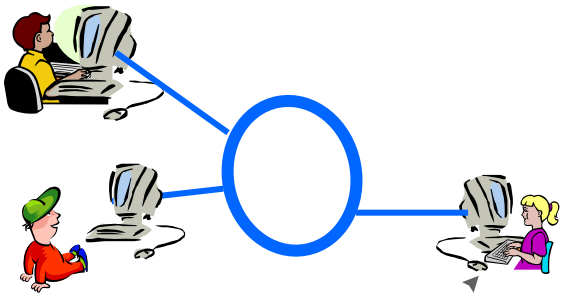
Using Ontological Engineering to Support the Development of Theory-aware Collaborative Learning Applications



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Agenda

1. The Challenges: Group Formation and CSCL Design and Analysis

2. Approach

- Typical Approach
- Ontological Approach
- Main Goals

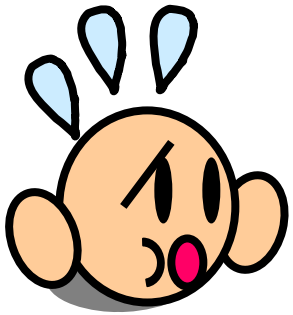
3. GMIP – Growth Model Improved by Interaction Patterns

- Ontological Structure to Describe Learning Theories
- Benefits
- Applications

4. Overview of CSCL Research Area

5. Conclusions

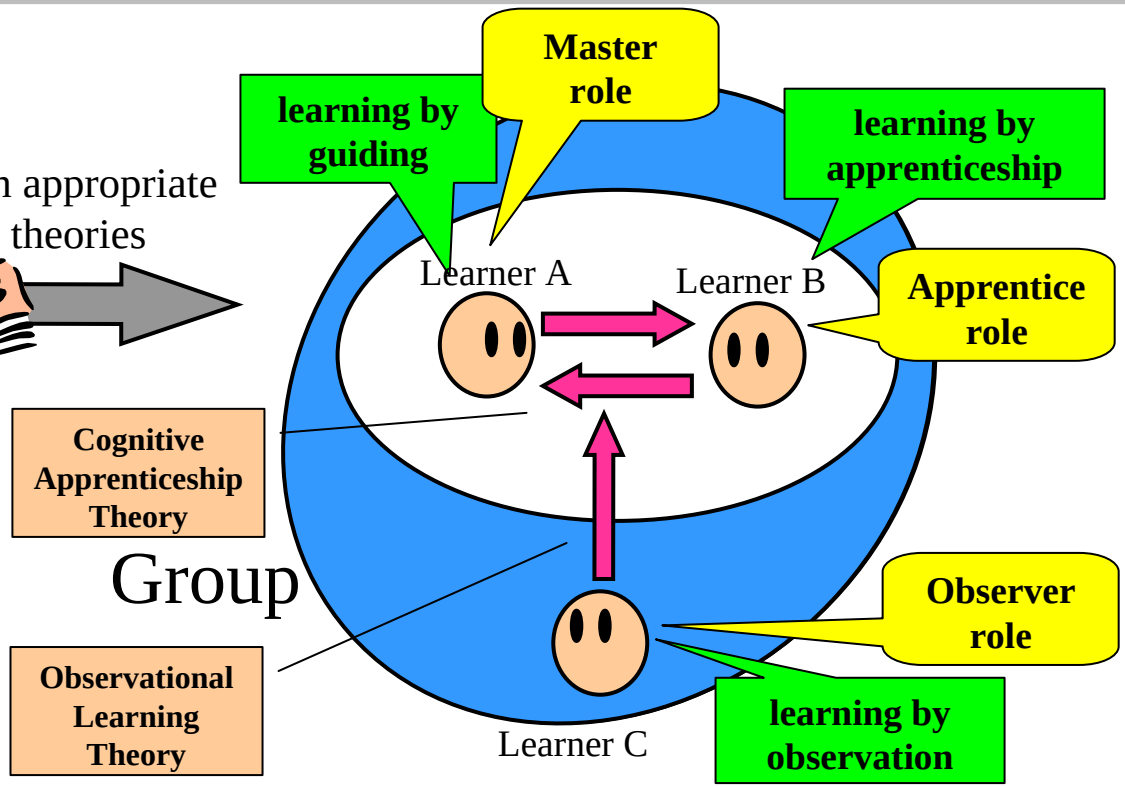
The Problems: Collaborative Learning Design and Analysis



Teacher/Instructor

Selection of an appropriate set of learning theories

How to design the best learning activities? Which Theory? What kind of benefits? How to analyze?



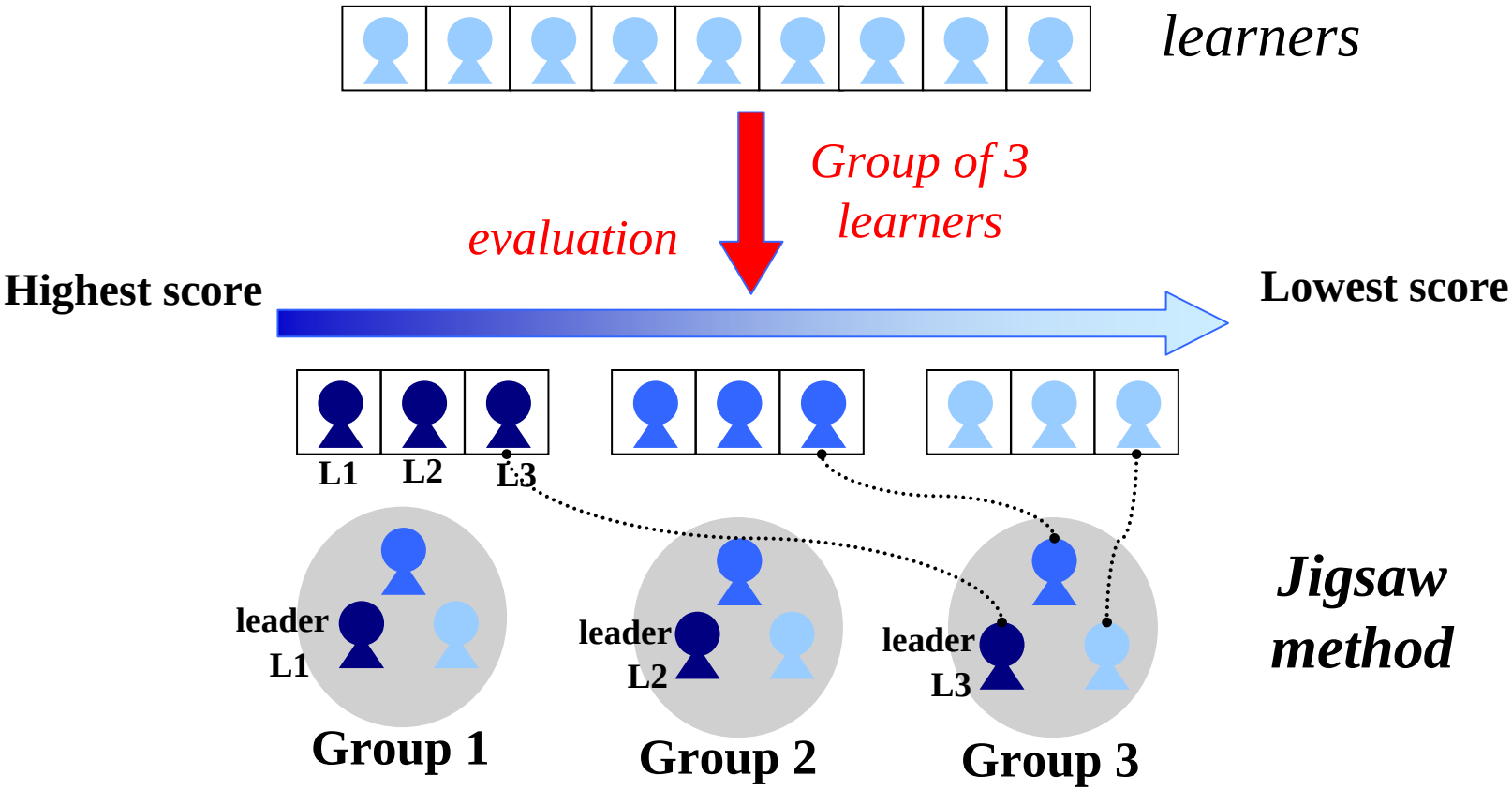
Learner	Supported theory	Learning strategy	Role for learner	Proposed activities	desired Benefit
Learner A	Cognitive apprenticeship	Learning by guiding	Master	Guide learner B	Skill development
Learner B	Cognitive apprenticeship	Learning by apprenticeship	Apprentice	Imitate learner A	Skill development
Learner C	Observational learning	Learning by observation	Observer	Observe the interactions between A and B	Knowledge acquisition

The Problem

- **Learning theories**
  - hard to understand
  - too complex & ambiguous
  - There is not a common vocabulary to describe them
  - Different point of views, levels of aggregation, perspective and emphasis

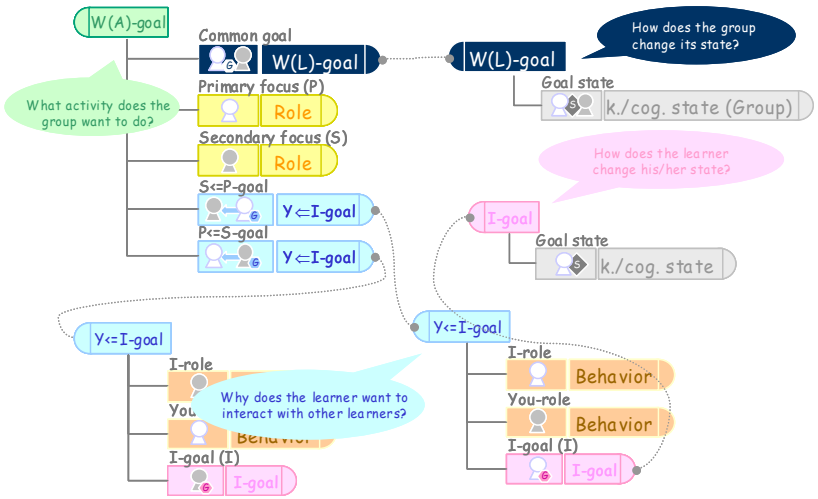
- **How to “unfold” the theories into a set of activities for a group?**
- **How to develop programs to support effective group formation and to design and to analyze group activities based on an well-grounded theoretical knowledge?**

Typical Approach and Limitations: Example



Soh, L., et al. Multiagent Coalition Formation for Computer-Supported Cooperative Learning. In *Proceedings of IAAI*, 2006, 1844-1851.

Our Approach



Ontological structure

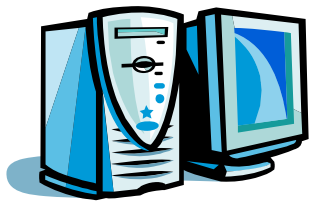
Use ontological engineering to describe theories for CSCL

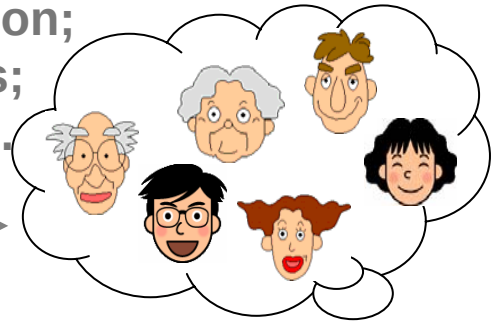
learning theories

Use ontologies to support the development of ontology-aware systems

The systems help users to:

- propose group formation;
- design group activities;
- estimate benefits, etc..

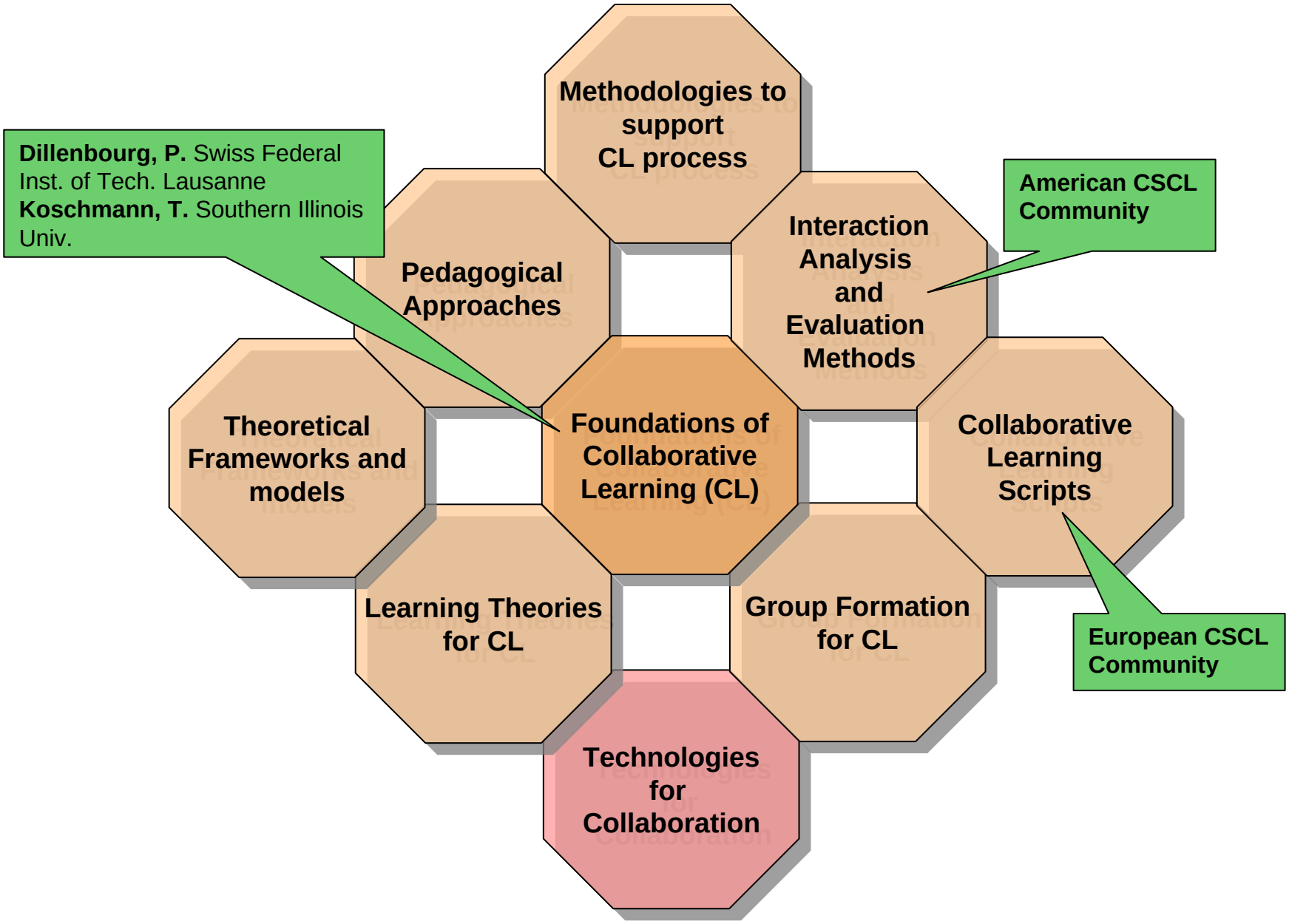


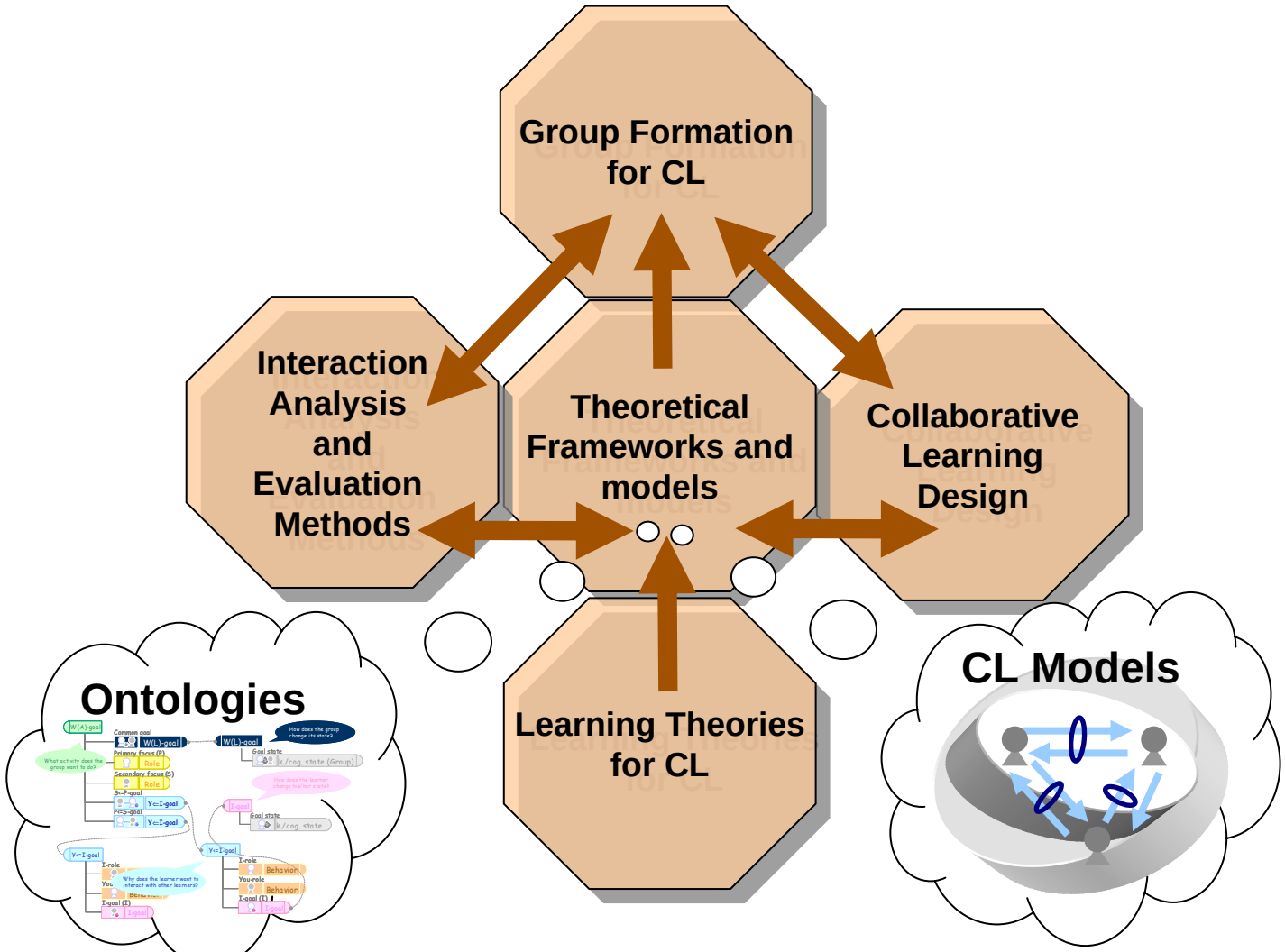


users

teacher/instructor/designer

Overview of CSCL Research Area





Fundamental settings for an effective CL session → **Essential conditions to predict the impact of interaction in the learning process**

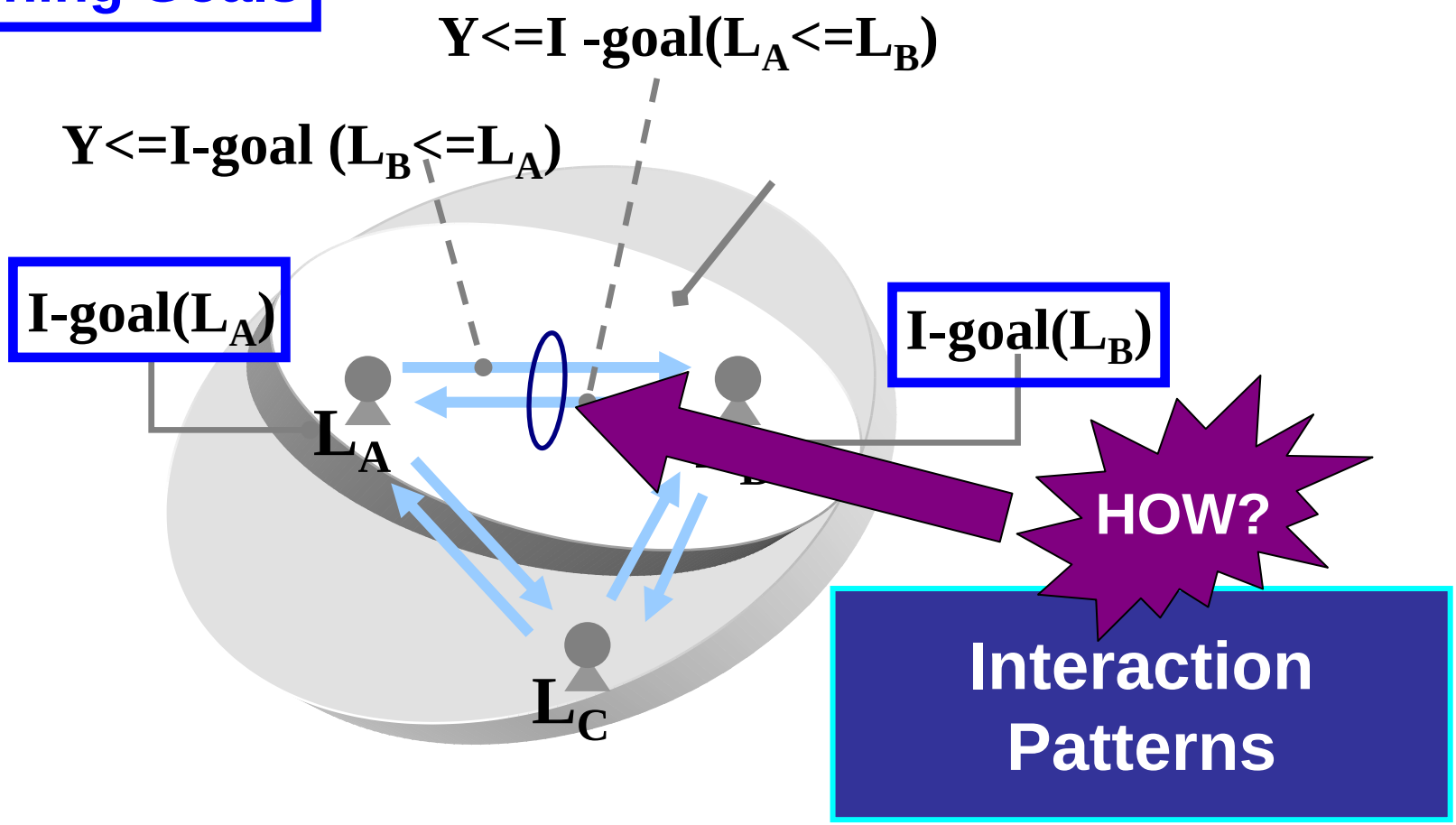
The Main Contribution of this Research

1. Making tacit characteristics of learning theories explicit;
2. Identifying the relationships among interaction, learning strategies and learning goals;
3. To propose an ontological structure to describe learning theories and to extend the **Collaborative Learning Ontology** [Inaba et al, 2000].
4. To support effective group formation, the design of CL activities and the analysis of learner's interactions.

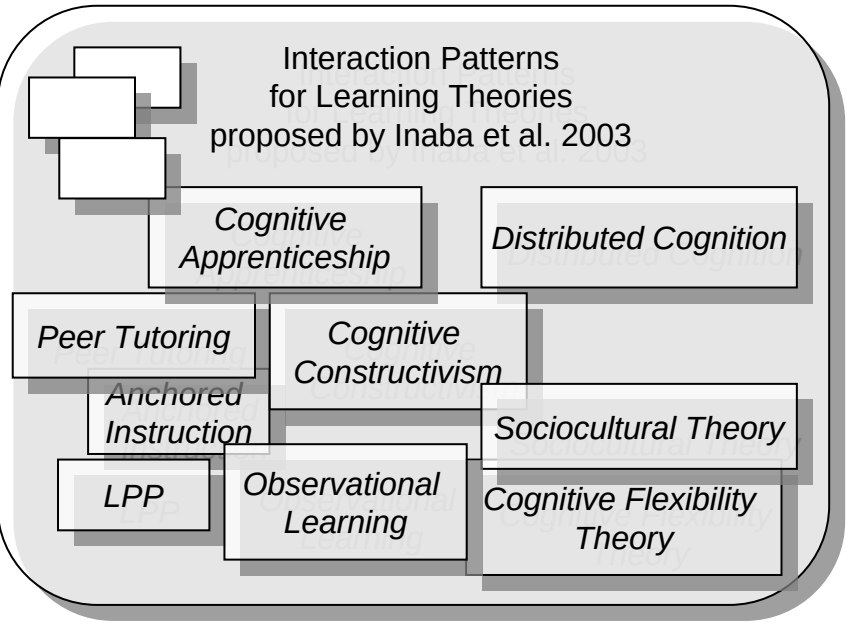
"We are NOT trying to coalesce several learning theories into a single ontology"

Collaborative Learning Ontology [inaba et al, 2000]

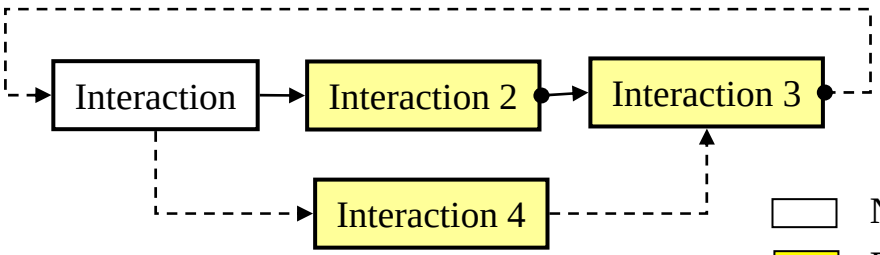
- ✓ Learning Strategies
- ✓ Learning Goals



Analyzing and Remodeling Interaction Patterns

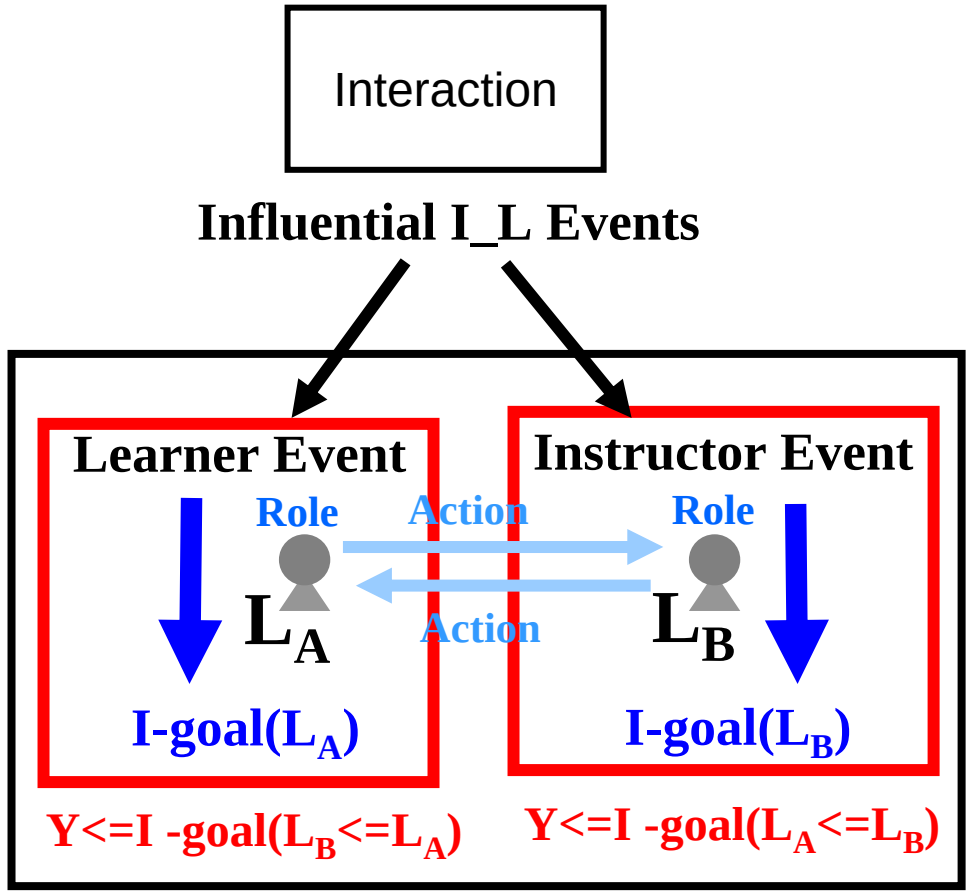


Pattern



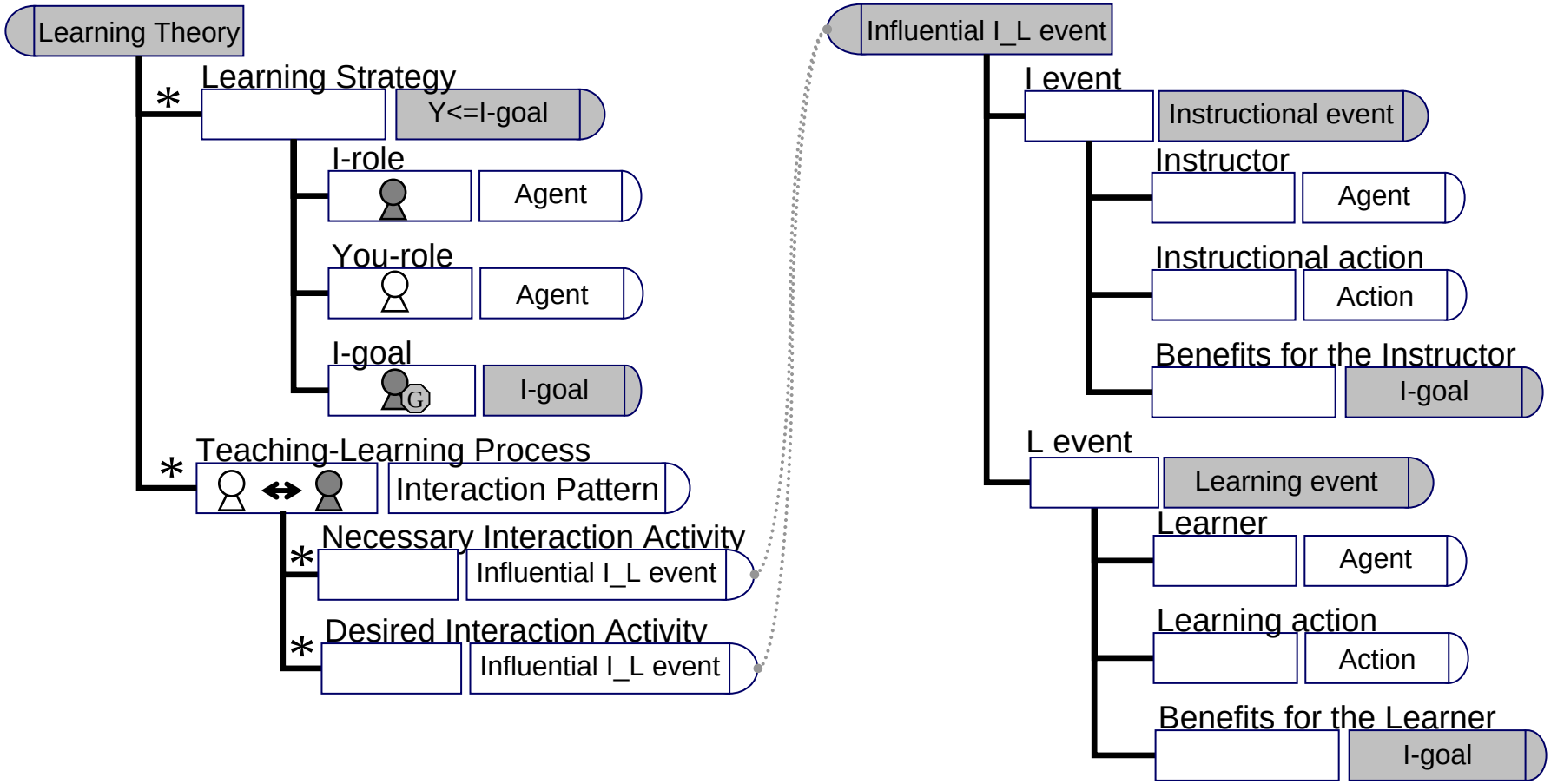
Necessary Interaction

Desired Interaction

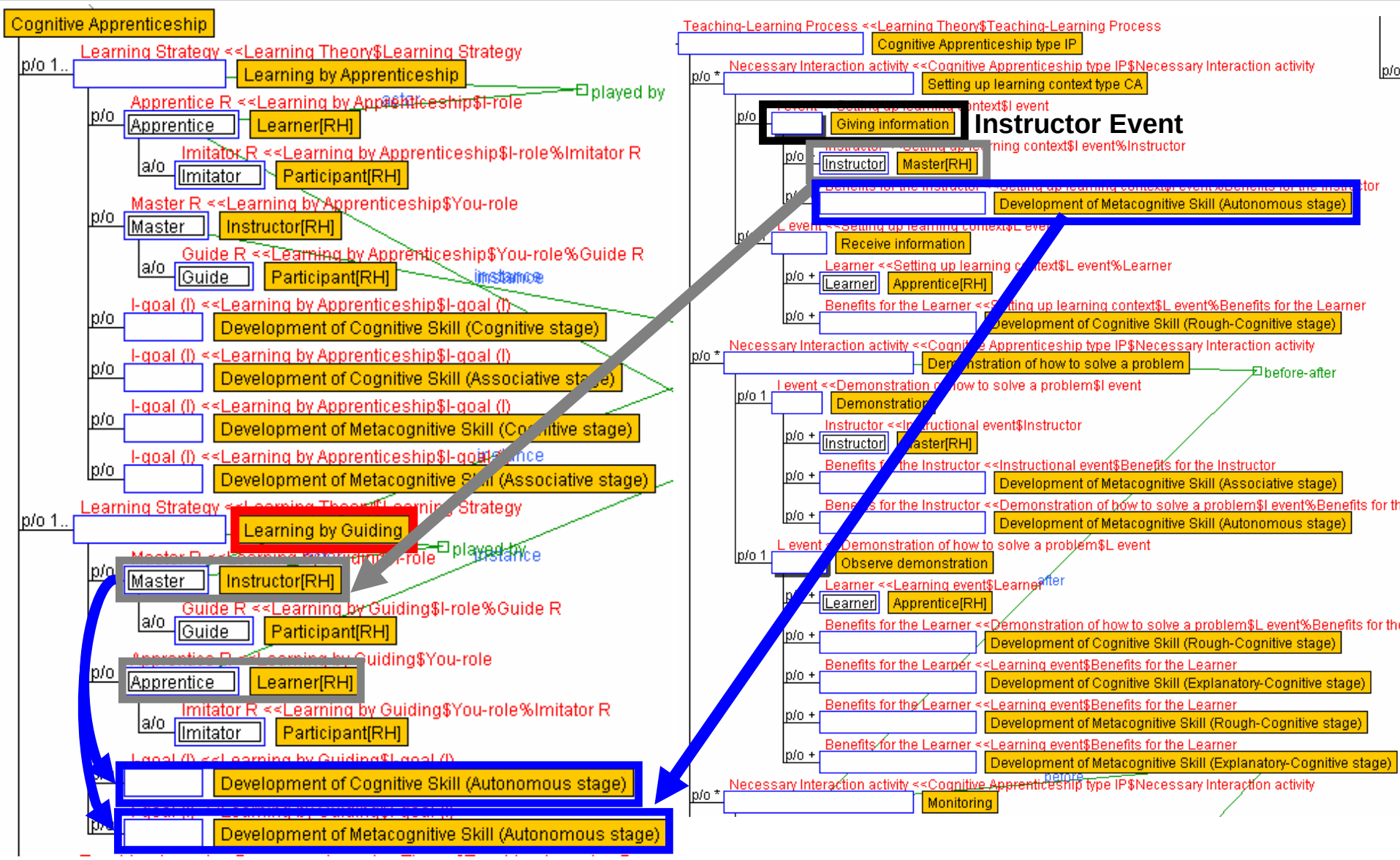


Learning Theory

Ontological Structure to Describe a Learning Theory

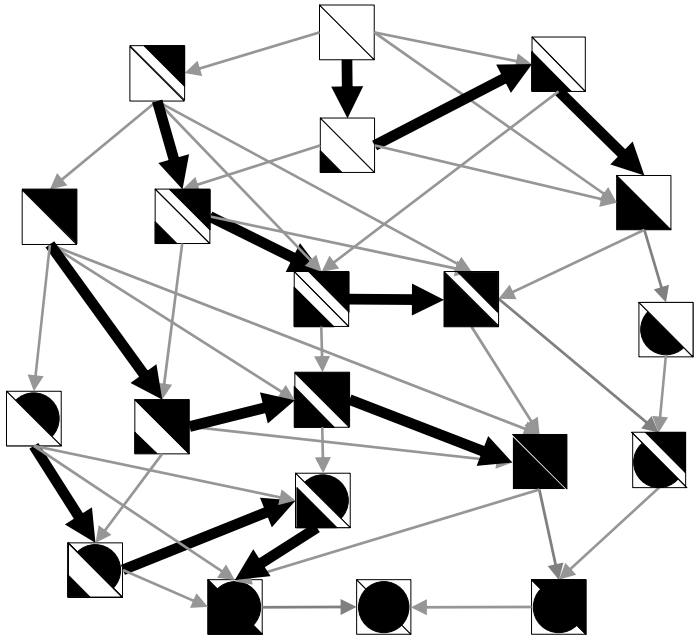


Example: Cognitive Apprenticeship Theory

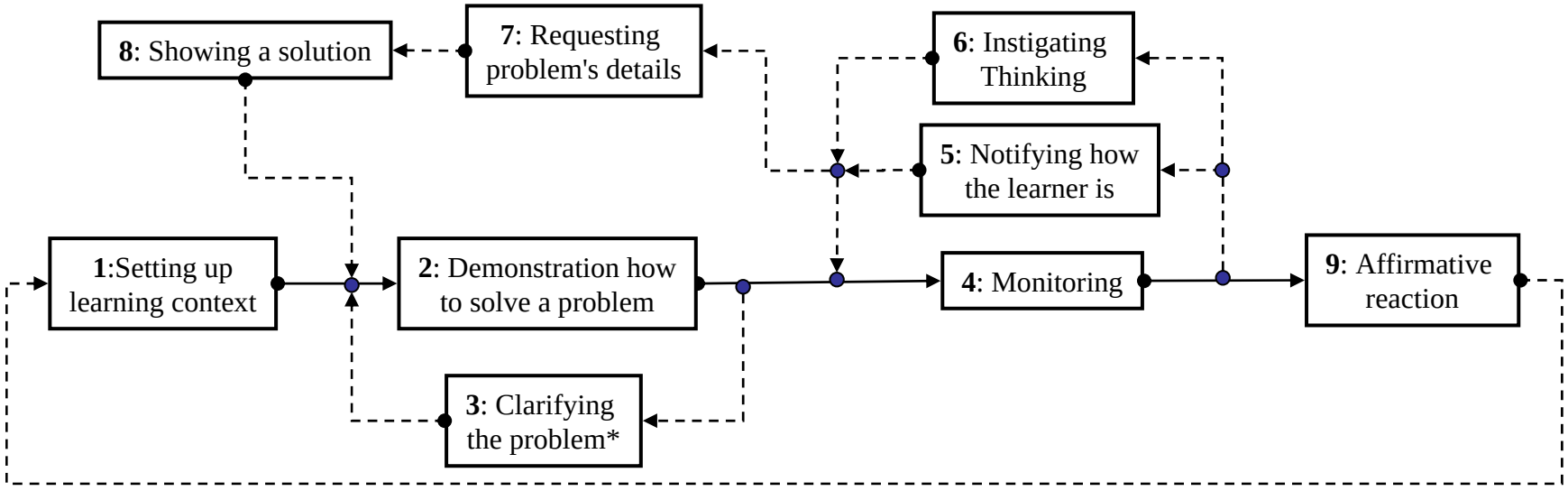


Cognitive Apprenticeship

➢**LGM – Learner's Growth Model** [extend from Inaba et al, 03]:
it shows the learner's knowledge acquisition process [Rumelhart & Norman,78] and skill development process [Anderson, 82].



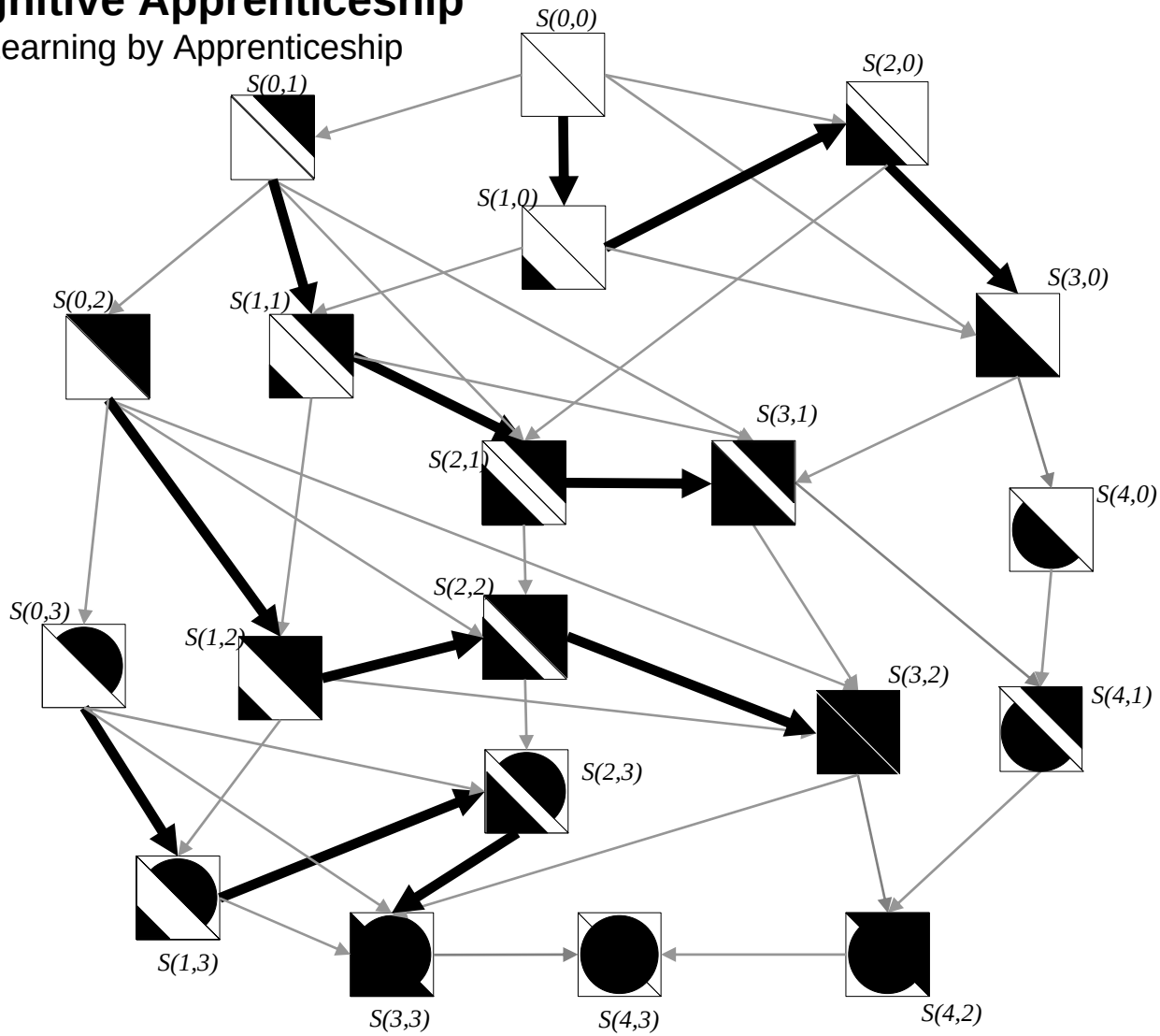
➢**Interaction Pattern represented by Influential I_L Events**



GMIP - Growth Model Improved by Interaction Patterns

Cognitive Apprenticeship

Learning by Apprenticeship



[Stages of Skill development]

- nothing (0)
- rough cognitive stage (1)
- explanatory cognitive stage (2)
- associative stage (3)
- autonomous stage (4)

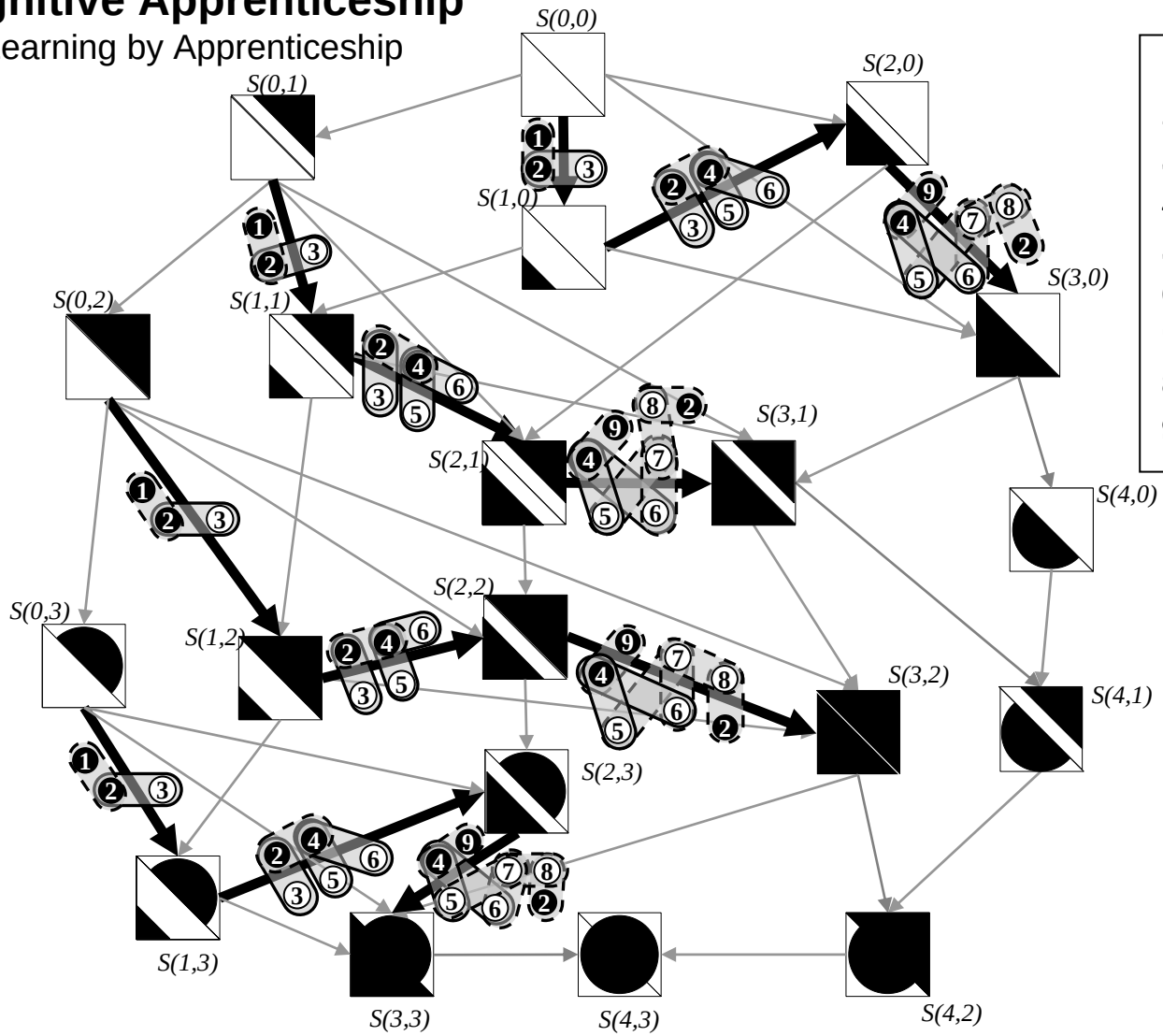
[Stages of Knowledge acquisition]

- nothing (0)
- accretion (1)
- tuning (2)
- restructuring (3)

GMIP - Growth Model Improved by Interaction Patterns

Cognitive Apprenticeship

Learning by Apprenticeship



[Interactions]

1. Setting up the learning context
2. Demonstrating how to solve a problem
3. Clarify the problem
4. Monitoring
5. Notifying how the learner is
6. Instigating thinking
7. Requesting problem's details
8. Showing a solution
9. Affirmative reaction

(x) Complementary Interaction

(y) Necessary Interaction

The dashed ellipses means that the interaction on the top/left must be followed by another interaction bottom/right.

The ellipses means that the interaction on the top/left will be followed by another interaction bottom/right and vice-versa (cycle)

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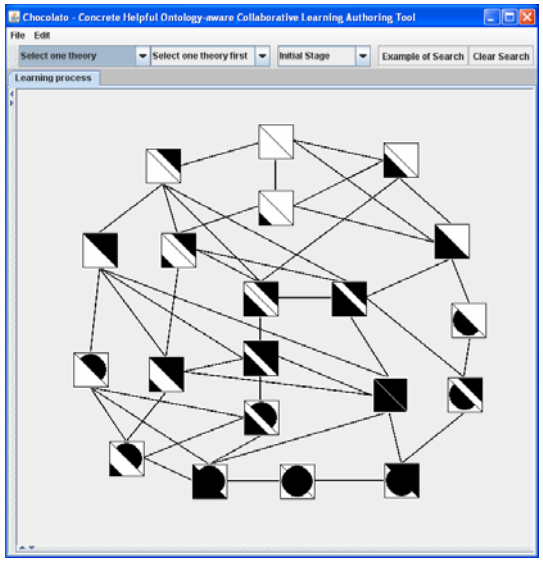
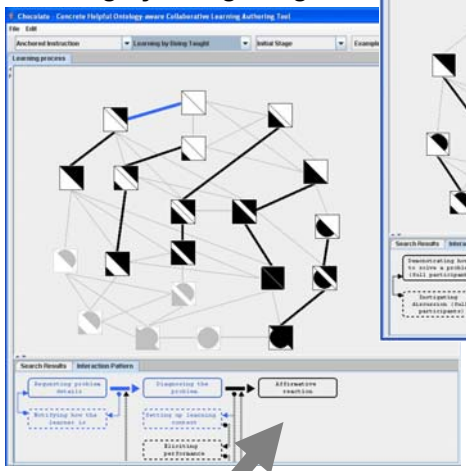
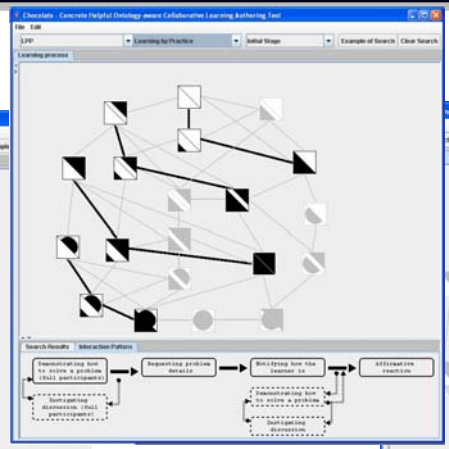
Collaborative Learning Authoring Tool

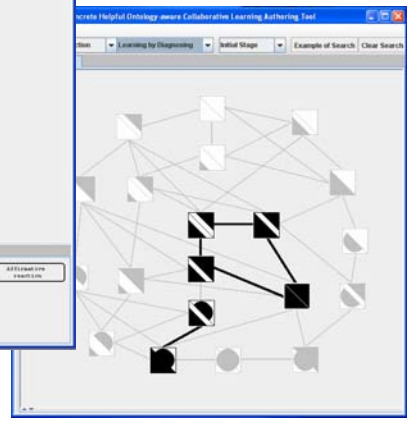


Anchored Instruction
Learning by Being Taught



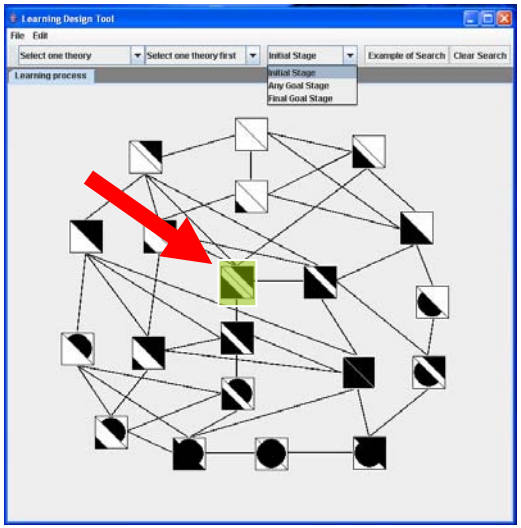


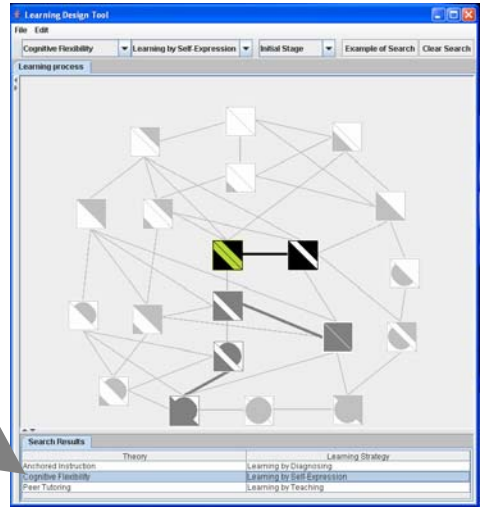
LPP
Learning by Practice



Anchored Instruction
Learning by Diagnosing

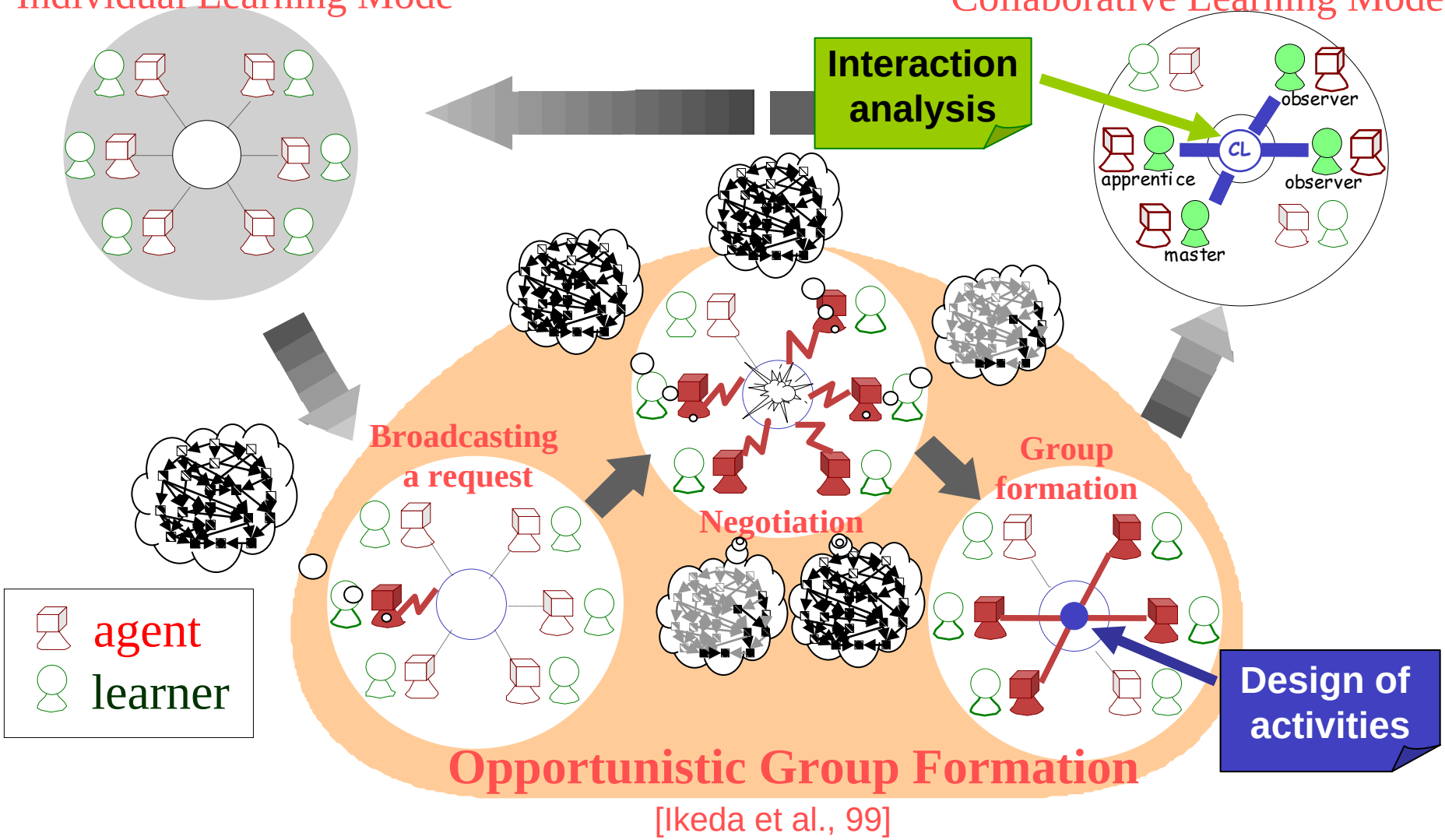
Interaction Pattern





Search Results

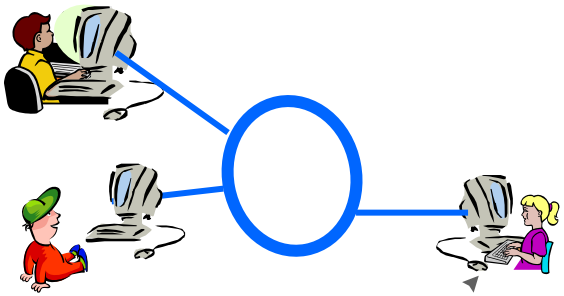
Applications: Effective group formation/ Design of activities/ Interaction analysis



Conclusions

- We have been using ontologies to establish a **common understanding of what a learning theory is** by representing it in terms of its **explicitness**, **formalism**, **concepts** and **vocabulary**.
  - This makes theories understandable and sharable, both by computers and humans.
- We use previous achievements in using ontologies for CL to clarify how interactions can affect learner's development to propose another model, called **GMIP.**
  - Explicitly identify the relationships among interaction patterns, learning strategies and learning goals.
  - For users the GMIP allows the graphical visualization and use of learning theories. ***Thus, users can quickly interpret the theories, their benefits and can propose sequence of activities in compliance with them.***
  - For computers, it provides a ***formal structure*** which allows systems to reason on learning theories to support ***effective group formation***, the ***design of group activities*** and the ***analysis of interactions***.
- Re-formation of groups based on effective interaction analysis and accumulation of knowledge.

Thank you!



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