Researching students' learning of computer science - Qualitative Research in Computing Education Research

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Today

- Research into students' learning of computing
- More precisely qualitative research in students' learning of computing.
- The nature of the results of different ways to perform research.
- Illustrates some ways to do research (selected for their relevance in CER) with their empirical results.

Different ways to perform research into learning
- Quantitative and qualitative research approaches
- Phenomenography
  - Grading in a project course in computer systems?
  - What do students strive to learn in a project course in computer systems?
- Socio-cultural research perspective
  - Why do teams of students produce so different results?
- Constructivism
  - Smaller examples, conclusions for teaching.

Summary

Lab "Understanding object and class"

Preparation
- Read transcripts on the web (31 interview excerpts).
- Print them out, cut them into 31 pieces so that each interview section is on a separate, small piece of paper.
- Skim Berglund, 2006.

After lab
- Write a 1-2 page reflection.
- (If you cannot attend, talk to Anders)

Next week
- Some more papers on the web (Thursday evening).
- Prepare questions, comments to papers
- An open discussion
- Group size?
- Write reflections, individual 1-2 pages
- (If you cannot attend, talk to Anders)

Why focus on “learning” in Computing Education Research?

- How do our students understand and learn computer science concepts?
- How to teach computer science?
- Learning and researchability are closed connected in this context
What does it mean to learn something?

*Unfortunately (?)...*

- General case: A “meaningless” question
- It all depends on “what you mean by learning” or “how you see things”

A research approach/methodology/framework

- Offers a way to perform research in learning.
- Organizes “ways to see things”.
- A lens with a certain focus.
- With a specific research approach: Some issues get clearer, others blurred.
- Offers theoretical stand on learning, ways to see possibilities and limitations, opens to communicate with other researchers etc.

A research approach

- The approach determines the nature of the results that you can get.
- You have to select an appropriate research approach!

An “simple” distinction

- Quantitative research approaches (in the natural science tradition)
- Qualitative research approaches (in the social science tradition)
- There are several more distinctions and some fine-grained nuances

Quantitative/Qualitative research

- Quantitative research is grounded on
  - “… the assumption that features of the social environment constitute an objective reality … collecting numerical data on observable variables”
- Qualitative research is grounded on
  - “… the assumption that individuals construct a social reality in the form of meanings and interpretations. … studying … intensively in natural settings”

*Implications for the role of the researcher, the concept of evidence, interpretation etc.*

(Gall, Borg & Gall, 1996)
Quantitative and Qualitative approaches

**Quantitative approaches**
- Quantitative results
- Observable variables, “hard” evidence
- Social environment constitute an objective reality
- Experiments
- Fragmented view

**Qualitative approaches**
- Descriptions
- Interpretations, researcher is present
- Social environment is constructed
- Studies in naturalistic settings
- Broad understanding

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**Qualitative Research in Computing Education Research**

Qualitative research approaches discussed:
- Phenomenography
- Socio-cultural studies
- Constructivism

Selected since they are frequently used in CS education research

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**What is phenomenography?**

- Describes learning and understanding from the learners’ perspective
- Aims at analysing and describing the different ways in which students’ understand something.
- Discusses learning in a collective.
- Outcome: A few qualitatively different ways, in which something is understood within a student cohort.

Example: The concepts of “class” and “object”; the role of the teacher

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**Phenomenography**

The students study OOP
- The researcher studies the different ways in which the students understand OOP

Students taking a course
- The researcher is a learner in relation to his study object
- The researcher shapes the results
Phenomenography

Ontology: Non-dualistic – study object is in the relationship between the physical world and the experienced world

Epistemology: Ph. studies how someone experiences something

Methodology: Interviews and sorting of data

Pedagogy: Variation

Examples of phenomenographic results

- How do students go about programming? (Booth, 1992)
  - Expedient.
  - Constructional.
  - Operational. “It works”
  - Structural.

- What is a computer network protocol? (Berglund, 2002)
  - A way to communicate between two computers.
  - A method for communicating on an internet.
  - A set of rules.
  - A standard.

Two larger phenomenographic examples

1. Grading in the Runestone course
2. What do students strive to learn in the Runestone course?

Background

A project course in computer systems

- USA
- Sweden

- Communication by e-mail and chat

- 3 + 3 advanced CS students per team
- 16 teams in total
- No lectures
- Tutoring by e-mail and chat

Student project

- Student project: Produce a software system to control a (modified) Brio labyrinth from any Web-browser.
- The task demands computer communication solutions.
- The task requires collaboration within the team of 6.

Example 1: Grading in Runestone

- Both process and product are graded
- Team members are graded by “their” instructor
- Process grade is based on weekly meetings

- Components:
  - Team performance, in relation to the team’s own plan
  - Individual contribution
  - Peer evaluation
  - The instructor’s decision

- Different grading schemes in Sweden and US
  - Sweden: pass/fail
  - US: A to E

Problematic???
Analysing the grading in Runestone

- Teachers’ distribution of grades (quantitative)
- Peer evaluation
  - The students’ evaluation of each others’ contributions (quantitative)
- Students’ experienced purpose of being graded (qualitative)

Grades

- Grades awarded by the instructors, according to the Runestone scheme (Max = 100, Pass ≈ 60)
  - To all students: 83.61
  - To Americans: 81.55
  - To Swedes: 85.05

Peer evaluation

- Each student awarded USD 120.- to his team-mates

<table>
<thead>
<tr>
<th>From</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>From Swede to Swede</td>
<td>22.25</td>
</tr>
<tr>
<td>From Swede to American</td>
<td>18.79</td>
</tr>
<tr>
<td>From American to American</td>
<td>20.07</td>
</tr>
<tr>
<td>From American to Swede</td>
<td>20.07</td>
</tr>
</tbody>
</table>

*Then, what is the driving force?*

The experienced purpose of being graded

<table>
<thead>
<tr>
<th>Cat</th>
<th>Getting a good grade...</th>
<th>Focus is on</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ... has a value on its own</td>
<td></td>
<td>The grade per se</td>
</tr>
<tr>
<td>2. ... is a tool to reach other aims</td>
<td></td>
<td>The benefits of a good grade</td>
</tr>
<tr>
<td>3. ... is sub-ordinated to other aims</td>
<td></td>
<td>Me and the team</td>
</tr>
<tr>
<td></td>
<td></td>
<td>My team and other teams</td>
</tr>
</tbody>
</table>

Results on grading

- Getting a good grade is not the driving force for most students in this project.
- “Me in the team” or “My team in front of other teams” is often important.
- How generalizable are these results?
- How can we use this in our teaching?

Two larger phenomenographic examples

1. Grading in the Runestone course
2. What do students strive to learn in the Runestone course?
Example 2
What do students in Runestone strive to learn?

“I guess I learned a lot, but what I learned wasn’t what I expected to learn.”

What does it mean to learn something?
(from phenomenographic theory of learning)

The experience of learning something

What-aspect

Direct object

Act of learning

Motive

Example TCP

Example: Understanding TCP as communication between two computers

Example: Learning by memorizing

Example: Getting a grade

How-aspect

What do students in Runestone strive to learn?

What do students, who participate in an internationally distributed project-based course, strive to learn?

A. Academic achievements

Academic achievement can be experienced as striving for:

1. Getting a grade
   “Some of my other group members here, um, they just want to do their job good enough to pass.”
2. Learning CS for the project
   “Do you together know enough computer science?”
   “If not, we can learn that, I believe”
3. Learning how to learn CS
4. Learning something new
   “I still enjoy it because I’m doing something I never did before.”

The motive:

“What do the students strive for?”

Three different motives are identified:

A. Academic achievement
B. Project and team working capacity
C. Social competence

The motives can in their turn be experienced in different ways.

The motive:

“A student takes his/her course(s) in various ways.”

The grade

University requirements

Educational framework

Content of learning

Dependency vs. responsibility

Dominating aspect

A1
To get a grade
The grade
University requirements

A2
To learn CS for the project
Isolated concepts
University requirements

A3
To learn how to learn CS
Learning to learn
Personal learning

A4
To learn something new
The new
Independent learner

A. Academic achievements

Are some categories better?
B. Project and team working capacity

- Project and team working capacity can be experienced as striving for:
  1. Passing the project
  2. Gaining familiarity with working in projects
  3. Learning how a project functions
  4. Becoming a better professional

C. Social competence

- Social competence can be experienced as striving for:
  1. To learn particular social skills
  2. To learn together
  3. To take responsibility for the team

Why the learners’ perspective?

- An understanding of how students learn about something (CS concepts) is a good tool to improve teaching.
- A change that is not perceived as “good” by the students does not improve learning.
  - Example: Grades are not the driving force for most students in Runestone.

Phenomenography

- Key idea: Exploring the variations in how students experience (understand, perceive) something.
- Value: To study learning from the students’ perspective.
  - Empirically based research approach
  - Outcome: A few categories describing qualitatively different ways, in which something is experienced/understood.

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Socio-cultural theory

- A framework for describing learning and/or development in a situation.
- Focus is on social interaction, the use of language and tools.
- Language and tools contain in themselves a social interaction and a history
- The result is a description in which some issues get clearer.
- The separation between different entities is analytical and serve to build models
Socio-cultural studies

Ontology: No firm stand

Epistemology: The world is socially constructed in an ongoing "game"

Methodology: Often observations

Pedagogy: Putting problems into context makes them easier to solve

Empirical results from socio-cultural studies in CS Education

- The example: Open source community - Linux
- Why do our students hand in "incorrect" programs? (Ben-David Kolikant, 2002)
- Why do teams of students interpret a programming task so differently? (Holland & Reeves, 1996)

Example:
Three software development student teams were followed

- Three teams of students (in the US) followed a project course.
- Task: Write a program for a "client".
- Approx. size: One course module.
- For the three teams: Same setting, similar task, similar students.

The results of the three teams were completely different.
- Team A: Excellent code, not necessarily solving the right problem
- Team B: Fulfilled all formal requirements.
- Team C: Poor result, mainly internal problems.

Why were the results of the three teams different?

- Initial assumption:
  - The university sets the task, the rules and the learning environment.
  - Still something differs.

- Data collection:
  - Observation (to see how the teams collaborated)
  - Interviews

Activity theory as a way to analyze group work

<table>
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<tr>
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<th>Object</th>
<th>Outcome</th>
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<td>A team member</td>
<td>Text editors, compilers, but also specifications etc.</td>
<td>A view on the on-going project</td>
<td>A final project outcome</td>
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Team A: Decided to work for “the code”. This influences other factors

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Team B: Decided to work for “the grade”. This influences other factors

Subject

A team member

Tools

Compliers, etc.
But also grading scales

Object

The grade
A final project outcome

Rules

“Look good”

Community

Pleasing the teachers

Division of labour

Who is doing what?

Why were the results of the three teams different?

- The different teams negotiated between the members to work for a different aim/object.
- Each team selected tools, rules etc in relation to their aim.
- Team C failed this negotiation.

Team C: Did not agree on an object. This influences other factors

Subject

A team member

Tools

?

Object

?

Rules

?

Community

?

Division of labour

?

Who is doing what?

Socio-cultural studies, activity theory, situated learning (Vygotskian tradition)

Key idea:

Thinking/Learning is not only influenced by the environment

Thinking/Learning is an interaction between the individual and the environment

Value: To explore the students’ learning in interaction with the environment (culture, tools, other students etc.)

Qualitative Research Projects in Computing Education Research

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**Empirical results from constructivism in CS Education**

- Students construct rules for parameters. They are only sometimes successful. (Fleury, 1991)
- Students construct their own understanding of variables. (Paz, 1996; and others)
- Software visualization in itself does not help students understanding (Mulholland, 1997)

**Constructivism**

- **Epistemology:** Knowledge is constructed by each individual
- **Ontology:** Reality is rejected or irrelevant
- **Methodology:** No firm position
- **Pedagogy:** Passive learning will fail

**Results from constructivism in computing education research**

- Think twice before using visualizations
- Explicitly teach the model of the computer
- Don’t start with abstractions
- Teach planning, teach to avoid “bricolage”
- Don’t run to the computer
- Organize “closed labs”

(from Ben-Ari, 2001)

**Constructivism**

- **Key idea:**
  
  Students construct their own understanding of what they learn

  **Value:** Defines a pedagogy

  - Extremely influential in school teaching.

**Qualitative research projects in CER**

- A summary
  
  - The perspective of what reality is, what can be studied, what can be known, what the researcher’s role is, how research is performed etc. varies.
  - Qualitative research approaches in CER open new researchable questions.
  - Different research approaches offer various contributions.
  - Qualitative research projects often answers why-questions by offering discussions, perspectives and insights.