Analysis of verbal data

Understanding the processes of collaborative learning
Overview

- Theoretical background of CSCL process analyses
- Steps in analysing CSCL processes based on verbal data
  - Analysing individuals in small groups
  - Transcription
  - Unit of analysis / Segmentation of verbal data
  - Categorisation
  - Determining reliability
  - Automatic analysis of verbal data
- Examples
  - Analysis of cognitive processes based on think-aloud data
  - High level analyses on the base of process analyses
General research paradigm

Triangle of hypotheses:

- Specific (learning) activities are positively related with a desired outcome. (b)
- An instructional support facilitates the specific (learning) activities. (a)
- The intervention fosters the desired outcome mediated by the specific (learning) activities. (c)
Framework on cooperative learning
(O‘Donnell & Dansereau, 1992)

Type of task

Individual Differences

Incentive structure

Scripts

| external | internal |

Small group interactions

Individual acquisition of domain-specific and domain-general knowledge
Individual acquisition of domain-specific and domain-general knowledge

Framework on cooperative learning
(O‘Donnell & Dansereau, 1992)

Scripts
- external
- internal

Type of task

Individual Differences

Incentive structure

Blind spot without process analyses

- $n \rightarrow \infty$

Interactions of conditions of cooperative learning

- Analysis of process-based phenomena (e.g., knowledge as co-construct, internal scripts)

- examination of process-oriented theories

Individual acquisition of domain-specific and domain-general knowledge
Text-based communication

Self-transcription of dialogues
Joint, argumentative knowledge construction: Talking, Thinking, Learning

Example coding scheme: Weinberger & Fischer, 2006
Granularity of segmentation

Fine granularity

- signs
  How many letters do the learners use?
- words
  How many technical terms are being used?
- speech acts
  How do learners coordinate discourse?
- sentences
  How do learners structure their utterances?
- propositions
  Which concept do learners discuss?
  What claims are being made?
- arguments
  How do learners link concepts to construct arguments?
- argumentations
  What standpoints are being defended?

Theoretical relation to learning?

Coarse granularity

The granularity of the segmentation represents different types of knowledge in discourse (Chi, 1997)
Example of Different Degrees of Fine-grainedness for Segmentation

Original messages

**Jim:**
The teacher attributes Michael's failure in an internal variable manner. She argues that Michael is just plain lazy.

**Carolyn:**
I don’t think so! The teacher is just making Michael feel bad.

Segmented messages

**Jim:**

- The teacher attributes Michael’s failure in an internal [manner]
- [She argues that Michael is just plain lazy. ]

- [The teacher attributes Michael’s failure in an] variable manner.
- She argues that Michael is just plain lazy.

**Carolyn:**

- I don’t think so! The teacher is just making Michael feel bad.
Categorisation

- Qualitative steps
  - (Development of) categories is related to state of the art of research
  - Generating hypotheses: Paraphrasing (Mayring), Coarse analyses (Forming clusters)

- Development of a coding scheme
  - Exhaustive: Every segment is being coded
  - Exclusive: Only one category applies per segment per dimension
  - Documentation of rules, e.g., in the form of a decision tree
Decision Tree for Epistemic Activities

Does the segment contain information from problem space?

- yes
  - Does the theoretical concept relate to problem space?
    - yes
      - Subject mentioned
    - no
      - elaboration of problem space

- no
  - elaboration of theory
    - yes
      - Concept mentioned
    - no
      - off-topic

Legend
- Top-down decision nodes: white rectangles
- Bottom-up decision nodes: grey rectangles
- End nodes (categories): triangles

Concepts mentioned (and part of the theory space)
- A: locus
- B: stability
- C: controllability
- D: attributing failure
- E: attributing success
- F: re-attribution training
Example for coding rules in form of a decision tree (Wecker, 2006)

1. Is there any talk in the segment at all (incl. mumbling)? yes: 2, no: 4

2. Is there any talk longer than 1 sec.? yes: 6, no: 3

3. Do the learners ask about the (i) reading progress (e.g., „Are you done?“), (ii) protest against scrolling down (e.g., „Stop!“), (iii) comment about any text (e.g., „Haha: 'chacked'!“; „What means 'focused'?“) or (iv) describe the current activity (e.g., „We are reading.“)?
   1. yes: Coding „Information intake“ for the current segment and all prior segments up to that segment that has been coded as „no activity (silence)“
   2. no: 4
Example for a framework for analysing verbal data in CSCL environments (Weinberger & Fischer, 2006)

- Multiple dimensions:
  - Participation dimension
  - Epistemic dimension
  - Formal-argumentative dimension
  - Dimension of social modi of co-construction (incl. transactivity)
## Multiple Dimensions of Argumentative Knowledge Construction

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participation</strong> <em>(Words and messages; Cohen, 1994)</em></td>
<td>Do learners participate (at all) in Online-Discourse?</td>
</tr>
<tr>
<td>- Quantity</td>
<td></td>
</tr>
<tr>
<td>- Homogenity</td>
<td></td>
</tr>
<tr>
<td><strong>Epistemic Activities</strong> <em>(κ = .90; Fischer, Bruhn, Gräsel, &amp; Mandl, 2002)</em></td>
<td>Do learners argue on task? Do learners construct arguments based on the relevant concepts?</td>
</tr>
<tr>
<td>- construction of problem space</td>
<td></td>
</tr>
<tr>
<td>- construction of conceptual space</td>
<td></td>
</tr>
<tr>
<td>- construction of relations between conceptual and problem space</td>
<td></td>
</tr>
<tr>
<td><strong>Argumentation</strong> <em>(κ = .78; Leitão, 2000)</em></td>
<td>Do learners construct formally complete arguments and argument sequences?</td>
</tr>
<tr>
<td>- construction of single arguments</td>
<td></td>
</tr>
<tr>
<td>- construction of argumentation sequences</td>
<td></td>
</tr>
<tr>
<td><strong>Social Modes of co-construction</strong> <em>(κ = .81; Teasley, 1997)</em></td>
<td>Do learners operate on the reasoning of their learning partners? How do learners build consensus?</td>
</tr>
<tr>
<td>- Externalization</td>
<td></td>
</tr>
<tr>
<td>- Elicitation</td>
<td></td>
</tr>
<tr>
<td>- Quick consensus-building</td>
<td></td>
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<tr>
<td>- Integration-oriented consensus-building</td>
<td></td>
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<tr>
<td>- Conflict-oriented consensus-building</td>
<td></td>
</tr>
</tbody>
</table>
Macro-coding

- Externalisation
- Elicitation
- Quick consensus building
- Integration
- Conflict-oriented consensus building
- Coordination
- Task-related utterances
Testing and documenting reliability

- Objectivity of coding -> interrater reliability
  - Two or more coders code the same segments
  - Similarity between codes is compared
    (-> Cohen‘s Kappa, Krippendorff‘s alpha, ICC)
- Objectivity requires training
Standard training process

- Explanation phase
  - Definition of dimensions and codes

- Modelling phase
  - Joint coding of example data

- Practice
  - Individual coding of example data
    - if objectivity sufficient -> training successful
    - if objectivity not sufficient -> modelling phase + feedback
Training material

- Rule of thumb: 10% of the raw data per testing/practice
- Randomly selected data
  - All experimental conditions have to be represented
  - All codes need to be coded at least several times to test objectivity
### Feedback: Crosstables

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>88</th>
<th>99</th>
<th>Gesamt</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D</strong></td>
<td>1</td>
<td>13</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
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<td>6</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Gesamt</td>
<td>16</td>
<td>18</td>
<td>1</td>
<td>8</td>
<td>10</td>
<td>7</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maß der Übereinstimmung</th>
<th>Wert</th>
<th>Asymptotischer Standardfehler a</th>
<th>Näherungswertes T b</th>
<th>Näherungswert Signifikanz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>.456</td>
<td>.078</td>
<td>7.440</td>
<td>.000</td>
</tr>
<tr>
<td>Anzahl der gültigen Fälle</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Typical consequences of low objectivity

- Refinement of coding scheme, i.e. clarification of rules, additional examples
- Adaption of coding scheme
  - combination of codes
  - additional codes
- Beware of skewed data:
  - High objectivity due to code „other“
## Micro-Coding

<table>
<thead>
<tr>
<th>Lombard et al. - Criteria</th>
<th>1st wave of studies 00/01</th>
<th>2nd wave of studies 02/03</th>
<th>3rd wave of studies 03/04</th>
</tr>
</thead>
<tbody>
<tr>
<td>size of reliability sample</td>
<td>ca. 500 Seg.</td>
<td>199 Seg.</td>
<td>176 Seg.</td>
</tr>
<tr>
<td>relationship of the reliability sample to the full sample</td>
<td>105 participants 2821 segments</td>
<td>289 participants 6296 segments</td>
<td>243 participants 9825 segments</td>
</tr>
<tr>
<td>N of coders</td>
<td>2 students</td>
<td>6 students</td>
<td>5 students</td>
</tr>
<tr>
<td>amount of coding</td>
<td>50% each</td>
<td>ca. 17% each</td>
<td>ca. 17% each</td>
</tr>
<tr>
<td>Reliability indices</td>
<td>Seg.: 87% Epi.: $\kappa = .90$ Arg.: $\kappa = .78$ Soz.: $\kappa = .81$</td>
<td>Seg.: 83% Epi.: $\kappa = .72$ Arg.: $\kappa = .61$ Soz.: $\kappa = .70$</td>
<td>Seg.: 85% Epi.: $\kappa = .89$ Arg.: $\kappa = .91$ Soz.: $\kappa = .87$</td>
</tr>
<tr>
<td>Reliability of each variable</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>amount of training</td>
<td>ca. 500 h in each wave trained with 1000 to 1500 discourse segments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>references</td>
<td>Weinberger, Fischer, &amp; Mandl, 2001; Weinberger &amp; Fischer, 2006</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Automatisation of coding

- Machine learning algorithms learn from already coded data

- Features of written text need to be extracted (e.g. word count, unigrams, bigrams, punctuation)

  - LightSIDE or TagHelper extract features and prepare them for the training of machine learning algorithms
Automatisation: Step 1

- Get the software „LightSIDE“ (it’s free):

http://ankara.lti.cs.cmu.edu/side/download.html
Automatisation: Step 2

- Prepare your data
  - First column: text
  - Second column: code
- Save as csv-file
- Load file csv-file into LightSIDE
Automatisation: Step 3

- Extract features
Automatisation: Step 4

- Train model
Automatisation: Step 5

- Improving models
  - exclude rare features
  - exclude misleading features
  - add semantic rules
Automatisation: final step

- Apply model to new material
  - Must not be different from training material -> change of context, topic, sample may cause problems

- Automatically coded data require careful supervision
# Automatisation: Does it work?

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison without and with the layer of extracting attributes to automate the content analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without extracting attributes</td>
</tr>
<tr>
<td></td>
<td>Cohen’s Kappa</td>
</tr>
<tr>
<td>Segmentation layer II</td>
<td></td>
</tr>
<tr>
<td>Kappa SIDE-Training Material</td>
<td>0.84</td>
</tr>
<tr>
<td>Kappa SIDE-Testing Material</td>
<td>0.86</td>
</tr>
<tr>
<td>Major choice</td>
<td>0.80</td>
</tr>
<tr>
<td>Math</td>
<td>0.86</td>
</tr>
<tr>
<td>Class reunion</td>
<td>0.87</td>
</tr>
<tr>
<td>Between-culture variance</td>
<td>0.90</td>
</tr>
<tr>
<td>Text-analysis</td>
<td>0.83</td>
</tr>
<tr>
<td>Coding layer III</td>
<td></td>
</tr>
<tr>
<td>Kappa SIDE-Training Material</td>
<td>0.70</td>
</tr>
<tr>
<td>Kappa SIDE-Testing Material</td>
<td>0.61</td>
</tr>
<tr>
<td>Major choice</td>
<td>0.63</td>
</tr>
<tr>
<td>Math</td>
<td>0.67</td>
</tr>
<tr>
<td>Class reunion</td>
<td>0.47</td>
</tr>
<tr>
<td>Between-culture variance</td>
<td>0.53</td>
</tr>
<tr>
<td>Text-analysis</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Checklist for argumentation analyses

• Theoretical framework
• Research questions and methods that can address those questions in a valid manner
• Explicit and theory-based set of rules for segmentation and categorization
• Testing and documenting reliability (see Lombard et al., 2002)
• Replication
Testing and documenting reliability: Part 1
(Lombard, Snyder-Duch, & Braaken, 2002)

- the size of and the method used to create the reliability sample, along with a justification of that method;
- the relationship of the reliability sample to the full sample;
- the number of reliability coders and whether or not they include the researchers;
- the amount of coding conducted by each reliability and non-reliability coder;
Testing and documenting reliability: Part 2

(Lombard, Snyder-Duch, & Braaken, 2002)

- the index or indices selected to calculate reliability and a justification of these selections;

- the inter-coder reliability level for each variable, for each index selected;

- the approximate amount of training (in hours) required to reach the reliability levels reported;

- where and how the reader can obtain detailed information regarding the coding instrument,

- procedures and instructions (for example, from the authors).
Conclusions

- CSCL is an ideal context to investigate collaborative and individual knowledge construction processes, which can be reliably assessed with a multi-granular and multi-dimensional framework (Weinberger & Fischer, 2006).

  but

- which requires major training efforts

- which captures most, but maybe not all cognitive processes of knowledge construction
Example 1

- Analyses of cognitive processes of learning through think-aloud protocols in CSCL
Analysis of cognitive processes

- Think-aloud protocols
- 10-Sec segments
- coding ($\kappa = .78$):
  - Elaboration depth
  - Elaboration focus
    - Elaboration of content
    - Elaboration of peer contributions
Good learner, no script
Learner with script, role of analytic

[Bar chart showing the distribution of transactivity of discourse, elaboration of contributions of the learning partner, epistemic quality of discourse, and elaboration of the learning material across different seconds.]
Learner with script, role of critic

Transactivity of discourse
- High
- Medium
- Low

Elaboration of contributions of the learning partner

Epistemic quality of discourse
- High
- Medium
- Low

Elaboration of the learning material

Seconds
Example 2

- CSCL-assumption learners are influencing each other
- Requirement for analysis is independence of observations
- Analyzing individuals, groups, or both with multi-level modeling

Abbildung 1-1: Beziehung zwischen sozialer Herkunft und Schulleistung in der Gesamtgruppe

Abbildung 1-2: Beziehung zwischen sozialer Herkunft und Schulleistung getrennt für beide Gruppen
Example 3

Student A
Pre-test
- Use public transportation
- Save water
- Use biodegradable bottles

Post-test
- Save water
- Recycle more
- Use solar energy

Text
- Save water
- Use biodegradable bottles

Student B
Pre-test
- Use public transportation
- Turn TV off
- Use solar energy

Post-test
- Recycle more
- Use wind energy
- Use public transportation

Text
- Recycle more
- Use wind energy

Collaboration (Knowledge sharing in collaboration)
- Use biodegradable bottles
- Save water
- Plant trees
- Recycle more
- Use solar energy

Text
- Save water
- Plant trees

Shared prior knowledge

Shared knowledge

Learning from fellow learner

Learning from fellow learner

Learning from fellow learner
Example 4

Inference: Adequate (-1)

Adequate inference between problem and theoretical concept (-2)

Writing/Thinking aloud (-1) *
Grounded claim (-1)

Writing/Thinking aloud (-1) *
Grounded claim with qualification (-1)

Writing/Thinking aloud (-1) *
conflict-oriented consensus building (-2)

Learning partner (-2)*
conflict-oriented consensus building (-2)

Learning partner (-2)*
integration-oriented consensus building (-2)

Learning partner (-2)*
grounded claim with qualification (-2)

Learning partner (-2)*

Theory paper (-2)

Task description (-2)

Problem information (-2)

Inadequate inference (-1)
(based on irrelevant prior knowledge)

Writing aloud (0) *
Adequate inference between problem and theoretical concept (0)
Literature


