Students’ Models of the Particulate Nature of Matter: Comparison Between Three Countries

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Motivation

- Particulate Nature of Matter
  - Significance across science
  - Difficult for students due to abstraction
  - Various aspects

- Cultural Comparison
  - Theoretical Framework—Constructivism
    - Knowledge before instruction
    - Knowledge to be taught

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Research Questions

- What are secondary students’ mental models of particulate nature of matter in the US, Germany and China?

- What differences, if any exist across students from U.S., Germany and China in terms of their mental models of the particulate nature of matter?

Methodology

- Survey—Particle Concept Inventory (PCI)*
  - 70 statements
  - Four-point Likert Scale + Certainty

- Participants
  - US (n=157, high school seniors, 17 years old)
  - Germany (n=244, middle school, 15 years old)
  - China (n=144, middle school, 15 years old)

* Silke Melkelskis-Seifert (2002)

Analyze Survey Data Using Concept Map

Goal

- Focus on students’ knowledge structure rather than its scientific correctness.

- Use students’ responses on the survey to construct a concept map representing students’ interconnections between these concepts i.e. their mental model.

Develop Concept Map

Step 1: Identifying the knowledge elements and associations in each statement.

Statement on PCI

“Particles have the same color as the object in which they are located.”

Is interpreted in the ‘concept map’ as:

Particle Color

same

Object Color
Develop Concept Map

- Step 2: Combining various elements and associations
  - Big map
  - Three themes emerged from this map
    - particle existence
    - particle interactions
    - macro-micro property connections
- Step 3: Deciding best fit statement to association

Develop Concept Map

Step 4: Calculating strength of association

"True" OR "More true than false" AND "Certain"

Association established

Percentage of students believed the link was attributed

Strength of the association

Results—The US Students’ Concept Map
Connection Between Particle and Object Properties

<table>
<thead>
<tr>
<th>% students to whom link is attributed</th>
<th>Line Style</th>
<th>Association Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-24%</td>
<td></td>
<td>Very Weak</td>
</tr>
<tr>
<td>25-49%</td>
<td></td>
<td>Weak</td>
</tr>
<tr>
<td>50-74%</td>
<td></td>
<td>Strong</td>
</tr>
<tr>
<td>75-100%</td>
<td></td>
<td>Very Strong</td>
</tr>
</tbody>
</table>

From German Students
Connection Between Particle and Object Properties

From Chinese Students
Connection Between Particle and Object Properties
Summary
Connection Between Particle and Object Properties

- A smaller percentage of German participants made associations between general particle properties and object properties.
- A larger percentage of US participants made associations between object temperature and particle properties.
- A smaller percentage of Chinese participants made all kinds of associations.
- A larger percentage of German participants believed that particles are spherical.

Limitation of Study

- Survey constrained the ways in which we can model student thinking, but allowed us to collect data from a vast population.
- Difficult to control the sample representation (students’ age, grade, school ranking…)
  - Do NOT intend to use our research results to represent each country as a whole.

Thank you!

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