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Learning and Sharing Disciplinary Knowledge

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Undergraduate teaching and learning in physics
Theoretical constructs from 15 years of research
The role of representations

• We work in very different environments

• However the questions are the same:

• What roles do representations play?

• What kinds of representations should we be using in our teaching?

• And how should they be used?
My interest

- Interested in the relationship between disciplinary knowledge in physics and its representation.
Discipline-based Education Research

“investigates learning and teaching in a discipline using a range of methods with deep grounding in the discipline’s priorities, worldview, knowledge and practices”.

Long-term goal: “to understand the nature of expertise in a discipline”.

US National Research Council (2012, p 9)
Disciplinary literacy?

We can partly talk our way through a scientific event or problem in purely verbal conceptual terms, and then we can partly make sense of what is happening by combining our discourse with the drawing and interpretation of visual diagrams and graphs and other representations, and we can integrate both of these with mathematical formulas and algebraic derivations as well as quantitative calculations, and finally we can integrate all of these with actual experimental procedures and operations. In terms of which, on site and in the doing of the experiment, we can make sense directly through action and observation, later interpreted and represented in words, images, and formulas.

Lemke (1998:7)
Today’s theme

• Two approaches to learning:
  • Students need to construct their own understanding with representations
    Learning physics
  • Students need to learn to represent physics knowledge as the discipline does
    Learning to ‘do’ physics
What is our goal?

• In undergraduate physics we are taking both of these approaches at once

• Easy to think that they are the same

• Not very efficient to learn physics by doing physics
Three concepts

• Critical constellations

• Disciplinary affordance

• Pedagogical affordance
Critical constellations

• Knowledge is constructed multimodally.

• We have argued that this is dependent on critical constellations of representations.
Critical constellations

A Physics Concept

Airey & Linder (2009)
There is a particular set of representations coordinated in a particular way that allows access to disciplinary knowledge.

(Airey & Linder 2009; Airey 2009)

Once you have accessed knowledge you no longer need this full set of representations.

Experts often share knowledge through a single representation
Disciplinary affordance

Fredlund et al. (2012) suggest the term **disciplinary affordance** for representations.

**Definition:**

The **agreed meaning making functions** that a representation fulfils for a particular disciplinary community.

Airey (2015)
Disciplinary affordance

Fredlund et al (2014)
Fredlund et al (2014)
Unpacking disciplinary affordance

Fredlund et al (2014)
Unpacking disciplinary affordance

The disciplinary affordance has been unpacked

The representation has been given more pedagogical affordance
Pedagogical affordance

Definition:
*The aptness of a representation for teaching some particular educational content*

Airey (2015); Airey & Linder (2017)
Unpacking disciplinary affordance

Unpacking a representation *increases* its *pedagogical affordance* but *decreases* its *disciplinary affordance*

Airey (2015)
2: Coordinate systems

In books coordinates appear fixed

One major disciplinary affordance of coordinate systems is that they are not fixed.
3: Noticing disciplinary affordance

Helping students to notice disciplinary affordances through variation theory

One other mistake that experts make is that they expect students to know where to look…
See Fredlund, Airey & Linder (2015a)

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Variation for noticing disciplinary affordance

1. Choose an appropriate representation

2. Get rid of unnecessary information

3. Hold all aspects constant except for the aspect you want students to notice

Summary

1. Unpacking
2. Variation for noticing

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Suggested that lecturers should build their teaching around these aspects.

Structured approach presenting the disciplinary affordances of the parts of the critical constellation through variation and unpacking.
The Problem

Suggested that lecturers should build their teaching around these aspects.

Structured approach presenting the disciplinary affordances of the parts of the critical constellation through variation and unpacking.

But…
The Problem

Students to need build their own understanding.

In our terms, they only want the pieces of the critical constellation as they are ready for them.
For discussion

How can we help students with the **dual task** of understanding through their own use of representations, whilst also introducing them to paradigmatic, disciplinary representation?

The two are often mutually exclusive.

The first is contributing to a critical constellation whilst the second is assuming this is already in place.
Comments and ideas?
References


