Methods and results
Researching students’ learning of computer science

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Outline
- Quantitative and qualitative research (again!)
  - Examples
    1. Quantitative, teaching recursion
    2. Qualitative, what students try to learn
    3. Qualitative and quantitative, grading in a project course
- Methods and results
- Trusting non-positivistic research

Based on lectures in CS Education at undergraduate level.

Quantitative/Qualitative research (methodological distinction)
- Quantitative research is grounded on
  - "... the assumption that features of the [...] 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)

Qualitative research (epistemological perspective)
- Much qualitative research interpretative (or non-positivist)
- Results are interpretations –
  - knowledge is gained through social constructs
  - not predefined independent and dependent variables, but a focus on complexity
  - understand phenomena through the meaning the people assign to them

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

Qualitative and non-positivistic
- Interpretations, researcher is present
- Social environment is constructed
- Studies in naturalistic settings
- Broad understanding

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Quantitative, statistical study
A family tree of ways to perform research

- Ontological level (existence)
  - The world exists objectively
- Epistemological level (knowledge)
  - The world can be measured
- Type of research question
  - This case: Yes/No (to some questions)
- Research approach
  - Quantitative, statistical
- Data collection and analysis methods
  - Tests, statistical correlation


- Research questions:
  1. Are concrete models better than abstract models in helping the students to learn recursion?
  2. Do students with an abstract learning style (as measured by Kolb’s test) outperform students with a concrete style, when learning recursion?
  3. Do students with a concrete learning style learn better when provided with a concrete model?
  4. Do students with an abstract learning style learn better when provided with an abstract model?

- How would you do?
  - Psychological test: “Determines” if students are abstract or concrete thinkers

- Assume that you believe in Kolb’s test

How Wu, Dale and Bethel did:
1. Let 237 students make a Kolb test (Result: 76 concrete learners, 161 abstract learners)
2. Split the students into two groups. Teach one group in a concrete way, the other one in an abstract way.
3. Compare results:
   - after end of lecture (indicating understanding)
   - after two and six weeks (indicating retention)

- They found that
  1. Concrete models are better for understanding
  2. Concrete models are somewhat better for retention
  3. Abstract learners do better than concrete learners
  4. No correlation between concrete/abstract learners and the concrete/abstract teaching

What did this tell us?

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, logically related, categories describing qualitatively different ways, in which something is experienced/understood.
Phenomenography

A family tree of ways to perform research

Ontological level (existence)
Non-dualistic
Epistemological level (knowledge)
We know what we can experience
Type of research question
Why-questions, In what way-questions
Research approach
Phenomenography
Data collection and analysis methods
Interviews, analysis

A larger phenomenographic example

What do students strive to learn in the Runestone course?

Background

The Runestone course
A project course in computer systems

USA
Communication by e-mail and chat

Sweden

• 2 + 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.

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 do students in Runestone strive to learn?

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

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.

A. Academic achievements

<table>
<thead>
<tr>
<th>motives</th>
<th>Dependency vs. responsibility</th>
<th>Dominating aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>To get a grade</td>
<td>University</td>
</tr>
<tr>
<td>A2</td>
<td>To learn CS for the project</td>
<td>University</td>
</tr>
<tr>
<td>A3</td>
<td>To learn how to learn CS</td>
<td>Personal</td>
</tr>
<tr>
<td>A4</td>
<td>To learn something</td>
<td>Independent</td>
</tr>
</tbody>
</table>

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: Responsibility for own learning
  3. To take responsibility for the team: Responsibility for others

Conclusions

- Three different motives are discerned:
  A. Academic achievement
  B. Project and team working capacity
  C. Social competence

- A teacher “knows” which of the motives that are desirable.
- Each motive can be experienced in different ways.
- The advanced ways of experiencing the motive are better than the less advanced.

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Grading in Runestone

- Both process and product are graded
- 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

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)

<table>
<thead>
<tr>
<th></th>
<th>To all students</th>
<th>To Americans</th>
<th>To Swedes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades</td>
<td>83,61</td>
<td>81,55</td>
<td>85,05</td>
</tr>
</tbody>
</table>

Problematic???
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>Swede to Swede</td>
<td>22.25</td>
</tr>
<tr>
<td>Swede to American</td>
<td>18.79</td>
</tr>
<tr>
<td>American to American</td>
<td>20.07</td>
</tr>
<tr>
<td>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.</td>
<td>... has a value on its own</td>
<td>The grade per se</td>
</tr>
<tr>
<td>2.</td>
<td>... is a tool to reach other aims</td>
<td>The benefits of a good grade</td>
</tr>
<tr>
<td>3.</td>
<td>... is sub-ordinated to other aims</td>
<td>Me and the team, 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.


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Methods and results

The examples

- The relationship between research question, the research approach and the outcome of the project is strong and complex.
- 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 opens new researchable questions.
- Qualitative research projects often answers why-questions by offering discussions, perspectives and insights.
- Different research approaches offer various contributions to our understanding of students' learning of CS.
Can we “do the same” for interpretative research?

**Classic criteria for trustworthiness in positivistic research**

- **Are the results valid?**
  - Internal validity – Do the instruments or procedures measure what they are supposed to measure?
  - External validity – Can the results can be generalized beyond the immediate study?
- **Are the results reliable?**
  - Stable, consistent

Are the results valid?

- Internal validity – We are the instruments
- External validity – Can the results can be generalized beyond the immediate study?

Are the results reliable?

- Would Mattias and I get the same results?
- Would I, myself, get the same results a second time?
- No, my new results would be more insightful.

Validity presupposes reliability

It’s a good idea to try!

Can phenomenographic research be trusted?

**Can phenomenographic research be trusted?**

- **Are phenomenographic results valid?**
  - Internal validity – We are the instruments
  - External validity – Can the results can be generalized beyond the immediate study?
- **Are phenomenographic results reliable?**
  - Would Mattias and I get the same results?
  - Would I, myself, get the same results a second time?
  - No, my new results would be more insightful.

- There are "methods" that aims to “implement” reliability and validity
  - Example “multiple judges” (triangulation).
  - Idea: Three researchers are more reliable than one, and become a “better” instrument

General concepts of trustworthiness in non-positivistic research

**General concepts of trustworthiness in non-positivistic research**

- **Credibility** – Do what you can to make your research become credible. (compare to quantitative: measure the right thing, internal validity)
- **Transferability** – The judgement of the “transfer” lies with the “user”, not the producer, of the research (compare to quantitative generalizability, external validity)
- **Dependability** – Take stability, consistency and the phenomenon into account (compare to quantitative reliability)

Trustworthiness of phenomenographic research

**Trustworthiness of phenomenographic research**

- As above, but also ...
  - The results are anchored in the researcher, and in her or his study object.
  - The **structural relationship between the categories** serves as an indication of consistency (but beware, the categories, and hence, their relations, are constructs)
  - The importance of a misinterpretation by the researcher is diminished by the **collective nature** of the results.