Pedagogical Agent Design for Distributed Collaborative Learning

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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)

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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

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Perspective

- CSCW
- CSCL
- Knowledge building

CSCW

- *C*omputer *S*upported *C*ooperative *W*ork
- *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

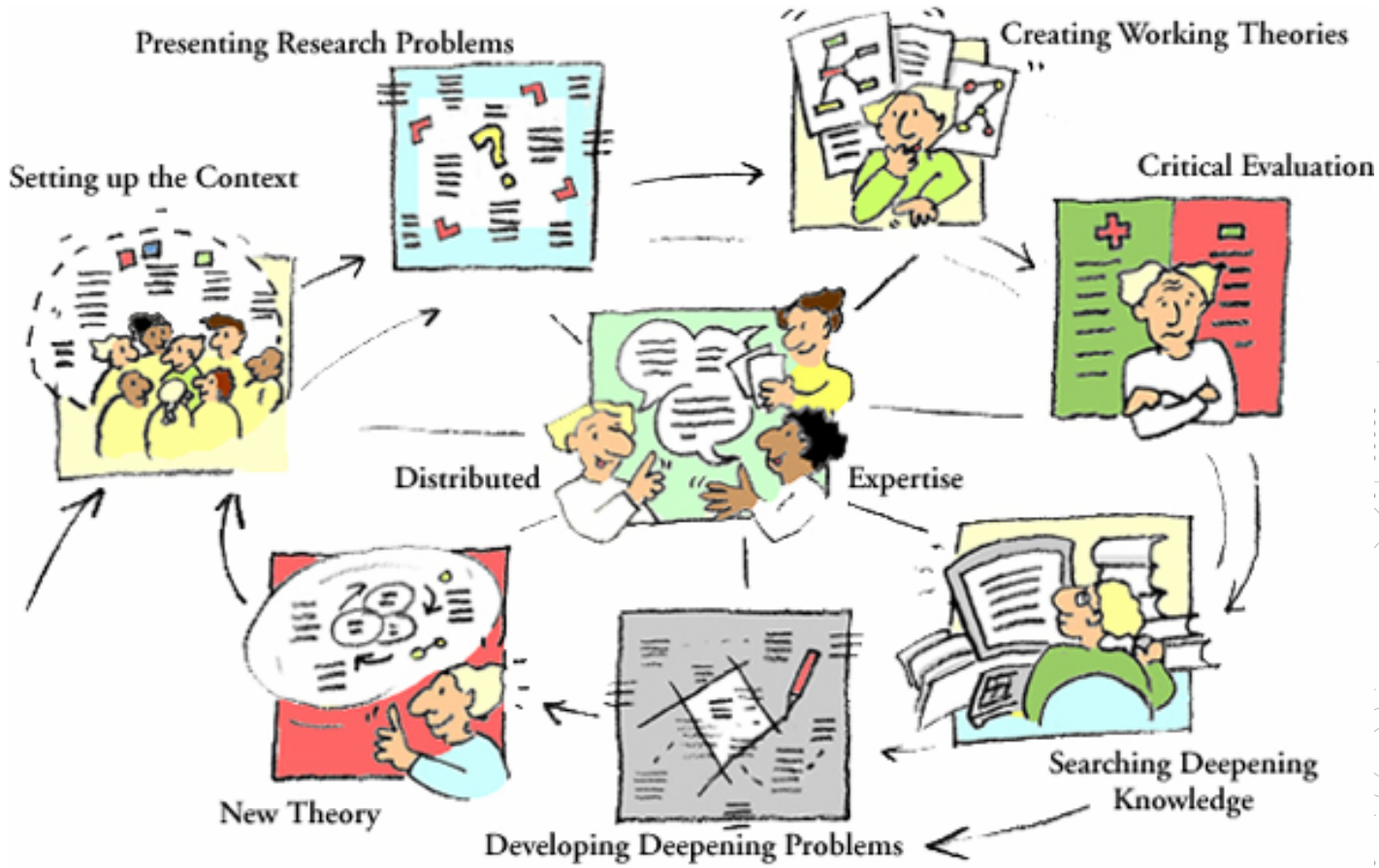
CSCL

- *C*omputer *S*upported *C*ollaborative *L*earning
- 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)

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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

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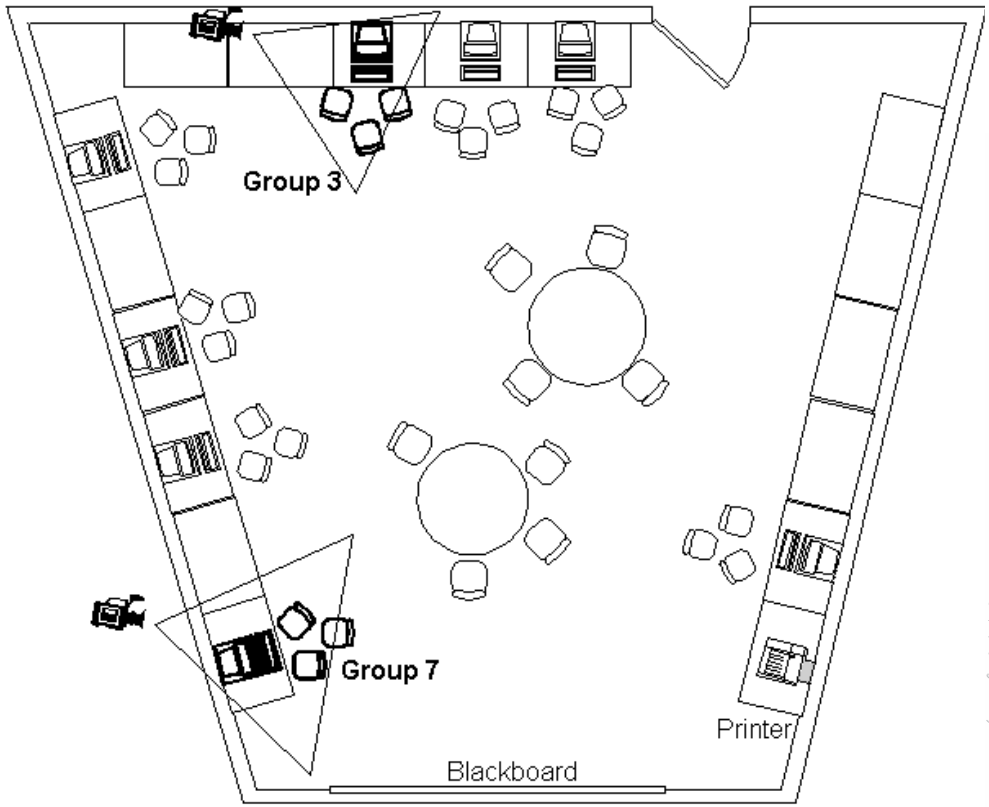
Physical set-up in school A



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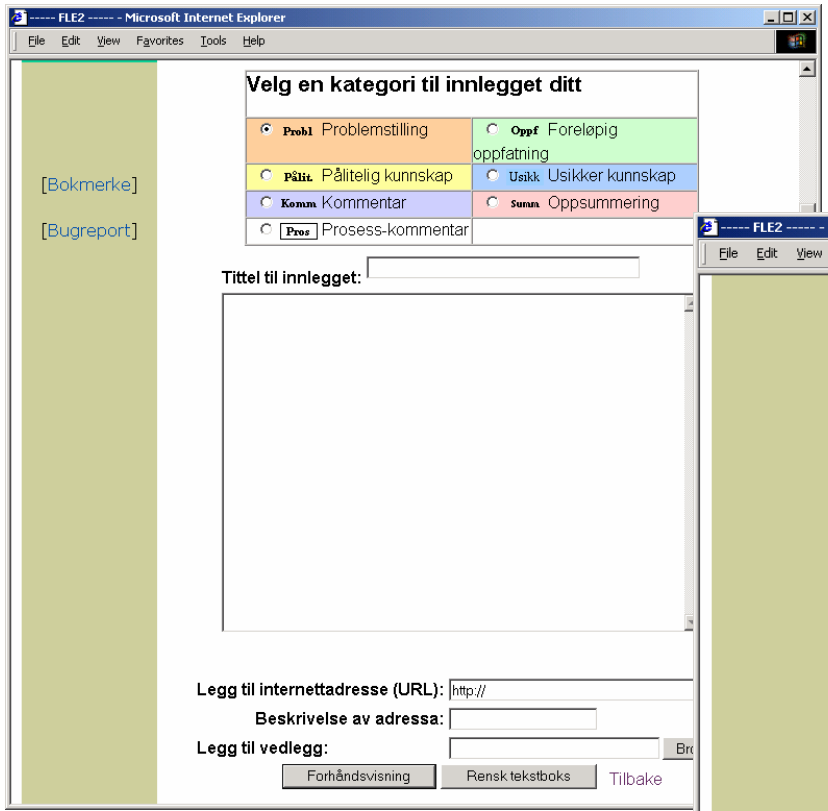
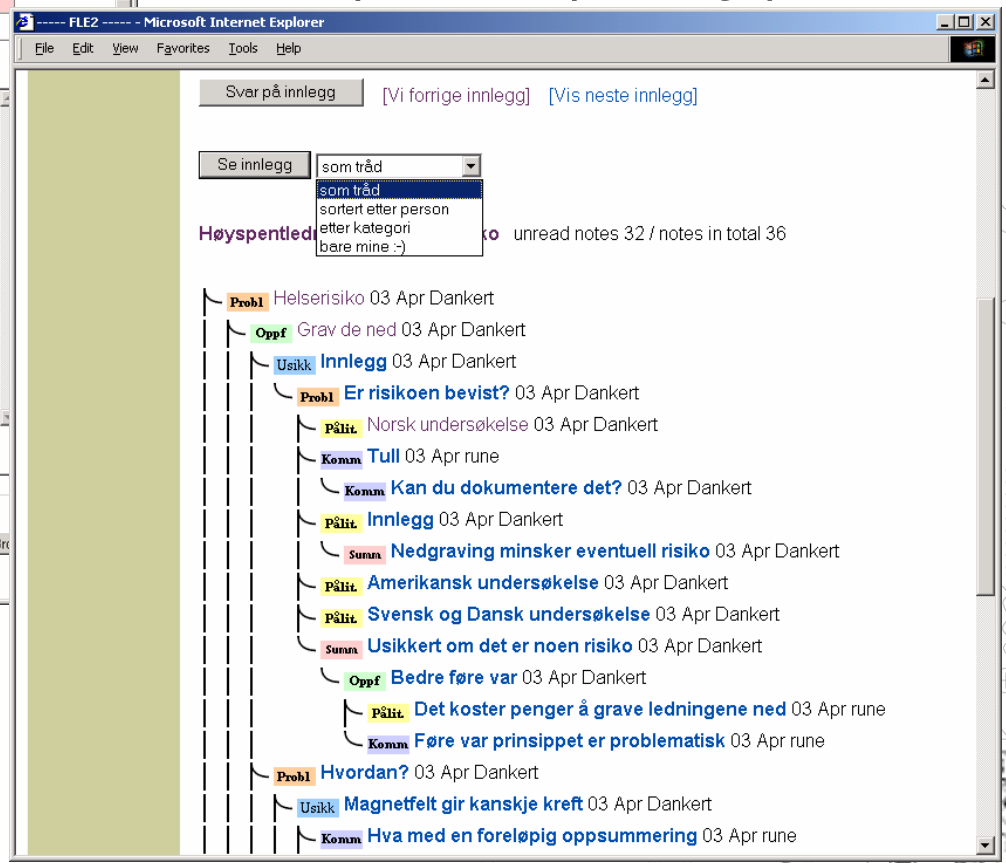
Fle2 interface



Writing/reply mode
(editor with message categories)

Viewing mode (threaded list of previous postings)



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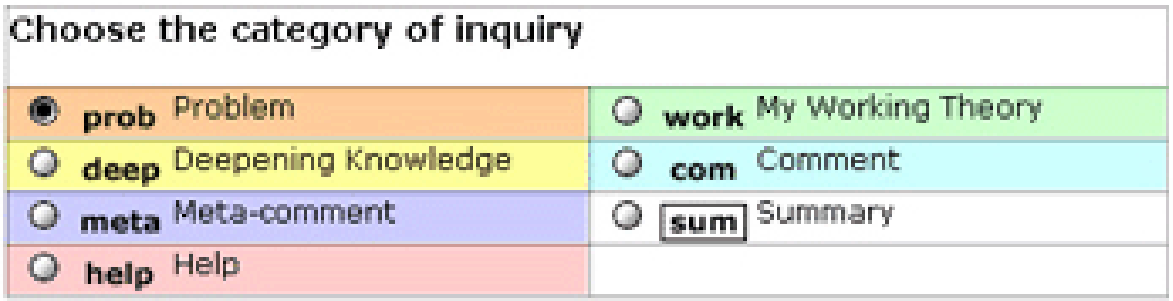
Scientific discourse



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

Our specialization of "deepening knowledge"

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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!"

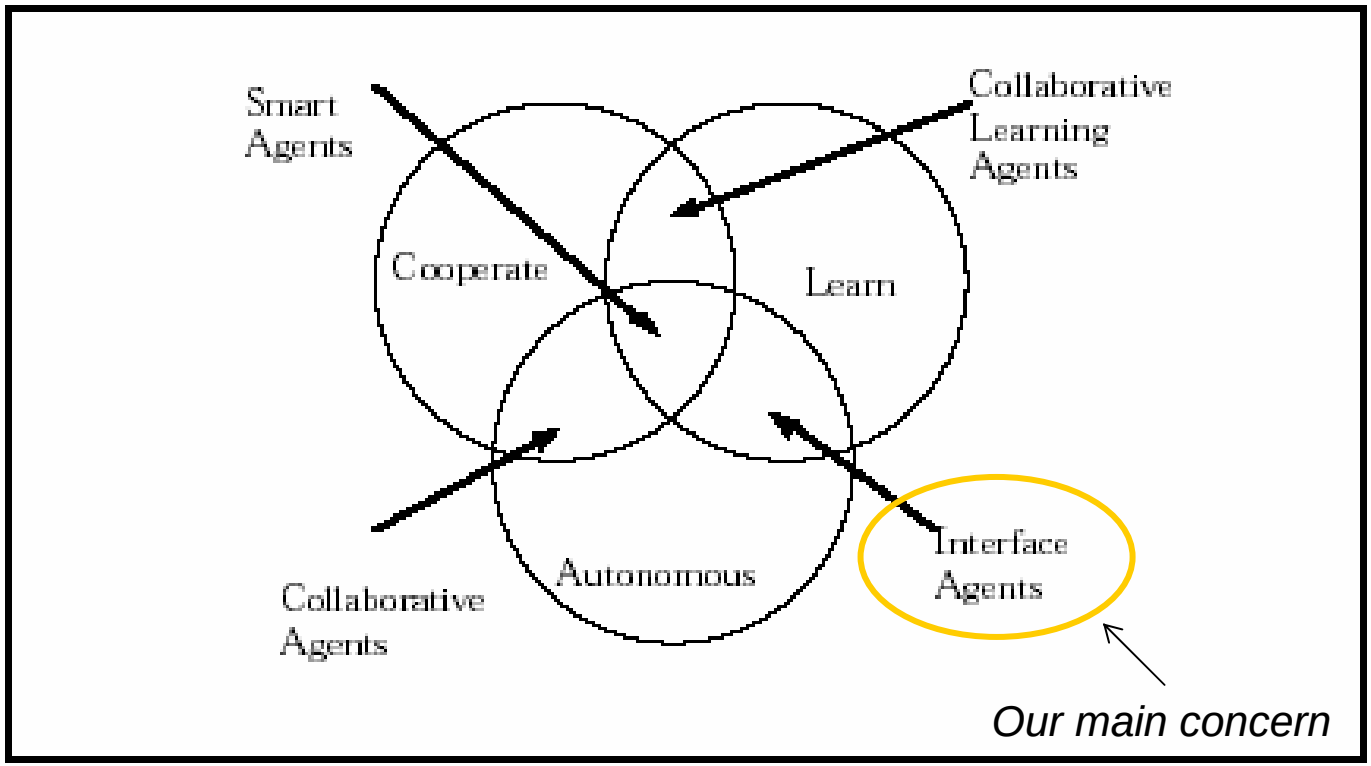
Summary of findings from pilot

- Students had difficulties choosing knowledge building categories
- Instructors have difficulties following the collaboration and giving continous 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

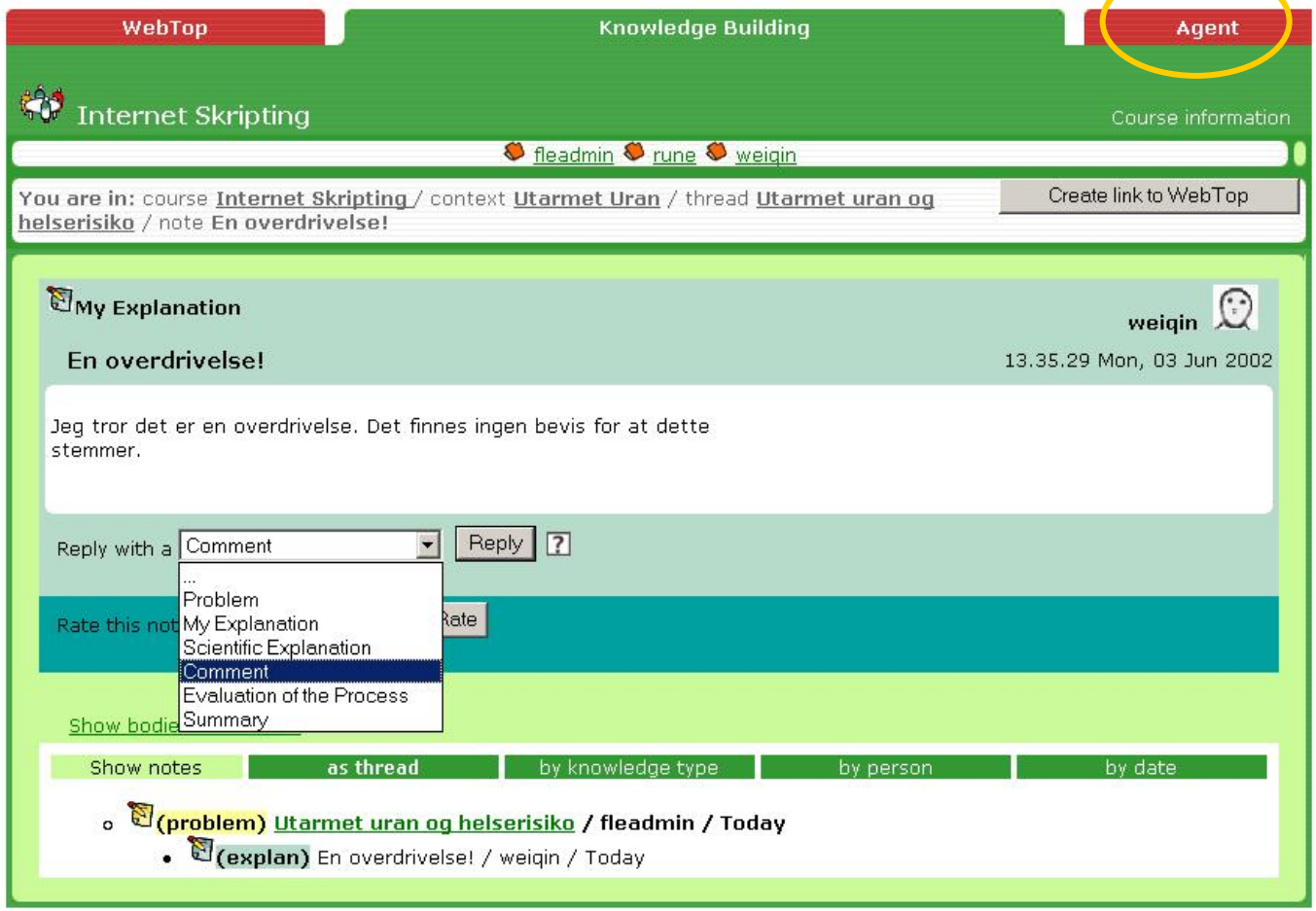
- Gather statistical information from database
- "Watch over shoulder" in the KB discussion forum and provide advice to the participants
  - Encourage non-active students to be more active
  - Suggest what messages to reply to and who should be doing so
  - Suggest what category to choose for the next 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



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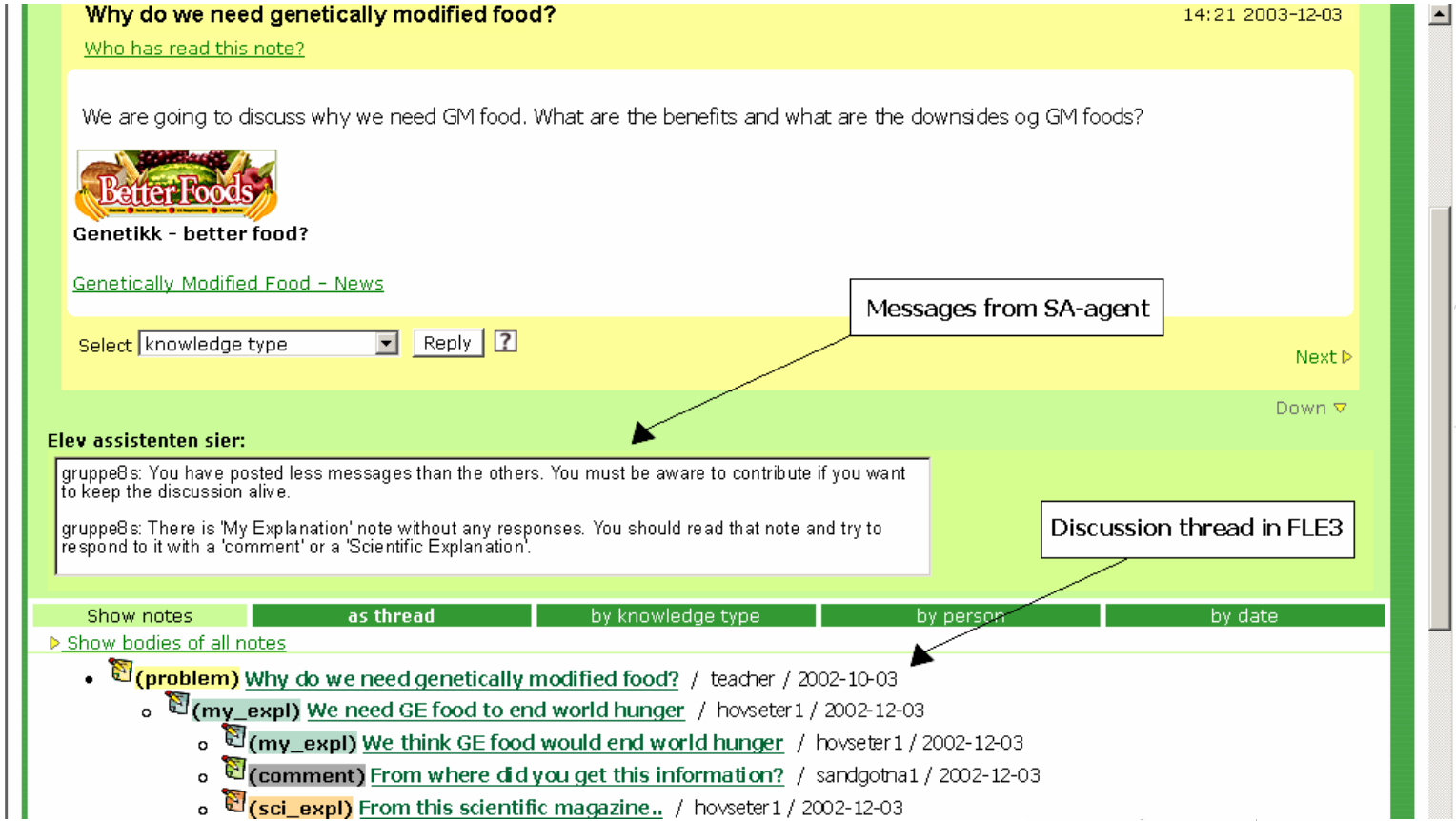
Agent system features

- 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



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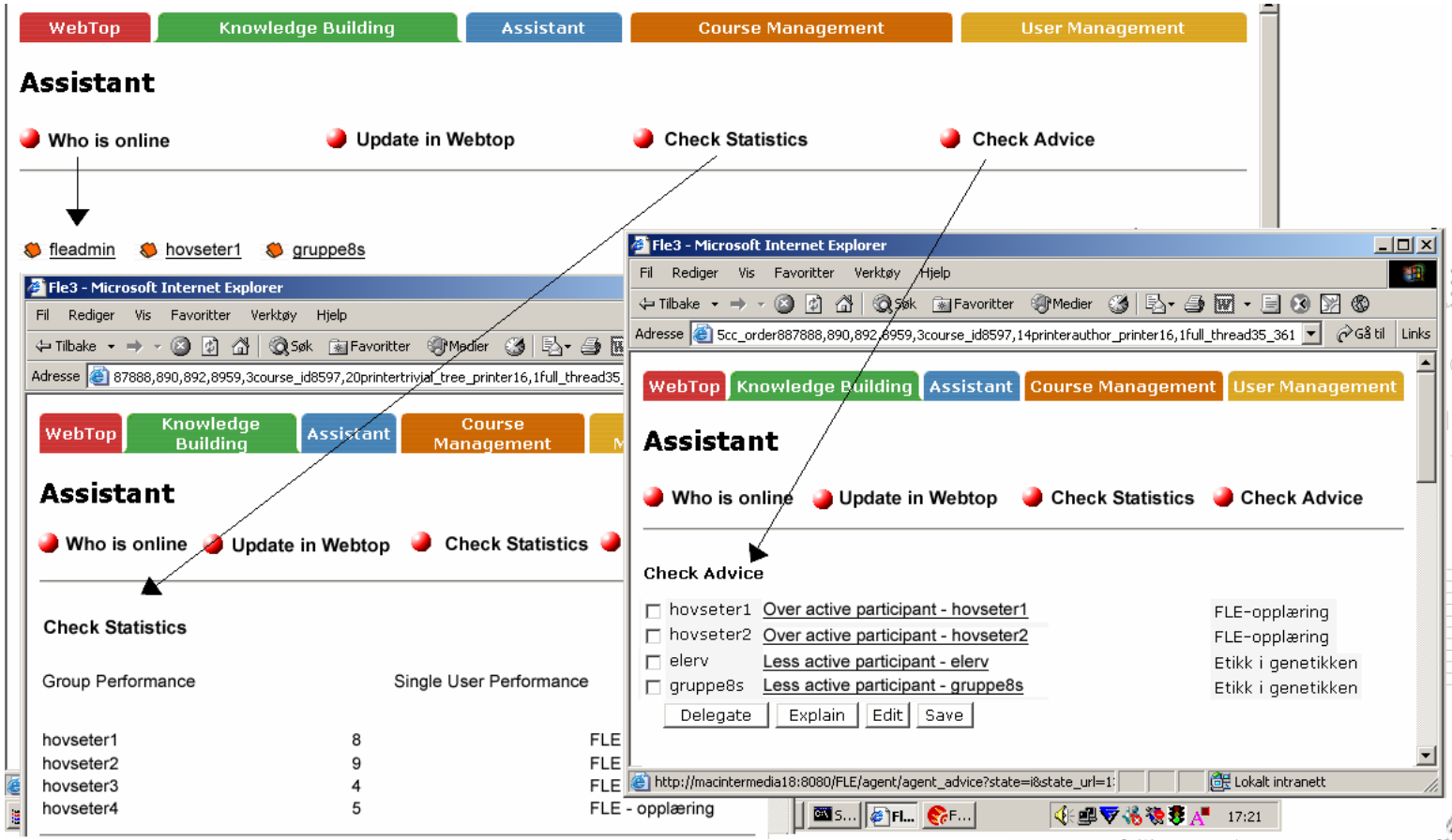
Instructor Assistant Interface



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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 per-formance, e.g. causing problem restructuring

Pedagogy dimension (CSCL)

- Agents serve as “conceptual awareness” mechanism, coordinating multiple know-ledge 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)

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