Teaching and Learning with Disciplinary Resources

John Airey

Department of Physics and Astronomy
Uppsala University

Department of Mathematics and Science Education
Stockholm University
• 120 employees
• Most work with teacher training
• Full spectrum pre-school to university-level
• Unique in Sweden
• Science faculty
• Develop education for the science faculty
• University teacher courses
• Workshops
• Consultations
• SAMTAL@SU
Uppsala Physics Education Research Group
Department of Physics and Astronomy
Undergraduate teaching and learning in physics
Unique in Sweden (Europe?)
In the US there are 86 physics education research centers that are part of a physics department.
Physics Education
Research
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)
My interest

Interested in the relationship between physics knowledge and disciplinary-specific resources.
Disciplinary resources in science

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)
My interest

Interested in the relationship between physics knowledge and disciplinary-specific resources.
Research

VR grants: 2 current
PhD students: 3 current

Urban Eriksson

Disciplinary discernment
Extrapolating 3-D from 2-D representations
Astronomical distance
Astronomical time

John Airey 7th Feb. 2020 Department of Astronomy
How resources develop
Newton 1672
How resources develop

Rationalization has occurred over many years.

”Meaning” may have changed several times.

Lecturers do not see that things have been left out.

What has been ”left out” might be what students need to make sense of the diagram.

John Airey 7th Feb. 2020 Department of Astronomy
Barriers to learning with disciplinary resources

- Omission
  Experts leave things out

- Overloading
  Experts give too much information

- History
  Disciplinary resources are idiosyncratic

- Expectations
  Students’ everyday heuristics
What about Astronomy?
The HR diagram

Mentioned to an astronomer that it was counterintuitive.

What!
But it’s perfect!
You can’t say that!
I use it every day!

John Airey 7th Feb. 2020 Department of Astronomy
Y-axis: ”Brightness”

Original magnitude scale
Hipparchos circa 134 BC
Brightest stars = 1
Weakest stars = 6
Y-axis: "Brightness"

1856 Pogson

Magnitude 1 is 100 times brighter than magnitude 6

Slight adjustment

Could deal with telescope observations
Y-axis: ”Brightness”

Stars at different distances

Bessel 1838 measure interstellar distance

Absolute magnitude

Kapteyn 1902  10 parsec

Kept the old system of brightness
Y-axis: ”Brightness”

Counterintuitive scale

Brighter stars have a lower numbers

Minus 10 to plus 20

Zero has no special meaning
x-axis: "surface temperature"

Herschel 1798 prism to separate spectra

Sechi 1868 400 stars four classes

Draper 16 classes A, B, C

Pickering, Maury, Fleming, Cannon

Harvard O,B,A,F,G,K,M

Relationship to surface temperature
Strange labels
No temperature shown (no label at all!)
Temperature increases towards the origin

x-axis: ”surface temperature”
Life and death

Temperature scale

Student expectations:

Increases to the right
Red is hot
Dead is colder than alive

John Airey 7th Feb. 2020 Department of Astronomy
Disciplinary discernment

We expect students to know what to see…

Takes time to develop disciplinary discernment

(Eriksson et al 2014)
Disciplinary discernment

Too much information

Students don’t know where to look!
Disciplinary discernment

Imagine you are out with your two-year old son.

You see a worm on the ground.

He doesn’t know what a worm is.

How do you get him to notice?
Hold all aspects constant except for the aspect of you want students to notice

See Fredlund, Airey & Linder (2015a)
This is the essence of variation theory
(Marton & Booth 1997)

We notice what changes.

John Airey 7th Feb. 2020 Department of Astronomy
What students need to know

1. The variables represented by the axes.

2. The major relationships that can be seen when the variables are plotted against one another.

3. The disciplinary meaning that has been assigned to these relationships.
Barriers to learning with disciplinary resources

• Omission
   Experts leave things out

• Overloading
   Experts give too much information

• History
   Disciplinary resources are idiosyncratic

• Expectations
   Students’ everyday heuristics
Questions and Comments
References


References (continued)


Middendorf, J., & Pace, D. (2004). Decoding the disciplines: A model for helping students learn disciplinary ways of thinking. New Directions for Teaching and Learning, 98(Summer 2004), 1–12. DOI: https://doi.org/10.1002/tl.142


Russell, H. N. (1914). Relations Between the Spectra and other Characteristics of the Stars. II. Brightness and Spectral Class. Nature, 93, 252–258. DOI: https://doi.org/10.1038/093252a0


