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Using variation and unpacking to help students decode disciplinary-specific semiotic resources

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Undergraduate teaching and learning in physics

Interested in how people become physicists

Theoretical multimodal constructs over 15 years

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Project funded by the Swedish research council

Interactive science education at the university level: Combining variation theory with social semiotics.

Project nr VR 2016-04113

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Overview

Social semiotics

Critical constellations

Disciplinary affordance

Learning as appreciating disciplinary affordance

Pedagogical affordance

Using variation and unpacking

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Social semiotics

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

Airey & Linder (2017:95)

(See also Halliday, 1978; van Leeuwen 2005)

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Social semiotics

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

Airey & Linder (2017:95)

(See also Halliday, 1978; van Leeuwen 2005)

Use social semiotics to analyse teaching and learning in university physics.

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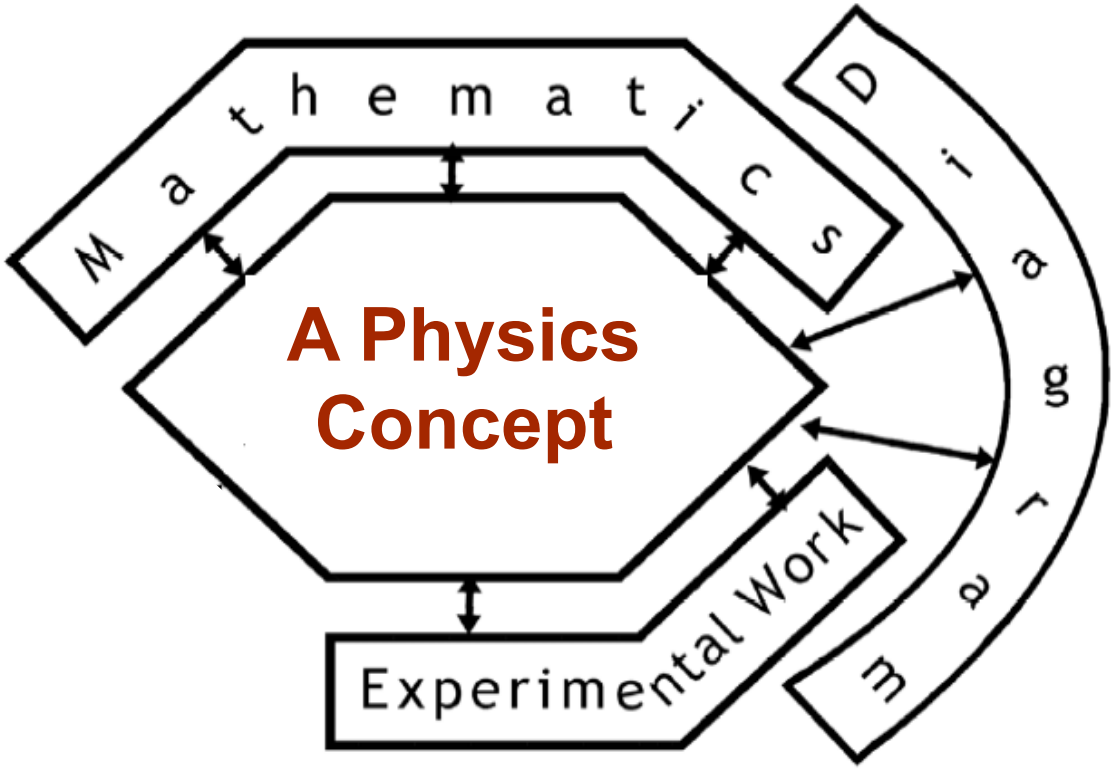
Critical constellations



Airey & Linder (2009)

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Metafunctions

Ideational

Textual

Interpersonal

Doran (2015)

Mathematics has no interpersonal metafunction

”borrows” this from language

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Disciplinary affordance

Physics forms a perfect playground for semioticians since disciplinary meaning is largely agreed and relatively fixed.

The semiotic resources used in physics often have specific disciplinary affordances.

Fredlund *et al.* (2012)

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Disciplinary affordance

Definition:

The agreed meaning making functions that a semiotic resource fulfils for a particular disciplinary community. **Airey (2015)**

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Disciplinary affordance

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

Materiality

Rationalization (carried out by the social group)

Historical anomalies

Airey (2014); cf Mavers *Glossary of Multimodal Terms*

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Learning and Disciplinary affordance

If each disciplinary-specific semiotic resource has a particular disciplinary affordance

Then

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

Fredlund *et al* (2012:658)

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Teaching with disciplinary affordance

Two problems:

1. **Experts leave things out**

   They know what to add

2. **Experts include irrelevant information**

   They know where to look

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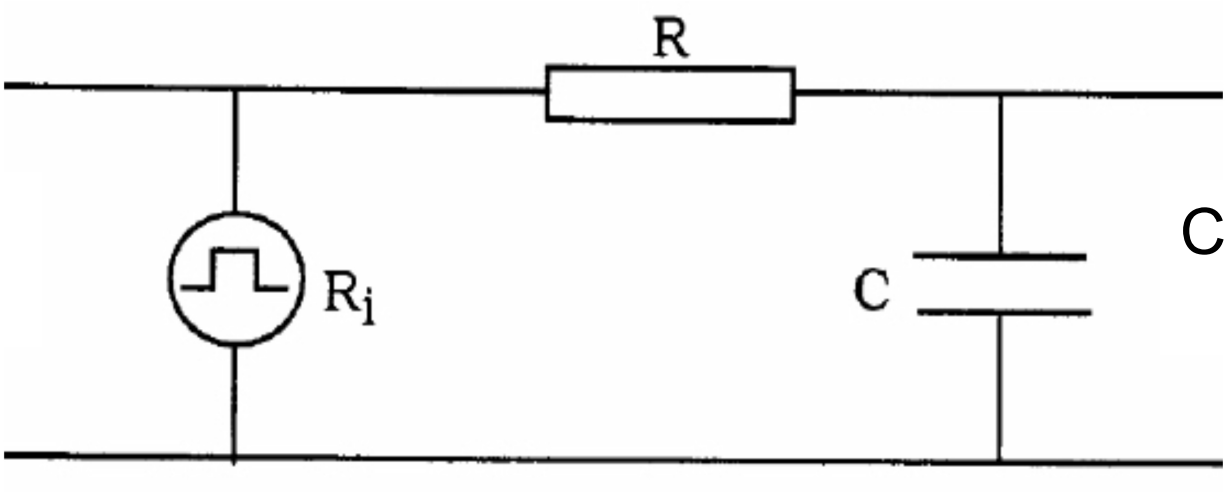
Leaving things out

Channel 2



Channel 1

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Disciplinary affordance

Six different ways to connect the circuit

Only one is correct

Deal with this problem by unpacking

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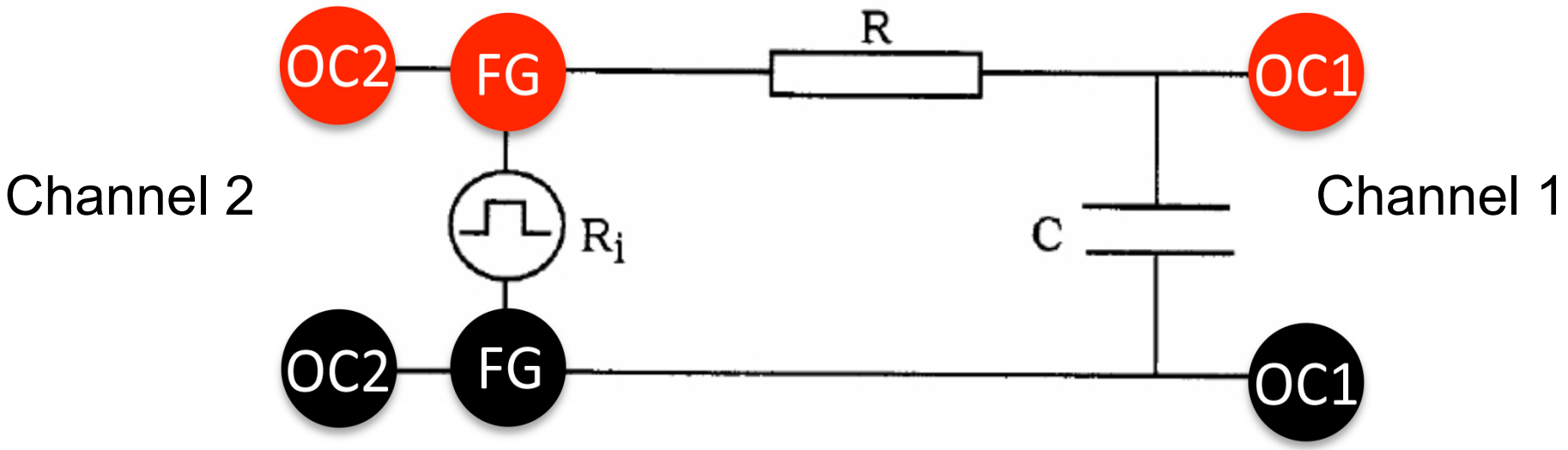
Unpacking disciplinary affordance



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Unpacking disciplinary affordance

The disciplinary affordance has been unpacked

The resource has been given more pedagogical affordance

But this means it has less disciplinary affordance

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Pedagogical affordance

Definition:

The aptness of a semiotic resource for teaching some particular educational content

Airey (2015); Airey & Linder (2017)

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Unpacking disciplinary affordance

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

Airey (2015)

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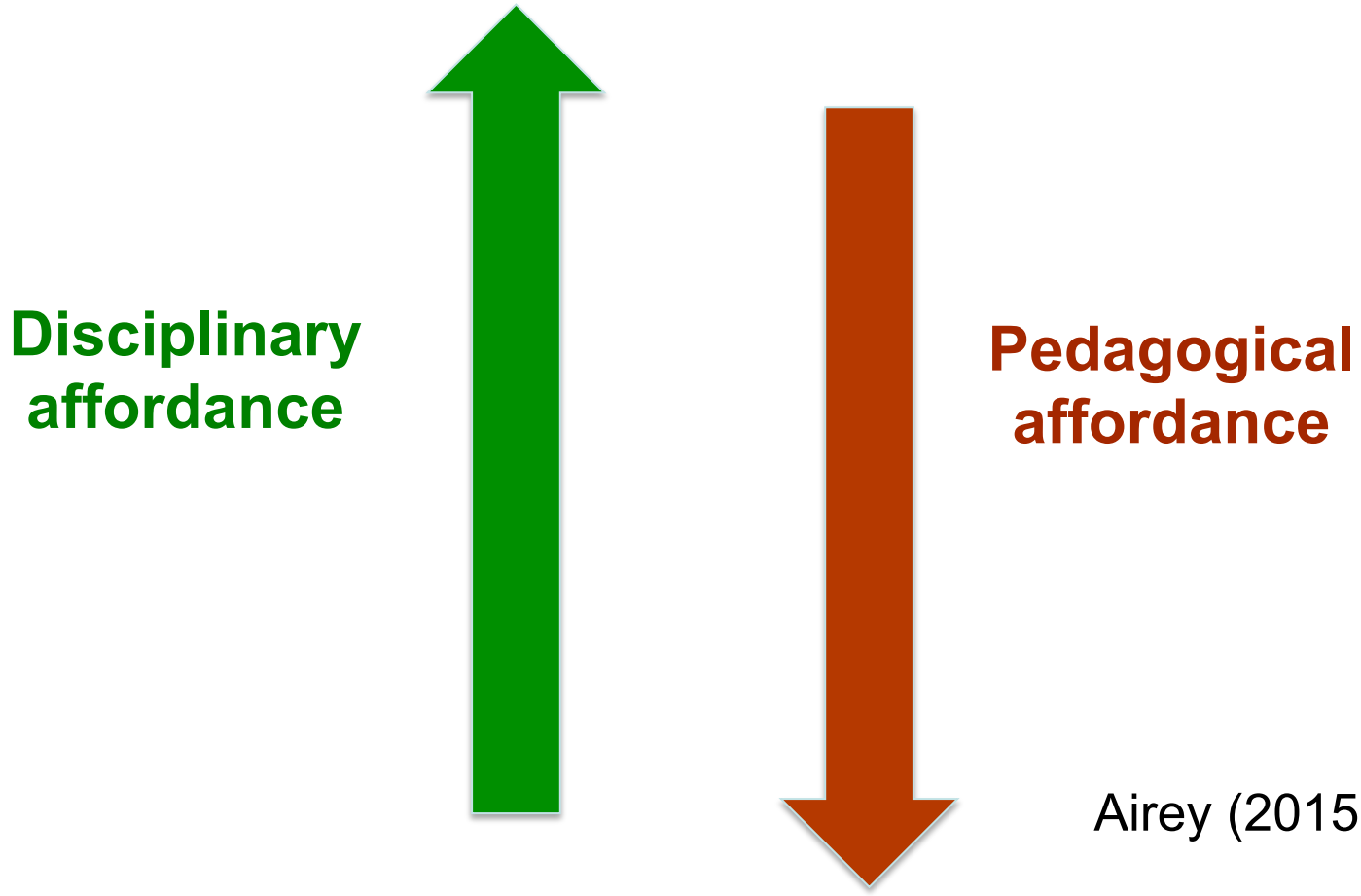
Pedagogical vs disciplinary affordance



Airey (2015)

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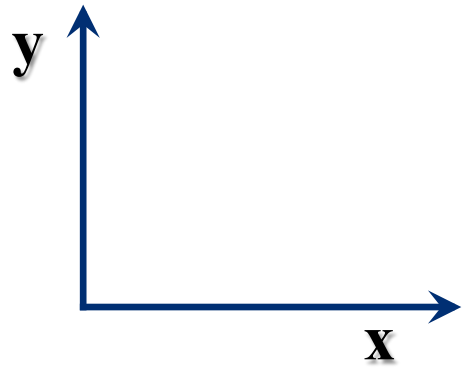
Coordinate systems

In books coordinates appear fixed



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

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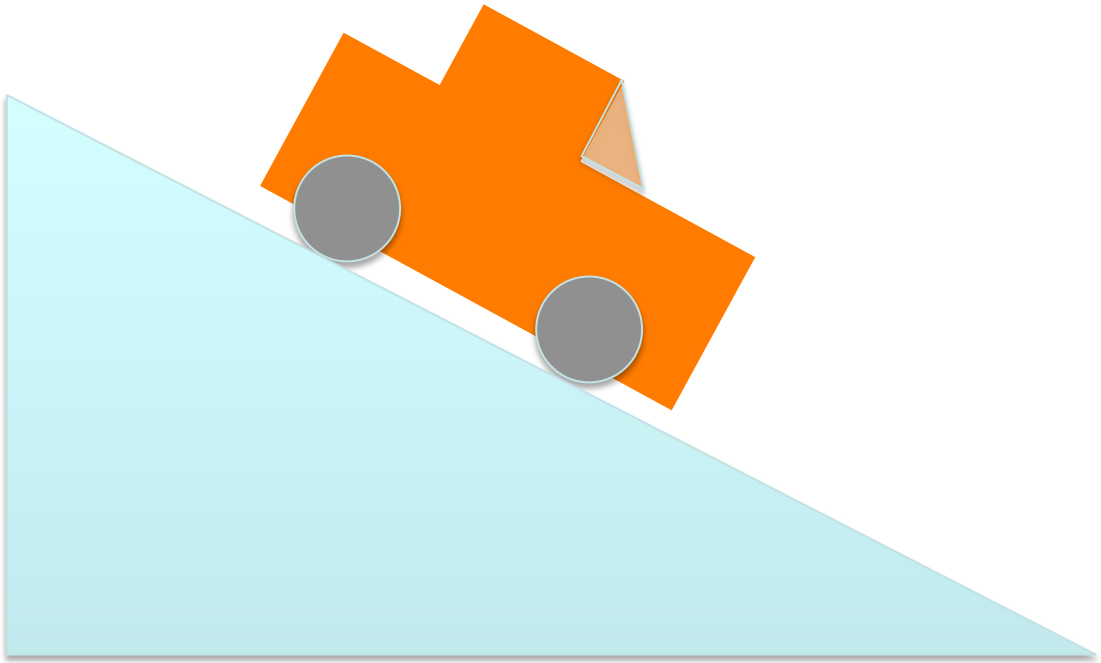
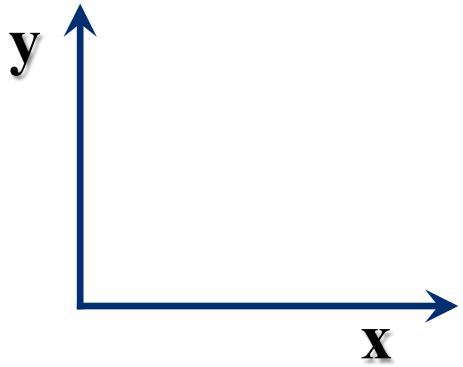
Coordinate systems





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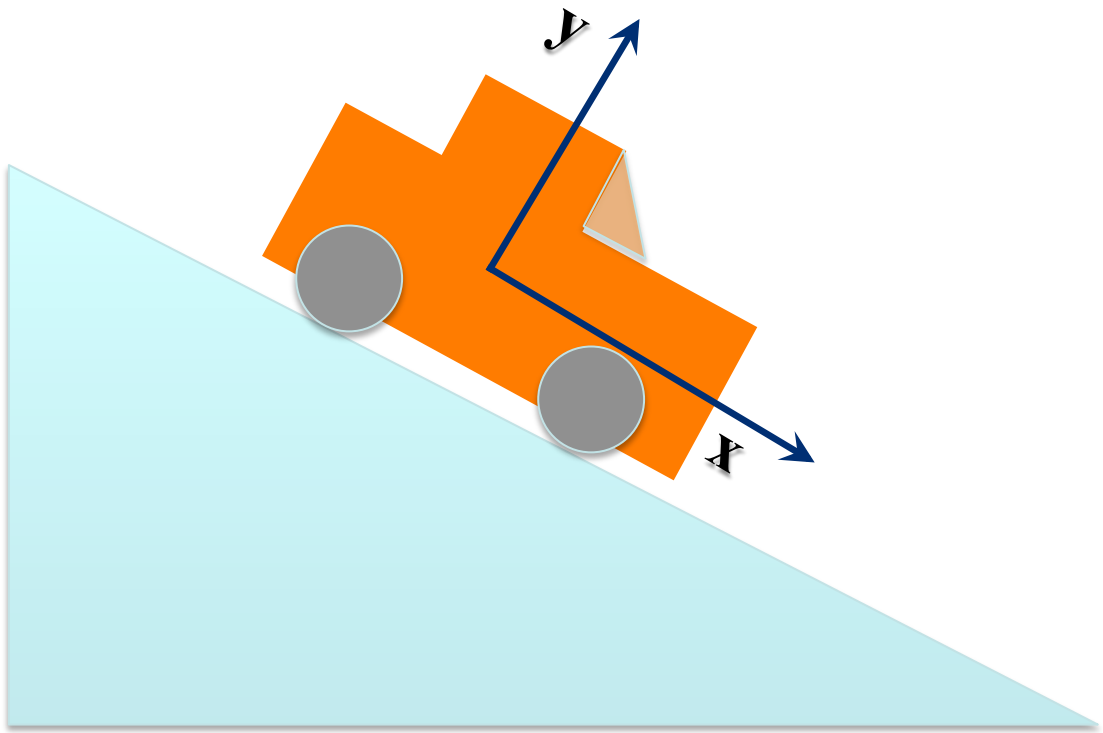
Coordinate systems



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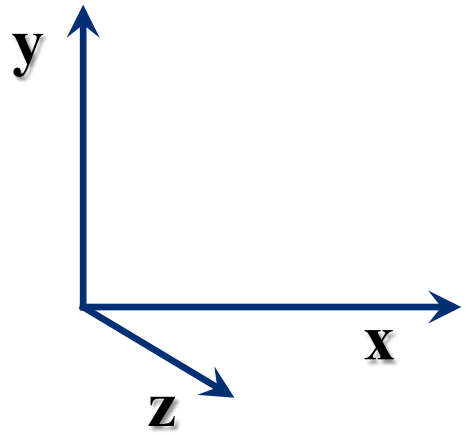
Coordinate systems



Coordinate systems have

high disciplinary affordance

But how can you teach this?

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Teaching with pedagogical affordance

Main problem:

Can’t usually do physics as easily (or at all)

Low disciplinary affordance

Usually need to change to another semiotic resource

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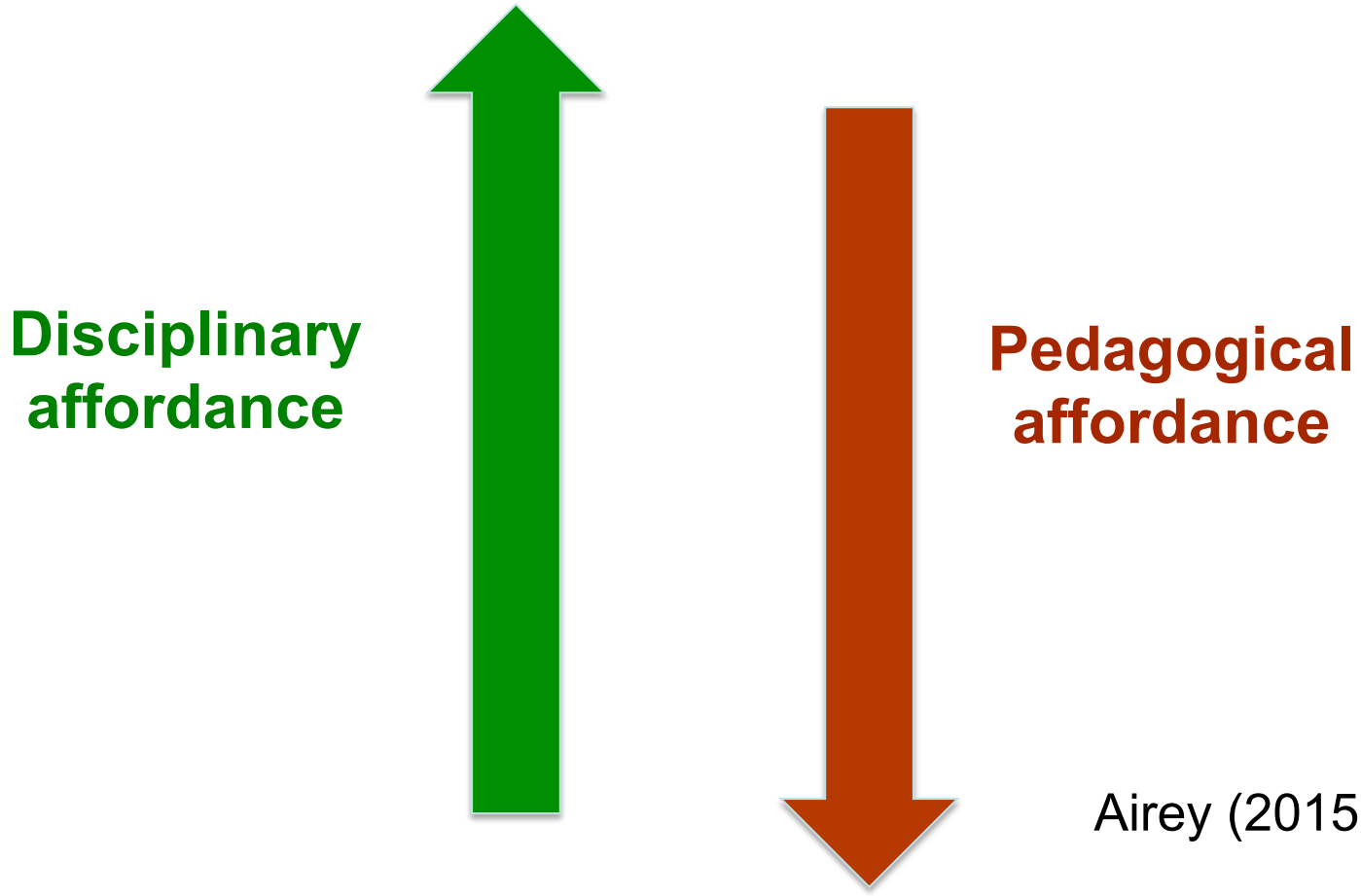
Pedagogical vs disciplinary affordance



Airey (2015)

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Teaching with disciplinary resources

Two problems:

1. **Experts leave things out**

   They know what to add

2. **Experts include irrelevant information**

   They know where to look

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This is the essence of variation theory

(Marton & Booth 1997)

We notice what changes against an unchanging background

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See Fredlund, Airey & Linder (2015a)

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Variation for noticing disciplinary affordance

1. Choose an appropriate semiotic resource

2. Get rid of unnecessary information

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

Fredlund (2015), Fredlund, *et al* (2015 a; 2015b; 2015c)

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Summary

Disciplinary Affordance

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

Pedagogical Affordance

The aptness of a semiotic resource for teaching some particular educational content.

These two are often in functional opposition

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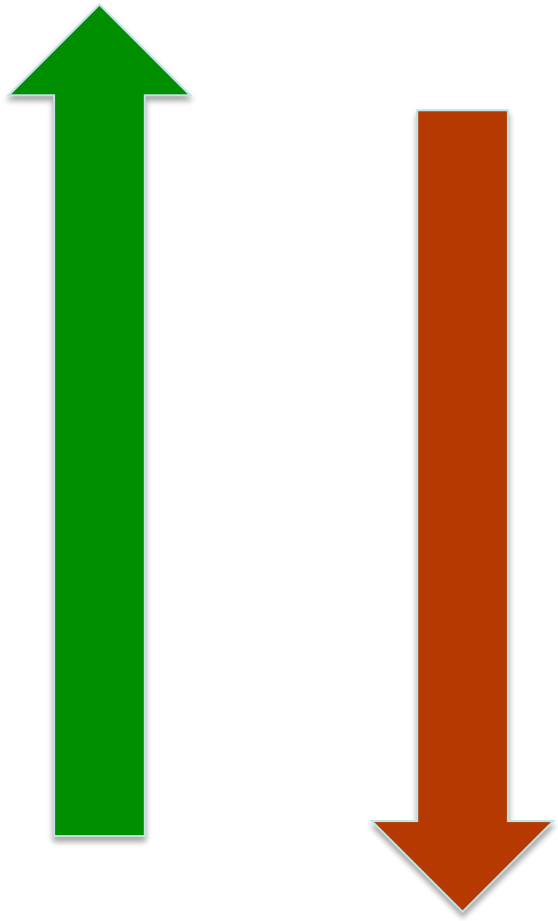
Summary

Disciplinary affordance



Pedagogical affordance

Airey (2015)

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Summary

When teaching with disciplinary resources experts tend to leave things out.

It is possible to solve the first problem by unpacking

Unpacking increases the pedagogical affordance but decreases the disciplinary affordance

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Summary

When teaching with disciplinary resources experts tend to include too much information.

It is possible to solve the second problem by using systematic variation to draw attention to the aspects you are interested in.

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Variation for noticing disciplinary affordance

1. Choose an appropriate semiotic resource

2. Get rid of unnecessary information

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

Fredlund (2015), Fredlund, *et al* (2015 a; 2015b; 2015c)

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Questions and Comments

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References

Airey, J. (2006). *Physics Students' Experiences of the Disciplinary Discourse Encountered in Lectures in English and Swedish*. Licentiate Thesis. Uppsala, Sweden: Department of Physics, Uppsala University.,

Airey J. (2009). Science, Language and Literacy. Case Studies of Learning in Swedish University Physics. Acta Universitatis Upsaliensis. Uppsala Dissertations from the Faculty of Science and Technology 81. Uppsala Retrieved 2009-04-27, from http://publications.uu.se/theses/abstract.xsql?dbid=9547

Airey, J. (2014) representations in Undergraduate Physics. Docent lecture, Ångström Laboratory, 9th June 2014 From http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-226598

Airey, J. (2015). Social Semiotics in Higher Education: Examples from teaching and learning in undergraduate physics In: SACF Singapore-Sweden Excellence Seminars, Swedish Foundation for International Cooperation in Research in Higher Education (STINT) , 2015 (pp. 103). urn:nbn:se:uu:diva-266049.

Airey, J. & Linder, C. (2015) Social Semiotics in Physics Education: Leveraging critical constellations of disciplinary representations ESERA 2015 From http://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Auu%3Adiva-260209

Airey, J., & Linder, C. (2009). "A disciplinary discourse perspective on university science learning: Achieving fluency in a critical constellation of modes." *Journal of Research in Science Teaching*, 46(1), 27-49.

Airey, J. & Linder, C. (2017) Social Semiotics in Physics Education : *Multiple Representations in Physics Education* Springer

Airey, J., & Eriksson, U. (2014). *A semiotic analysis of the disciplinary affordances of the Hertzsprung-Russell diagram in astronomy*. Paper presented at the The 5th International 360 conference: Encompassing the multimodality of knowledge, Aarhus, Denmark.

Airey, J., Eriksson, U., Fredlund, T., and Linder, C. (2014). "The concept of disciplinary affordance" *The 5th International 360 conference: Encompassing the multimodality of knowledge*. City: Aarhus University: Aarhus, Denmark, pp. 20.

Eriksson, U. (2015) *Reading the Sky: From Starspots to Spotting Stars* Uppsala: Acta Universitatis Upsaliensis.

Eriksson, U., Linder, C., Airey, J., & Redfors, A. (2014). Who needs 3D when the Universe is flat? *Science Education, 98*(3), 412-442.

Eriksson, U., Linder, C., Airey, J., & Redfors, A. (2014). Introducing the anatomy of disciplinary discernment: an example from astronomy. *European Journal of Science and Mathematics Education, 2*(3), 167-182.

Fredlund 2015 Using a Social Semiotic Perspective to Inform the Teaching and Learning of Physics. Acta Universitatis Upsaliensis.

Fredlund, T., Airey, J., & Linder, C. (2012). Exploring the role of physics representations: an illustrative example from students sharing knowledge about refraction. *European Journal of Physics, 33*, 657-666.

Fredlund, T, Airey, J, & Linder, C. (2015a). Enhancing the possibilities for learning: Variation of disciplinary-relevant aspects in physics representations. *European Journal of Physics*.

Fredlund, T. & Linder, C., & Airey, J. (2015b). Towards addressing transient learning challenges in undergraduate physics: an example from electrostatics. *European Journal of Physics.* **36** 055002.

Fredlund, T. & Linder, C., & Airey, J. (2015c). A social semiotic approach to identifying critical aspects. *International Journal for Lesson and Learning Studies* 2015 4:3 , 302-316

Fredlund, T., Linder, C., Airey, J., & Linder, A. (2014). Unpacking physics representations: Towards an appreciation of disciplinary affordance. *Phys. Rev. ST Phys. Educ. Res., 10*(020128).

Gibson, J. J. (1979). The theory of affordances *The Ecological Approach to Visual Perception* (pp. 127-143). Boston: Houghton Miffin.

Halliday, M. A. K. (1978). *Language as a social semiotic*. London: Arnold.

Linder, C. (2013). Disciplinary discourse, representation, and appresentation in the teaching and learning of science. *European Journal of Science and Mathematics Education, 1*(2), 43-49.

Marton, F., & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum Associates.

Norman, D. A. (1988). *The psychology of everyday things*. New York: Basic Books.

Mavers, D. Glossary of multimodal terms Retrieved 6 May, 2014, from http://multimodalityglossary.wordpress.com/affordance/

van Leeuwen, T. (2005). *Introducing social semiotics*. London: Routledge.

Volkwyn, T., Airey, J., Gregorčič, B., & Heijkenskjöld, F. (in press). Learning Science through Transduction: Multimodal disciplinary meaning-making in the physics laboratory. *Designs for Learning*.

Volkwyn, T., Airey, J., Gregorčič, B., & Heijkenskjöld, F. (2016). Multimodal transduction in secondary school physics *8th International Conference on Multimodality, 7th-9th December 2016. Cape Town, South Africa*. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-316982.

Wu, H-K, & Puntambekar, S. (2012). Pedagogical Affordances of Multiple External Representations in Scientific Processes. *Journal of Science Education and Technology, 21*(6), 754-767.