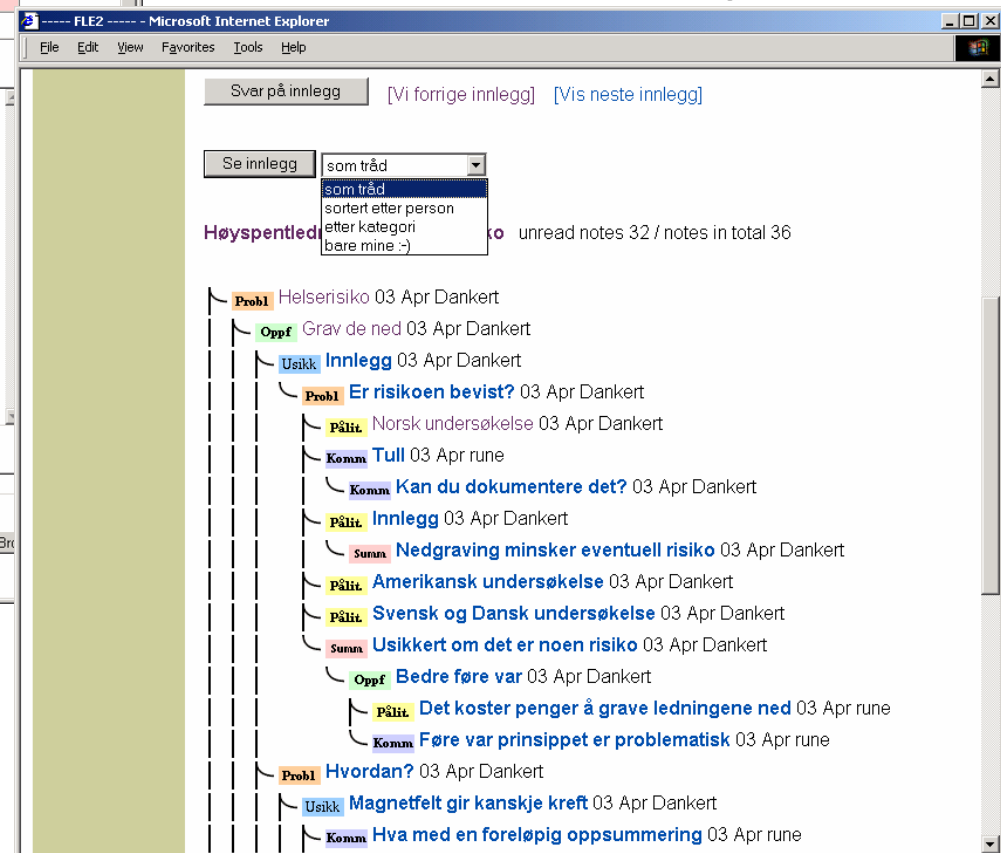


Fle2 interface



Writing/reply mode
(editor with message categories)

Viewing mode (threaded list of previous postings)



Scientific discourse

Choose the category of inquiry	
<input checked="" type="radio"/> prob Problem	<input type="radio"/> work My Working Theory
<input type="radio"/> deep Deepening Knowledge	<input type="radio"/> com Comment
<input type="radio"/> meta Meta-comment	<input type="radio"/> sum Summary
<input type="radio"/> help Help	

- Fle2 posting categories:
 - Problem
 - My working theory
 - Reliable knowledge
 - Uncertain knowledge

*Our specialization of
“deepening knowledge”*

Method

- Observation
- Video recording
- Data logging
- Interviews
- Interaction analysis

Data 1: Interaction excerpt

1. Student X: I wonder... reliable knowledge (interrupted by student Y)
2. Student Y: No – it's not reliable knowledge
3. Student X: No!!!
4. Student W: Reliable knowledge, sure...
5. Student Y: It's not, It's not reliable knowledge just because he says so (with temper)
6. Student W: Then, it's not reliable knowledge.
7. Student Y: It is different when it's that kind of statement, that's a kind of study."

Data 2: Interview with student

When asked about the usefulness of the Fle2 categories, a student said:

“It was kind of smart! Because you can see what it [the message] is about. That’s reliable knowledge and that’s a summary [pointing to two KB notes on the screen]. You know immediately what it is.”

However, when later asked to demonstrate his understanding of the difference between a “My Working Theory” note (MWT) and a “Summary” note he says:

“... if we had sent this to them [pointing to a note he has labeled MWT] and you ask what it is supposed to mean - is it a comment or is it a summary, right? But you see it first by its small [category abbreviation] ... oh -it is a summary after all, okay!”

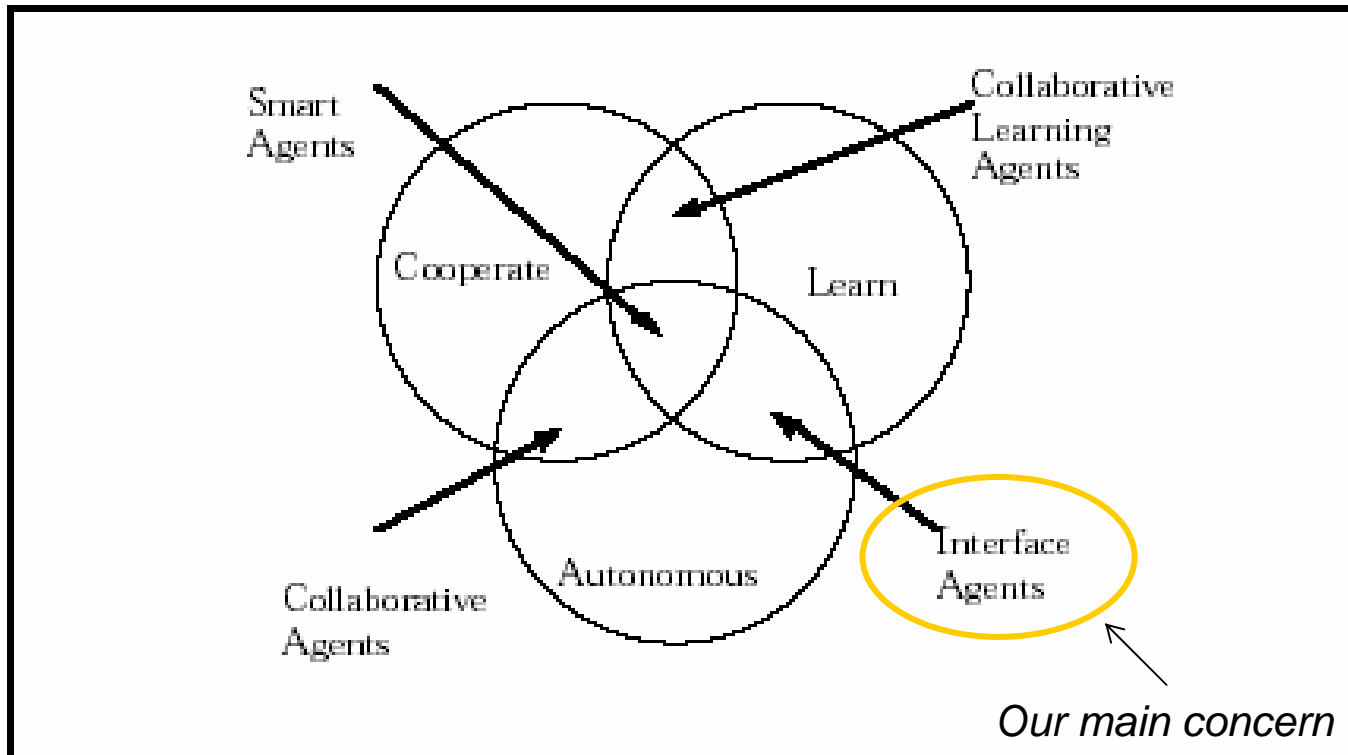
Summary of findings from pilot

- Students had difficulties choosing knowledge building categories
- Instructors have difficulties following the collaboration and giving continuous advice
- Need alternative ways of facilitating knowledge building

Design implications

- Claim: software agents can be useful as computer support in semi-structured knowledge domains
- Interface agents
- Pedagogical agents
- Role of pedagogical agents

Software agents



Typology based on Nwana's (1996) primary attribute dimensions:

Pedagogical agents

- “Pedagogical agents can be autonomous and/or interface agents that support human learning in the context of an interactive learning environment.”
 - Johnson, et al. (2000)

Role of agents

- Gather statistical information from database
- “Watch over shoulder” in the KB discussion forum and provide advice to the participants
 - Encourage non-active students to be more active
 - Suggest what messages to reply to and who should be doing so
 - Suggest what category to choose for the next message to be posted
 - Suggest when messages do not follow the scientific method of knowledge building; etc.

Two prototype systems

- Student Assistant (SA) agent
- Instructor Assistant (IA) agent

Fle3 Interface

Agent component

The screenshot displays the Fle3 interface for a course titled "Internet Skripting". The interface is divided into several sections:

- Navigation Bar:** Includes "WebTop", "Knowledge Building", and "Agent" (highlighted with a yellow circle and labeled "Agent component").
- Course Information:** Shows the course name "Internet Skripting" and "Course information" link.
- User Avatars:** Displays avatars for "fleadmin", "rune", and "weiqin".
- Location:** "You are in: course [Internet Skripting](#) / context [Utarmet Uran](#) / thread [Utarmet uran og helserisiko](#) / note [En overdrivelse!](#)".
- My Explanation:** A section for user "weiqin" with the title "En overdrivelse!" and the text "Jeg tror det er en overdrivelse. Det finnes ingen bevis for at dette stemmer." dated "13.35.29 Mon, 03 Jun 2002".
- Interaction:** Includes a "Reply with a" dropdown menu (set to "Comment") and a "Rate this note" dropdown menu (showing options like "Problem", "My Explanation", "Scientific Explanation", "Comment", "Evaluation of the Process", "Summary").
- Navigation:** Buttons for "Show notes", "as thread", "by knowledge type", "by person", and "by date".
- Summary:** A list of notes including "(problem) [Utarmet uran og helserisiko](#) / fleadmin / Today" and "(explan) [En overdrivelse!](#) / weiqin / Today".

Agent system features


- Agent as an *observer*
 - Collect information
 - Participant, activity, timestamp
 - Last log on, last contribution (for each participant)
 - Compute statistics
 - Present statistics in chart
- Agent as an *advisor*
 - Present updates, statistics
 - Advice instructor on possible problems and sending messages to students
 - Advice students on the use of categories

Student Assistant Interface

Why do we need genetically modified food? 14:21 2003-12-03

[Who has read this note?](#)

We are going to discuss why we need GM food. What are the benefits and what are the downsides og GM foods?



Genetikk - better food?

[Genetically Modified Food - News](#)

Select: Next ▶
Down ▼

Messages from SA-agent

Elev assistenten sier:






gruppe8: You have posted less messages than the others. You must be aware to contribute if you want to keep the discussion alive.

gruppe8: There is 'My Explanation' note without any responses. You should read that note and try to respond to it with a 'comment' or a 'Scientific Explanation'.

Discussion thread in FLE3

Show notes **as thread** by knowledge type by person by date

▶ Show bodies of all notes

-  **(problem)** [Why do we need genetically modified food?](#) / teacher / 2002-10-03
 -  **(my_expl)** [We need GE food to end world hunger](#) / hovseter1 / 2002-12-03
 -  **(my_expl)** [We think GE food would end world hunger](#) / hovseter1 / 2002-12-03
 -  **(comment)** [From where did you get this information?](#) / sandgotna1 / 2002-12-03
 -  **(sci_expl)** [From this scientific magazine..](#) / hovseter1 / 2002-12-03

Instructor Assistant Interface

The screenshot displays the Instructor Assistant Interface. At the top, there is a navigation bar with five tabs: WebTop (red), Knowledge Building (green), Assistant (blue), Course Management (orange), and User Management (yellow). Below the navigation bar, the 'Assistant' section is active, showing four buttons: 'Who is online', 'Update in Webtop', 'Check Statistics', and 'Check Advice'. A list of users is shown below these buttons: fleadmin, hovseter1, and gruppe8s.

A detailed view of the 'Check Advice' function is shown in a separate window. It displays a list of participants with their activity levels and course names:

Participant	Activity Level	Course
hovseter1	Over active participant	FLE-oppl�ring
hovseter2	Over active participant	FLE-oppl�ring
elerv	Less active participant	Etikk i genetikken
gruppe8s	Less active participant	Etikk i genetikken

Below the list, there are buttons for 'Delegate', 'Explain', 'Edit', and 'Save'. The interface also shows a table of group and single user performance data.

Group Performance		Single User Performance	
hovseter1	8	FLE	
hovseter2	9	FLE	
hovseter3	4	FLE	
hovseter4	5	FLE	oppl�ring

Tentative findings

- Agent feedback was positive received and triggered discussion in groups and some degree of reflection by individual students
- New problem emerged: brittleness of agent rules
- Agents need to be adaptive (automatically learn) *and* adaptable (end-user tailorable)
- Who should be allowed to tailor agents
 - All students?
 - Some (advanced) students?
 - Only instructors?

Design space for ped. agents

- Generalising our system building efforts
- Technological and conceptual dimensions providing guidance (questions, possibilities, constraints) for future design
- Dimensions:
 - presentation
 - intervention
 - task
 - pedagogy

Presentation dimension

- How an agent should present itself to the user
- Computational technique: Separate window, overlapping window, pop-up box, animated character, etc.
- How to present information :Text, speech, graphics, body language simulation, etc.
- Examples (MS Office Assistant, separate window in SA-agent, etc.)

Intervention dimension

- When the agent should present information to the user (a timing issue)
- Analogy with thermostat: When a certain environmental variable reaches a trigger value, an action is taken (e.g. turning on air-conditioner)
- Intervention strategies to be decided:
 - degree of immediacy (how soon)
 - degree of repetition (how often)
 - degree of intrusiveness (block or superimpose)
 - degree of eagerness (how important)

Task dimension

- Interacting with an environment w/agents is radically different from interaction with the same environment without agents
- Different tasks may require different agents
 - Well-defined tasks (eg. physics) are different from
 - Ill-defined tasks (e.g. city planning)
- Agents can help to simplify the task
- Agents can make the task harder to complete
- Agents can create “breakdown” in task performance, e.g. causing problem restructuring

Pedagogy dimension (CSCL)

- Agents serve as “conceptual awareness” mechanism, coordinating multiple knowledge sources (humans & online resources)
- A coordinator for distributed settings
 - A new person just logged on needs to be updated
 - Informing teachers about students’ activity
- Measure collaboration patterns
 - Division of labour
 - Equal participation
 - Scientific discourse (knowledge building)

Open issues

- Balancing the dimensions by choosing values for each of the four dimensions
- Do we need to take all of them into account, or is a subset sufficient?
- Are there other dimensions that should be included as well?
- How to find the right balance between agent facilitation and human facilitation for online groups?

Summary & lessons learned

- Scalability
 - from single user to multi user systems
 - from well defined to ill defined domains
- A series of system building efforts supplemented with empirical analysis
- Importance of understanding collaboration
- Integrating agents with human facilitation
- Instantiating various design dimensions
- Agents need to be adaptable and adaptive
- A full scale field study is needed to assess agents' usefulness for knowledge building

Related Work

- IDLC (Okamoto, Inaba & Hasaba, 1995)
- GRACILE (Ayala & Yano, 1996)
- Dillenbourg (1997)
- EPSILON (Soller, Cho & Lesgold, 2000)
- Suthers (2001)

References

- Jondahl, S. and Mørch, A. (2001). Simulating Pedagogical Agents in a Virtual Learning Environment, Proceedings IRIS-24, pp. 15-28.
- Chen, W. and Wasson, B. (2002) An Instructional Assistant Agent for Distributed Collaborative Learning. Proceedings ITS-2002, pp. 609-618
- Dolonen, J., Chen, W. and Mørch, A. (2003). Integrating Software Agents with FLE3. Proceedings CSCL 2003, Bergen, Norway, pp. 157-161.
- Ludvigsen, S. and Mørch, A. (2003). Categorization in Knowledge Building: Task-specific Argumentation in a Co-located CSCL Environment. Proceedings CSCL 2003, Bergen, Norway, pp. 67-76.
- Mørch, A., Dolonen, J., Jondahl, S., Nævdal, J.E. and Omdahl, K. (2003). Evolving Software Agents Toward Distributed Collaborative Learning. Manuscript in preparation.