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<tr>
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Learning computer networks in an international, distributed course

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Sweden
Aim of the research

- Understand how our students learn about computer systems, in order to improve learning and teaching of computer science at university level
Research question

- How do computer science students who take part in an international distributed project-centered course understand network protocols?
- What can we, from these results, say about our teaching and students' learning?
Learning computer networks ...

1. The setting
   - The project based course in computer systems
   - Phenomenography as a research approach
   - Computer networks, in particular TCP

2. Experience of learning computer networks
   - Results: Students’ understanding of TCP
   - Implications for teaching

3. Experience of learning in projects (current)
   - Activity theory as used in this project
   - An approach to study learning in a project course
   - Experience of being graded, a pilot study

4. Summary
Project course in computer systems

- 3 + 3 Master level students per group
- 16 groups in total
- No lectures
- Tutoring by e-mail and chat

USA

Collaboration by e-mail and chat

Sweden
Student project

- Course in computer systems for advanced CS students.
- Student project: Produce a software system to control a (modified) Brio labyrinth from any Web-browser.
- The task demands computer communication solutions.
Phenomenography

- Aims at analysing and describing variations in how a phenomenon is understood. *Research is open to students’ experiences*
- Empirical: Data stems from the students *Interviews with open questions*
- Outcome: A description of a limit set of qualitatively different ways, in which a phenomenon is understood *A description of understandings of computer networks*
- The subject area of the learning is in focus *Computer Science*
The perspective taken in phenomenographic research

Second order perspective
The researcher studies the relation between the students and a phenomenon

Students taking a course in computer systems

TCP

Researcher
Phenomenographic research project

Non-algorithmic

- Formulating research question
- Collecting data. *Interviews*
- Analysing
  - Transcribed interviews read
  - Interview excerpts are analysed.
    Decontextualisation - recontextualisation.
  - Outcome: Categories of description
- Deploying results. *Back into education*
Computer network protocol

- A set or rules that governs communication between two machines
- Computer comm. Is defined in layers, for example:
  - Semantically rich communication between programs
  - Physical transmission of raw data
TCP – a network protocol

- Transmission Control Protocol
- One of the most important internet protocols
- In practice “TCP” denotes
  - the abstract protocol
  - programming packages that implements the protocols
- Described here as understood by the students (in a slightly simplified form)
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4. Summary
# Understanding TCP, 3 categories

<table>
<thead>
<tr>
<th>Category</th>
<th>As what?</th>
<th>Part of which framework?</th>
<th>Technical character</th>
<th>Described in what way?</th>
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<td>Cat. 1</td>
<td>Safe communication</td>
<td>Two computers</td>
<td>Protocol with acknowledgement.</td>
<td>Concrete</td>
</tr>
<tr>
<td>Cat. 2</td>
<td>A connection</td>
<td>Internet</td>
<td>Protocol with acknowledgement.</td>
<td>Abstract</td>
</tr>
<tr>
<td>Cat. 3</td>
<td>Standard for comm.</td>
<td>A world outside Internet</td>
<td>Protocol with acknowledgement.</td>
<td>Meta-level</td>
</tr>
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The technical character varies between different protocols (UDP, RMI)

Anders Berglund, Department of Information Technology
What is good learning of computer networks?

- Differences in richness
  
  Different aspects held in focus in simultaneously

- Situational appropriateness
  
  Which aspect(s) are held in focus in a certain situation?

In short:

It is good to be capable of understanding TCP in several ways, and to choose well between them.
Relevant ways of understanding TCP

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<th>As what?</th>
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<th>Described in what way?</th>
<th>Relevant For?</th>
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<td>Programming</td>
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<td>Internet</td>
<td>Protocol with acknowledgement.</td>
<td>Abstract</td>
<td>Program design</td>
</tr>
<tr>
<td>Cat. 3</td>
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<td>Protocol with acknowledgement.</td>
<td>Meta-level</td>
<td>Policy issues</td>
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Teaching and learning of computer networks

- There are different understandings of network protocols in the group
- Students shift between understandings
- Different understandings are relevant with different tasks at hand
- Teaching should promote variation in students' understanding
- How?
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Learning in project courses – current research

- How to promote variation in a distributed project course (no lectures, no labs, no fixed schedule)?
- Study the learning environment, as it is experienced by the students
Activity theory
Engeström, 1987

- Framework for describing, analysing and explaining human activity, as learning in a complex setting.
- Socially based nature of human activity is stressed.
- An activity is dynamic
- An activity is described from the researcher’s perspective
An activity system

- Subject
- Tools
- Community
- Rules
- Object
- Division of labour
- Outcome
Research approach in this project

- Analyse and describe the learning of computer networks in a complex course environment as experienced by the students.

- The use of phenomenography is extended to include the variations in the relations between the students and phenomena contextual to the study object.

- Aim of approach: Study learning in this course, without loosing computer science.
Ways to analyse students’ experience of the activity

- Relate categories of description of various phenomena to the components of the activity system
- Resulting system is a description of the activity as experienced
- Resulting system can be further analysed as an activity system
  - Case studies
  - Study inner contradictions
  - Return to interview excerpts related to a component to reanalyse
Relating categories to an activity, an example

Experience of being graded

1. Getting a good grade is a goal in itself
2. Grading is not an important feature
3. Grading is an obstacle
The approach

- The activity is described as experienced
- The subject area is in focus
- Variation is the object of research
References

- Marton, F. & Booth, S. *The experience of learning*, 1997
- Engeström, Y. *Learning by expanding. An activity-theoretical approach to developmental research*, 1987
- Berglund, A., *Learning computer systems in a distributed course: Problematizing content and context*, 2002
Perspective on learning in this project

- Learning is seen as change in the relation between students and the object of their learning (Marton & Booth, 1997)

- Learning takes place as the students interact within the learning situation

- To understand the learning in the course, we must study the student’s relation to
  - object of learning,
  - issues contextual to the object of learning
Summary and further research

- Analyses of students understanding of computer network protocols presented March 2002
- Develop the approach
- Analyse and describe learning of computer networks in this situation
  ..... in order to finish my PhD in computer science
Principles of an activity system

- An activity is dynamic and has a history
- The object is the reason for its existence
- The activity is a context
- Activity is mediated
- Inner contradictions serve as driving forces
- Individual actions is parts of an activity