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Social semiotics in university physics education: Leveraging critical constellations of disciplinary representations

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Uppsala Physics Education Research Group
Department of Physics and Astronomy
Undergraduate teaching and learning in physics
Interested in how people become physicists
Theoretical constructs from ten years of research
Overview

What is social semiotics?

Constructs we have introduced
- Fluency in critical constellations
- Discourse imitation

More recent constructs
- Disciplinary affordance
- Pedagogical affordance
- Unpacking
- Patterns of variation
What is social semiotics?

The study of the development and reproduction of specialized systems of meaning making in particular sections of society.

Airey & Linder (in production)
(See also Halliday, 1978; van Leeuwen 2005)

Use as a lens to understand teaching and learning in undergraduate physics.
How is social semiotics different?

Only very small *difference in emphasis*

Interested in graphs, diagrams, equations, etc.

Use the term *semiotic resources* rather than representations

Don’t talk about internal and external representations

Work only with what we can *document* and its *meaning potential*
How is social semiotics different?

Ask slightly different questions
How is social semiotics different?

What meaning can this resource convey and how is that meaning constructed by students?

What does this represent?

Two reasons:

1) Not easy to answer for important physics resources such as *apparatus* and *action*

2) Semiotic resources have by definition a *range* of meaning potentials
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Learning a particular physics concept is dependent on becoming *fluent* in a *critical constellation of semiotic resources.*

(Airey 2009, Airey & Linder 2009)
Critical constellations

Airey & Linder (2009)
Discourse imitation is when students use semiotic resources appropriately \textit{without} the associated disciplinary understanding.

Discourse imitation occurs because students can’t become fluent in everything at once.

Teachers should expect discourse imitation

Airey (2009); Airey & Linder (2009)
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Disciplinary affordance

Introduced the term **disciplinary affordance** for semiotic resources

Fredlund et al. (2012)

**Definition:**

*The potential of a given semiotic resource to provide access to disciplinary knowledge*

Fredlund et al. (2012:658)

Focuses on the **discipline’s** interpretation of the resource rather than the learner’s experience
Disciplinary affordance

The agreed meaning making functions that a semiotic resource fulfils for the disciplinary community.  

Airey (2014)

The disciplinary affordance of a semiotic resource is shaped by its:

*Materiality*

*Rationalization*

*Historical convention*

Airey (2014); Mavers
Disciplinary affordance

Disciplinary learning can be problematised in terms of *coming to appreciate the disciplinary affordances of semiotic resources*

Fredlund *et al* (2012:658)
For our purposes, pedagogical affordance

*Usefulness for learning the discipline*

Airey (2015)
Two related affordances

Pedagogical affordance
*Usefulness for learning the discipline*

Disciplinary affordance
*Usefulness in the discipline*
Two related affordances

Pedagogical affordance
*Usefulness for learning physics*

Disciplinary affordance
*Usefulness in physics*
Life cycle of a massive star
Pedagogical vs disciplinary affordance

Disciplinary affordance

Pedagogical affordance

Airey (2015)
Disciplinary affordance

Appropriate disciplinary learning only possible when there is a *match* between:

- what a given semiotic resource *affords to the student*  
  (Gibson 1988; Norman 1979)

And

- *its disciplinary affordance*  
  (i.e. what it affords for the discipline)
Unpacking disciplinary affordance

RC-circuits  Fredlund et al (2014)

Channel 1:

Channel 2:
Unpacking disciplinary affordance
Unpacking disciplinary affordance
Table I (e) shows the oscilloscope indicating a square signal from the function generator on Channel 2, and a characteristic charging and discharging curve from the capacitor on Channel 1. The students could finally get on with their measurements.

<table>
<thead>
<tr>
<th>Description</th>
<th>Circuit connection</th>
<th>Image on the oscilloscope screen</th>
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</thead>
<tbody>
<tr>
<td>(a) The students’ first connection</td>
<td><img src="OC1" alt="Circuit Image" /> <img src="OC2" alt="FG" /> <img src="Rj" alt="R" /> <img src="C" alt="C" /> <img src="OC1" alt="OC1" /></td>
<td><img src="OC1" alt="Oscilloscope Image" /></td>
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<td>(b) The students’ simplified connection</td>
<td><img src="OC1" alt="Circuit Image" /> <img src="OC2" alt="FG" /> <img src="Rj" alt="R" /> <img src="C" alt="C" /> <img src="OC1" alt="OC1" /></td>
<td><img src="OC1" alt="Oscilloscope Image" /></td>
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<tr>
<td>(c) The circuit after the TA’s first intervention</td>
<td><img src="OC1" alt="Circuit Image" /> <img src="OC2" alt="FG" /> <img src="Rj" alt="R" /> <img src="C" alt="C" /> <img src="OC1" alt="OC1" /></td>
<td><img src="OC1" alt="Oscilloscope Image" /></td>
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<td>(d) The same circuit after having increased the frequency</td>
<td><img src="OC1" alt="Circuit Image" /> <img src="OC2" alt="FG" /> <img src="Rj" alt="R" /> <img src="C" alt="C" /> <img src="OC1" alt="OC1" /></td>
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<td>(e) The circuit after the TA’s second intervention</td>
<td><img src="OC1" alt="Circuit Image" /> <img src="OC2" alt="FG" /> <img src="Rj" alt="R" /> <img src="C" alt="C" /> <img src="OC1" alt="OC1" /></td>
<td><img src="OC1" alt="Oscilloscope Image" /></td>
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Unpacking

Unpacking a semiotic resource *increases* its *pedagogical affordance* but *decreases* its *disciplinary affordance*

Airey (2015)
Pedagogical vs disciplinary affordance

Disciplinary affordance

Pedagogical affordance

Airey (2015)
Patterns of variation

Explained earlier that semiotic resources have *multiple affordances*

Use *variation theory* to draw the appropriate disciplinary affordance to students attention  
(Marton and Booth, 1997; Lo, 2012; Marton, 2015)

We notice aspects that vary...
Hold all aspects constant except for the aspect of you want students to notice

See Fredlund, Airey & Linder (2015a)
Patterns of variation

Physics concepts have multiple aspects

For a given task, only a smaller set of these aspects are needed

These are the *disciplinary relevant aspects* for the task
Disciplinary Affordance | Available Semiotic Resources | Disciplinary Relevant Aspects | Physics concept
---|---|---|---
T | A | S | K
<table>
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<tr>
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<th>Disciplinary Relevant Aspects</th>
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Disciplinary Affordance

Available Semiotic Resources

- Graph
- Equation
- Diagram

Disciplinary Relevant Aspects

Physics concept

T  A  S  K
Physics concept

Disciplinary Affordance

Available Semiotic Resources

Disciplinary Relevant Aspects

Graph

Equation

Diagram

Vary

Physics concept

Airey (2015)
Patterns of variation

Identify disciplinary-relevant aspects
Select appropriate semiotic resources
Create systematic pattern of variation

Patterns of variation

Clearly better if required disciplinary affordance is in available in one single semiotic resource
e.g.
A qualitative description of refraction requires 3 disciplinary relevant aspects: medium, speed, direction

All three are present in a wavefront diagram

Fredlund et al (2015a)
Wavefronts

Fredlund et al (2015a)
Air+ Glass+

Air–Glass boundary

Air    Glass

Fredlund et al (2015a)
Fredlund et al (2015a)
Shown how this could be applied in Electrostatics

Fredlund (2015); Fredlund et al (2015b)
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Thanks for listening!
References


Airey, J. & Linder, C. (in production) Social Semiotics in Physics Education : Multiple Representations in Physics Education Springer


