UPPSALA
UNIVERSITET

Social semiotics in university physics education:

Leveraging critical constellations of disciplinary representations

John Airey[1,2] and Cedric Linder[1]

Department of Physics and Astronomy
Uppsala University, Sweden

School of Languages and Literature
Linnæus University, Sweden

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

UPPSALA UNIVERSITET

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

UPPSALA UNIVERSITET

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.

UPPSALA UNIVERSITET

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*

UPPSALA UNIVERSITET

How is social semiotics different?

Ask slightly different questions

UPPSALA UNIVERSITET

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

UPPSALA UNIVERSITET

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

UPPSALA UNIVERSITET

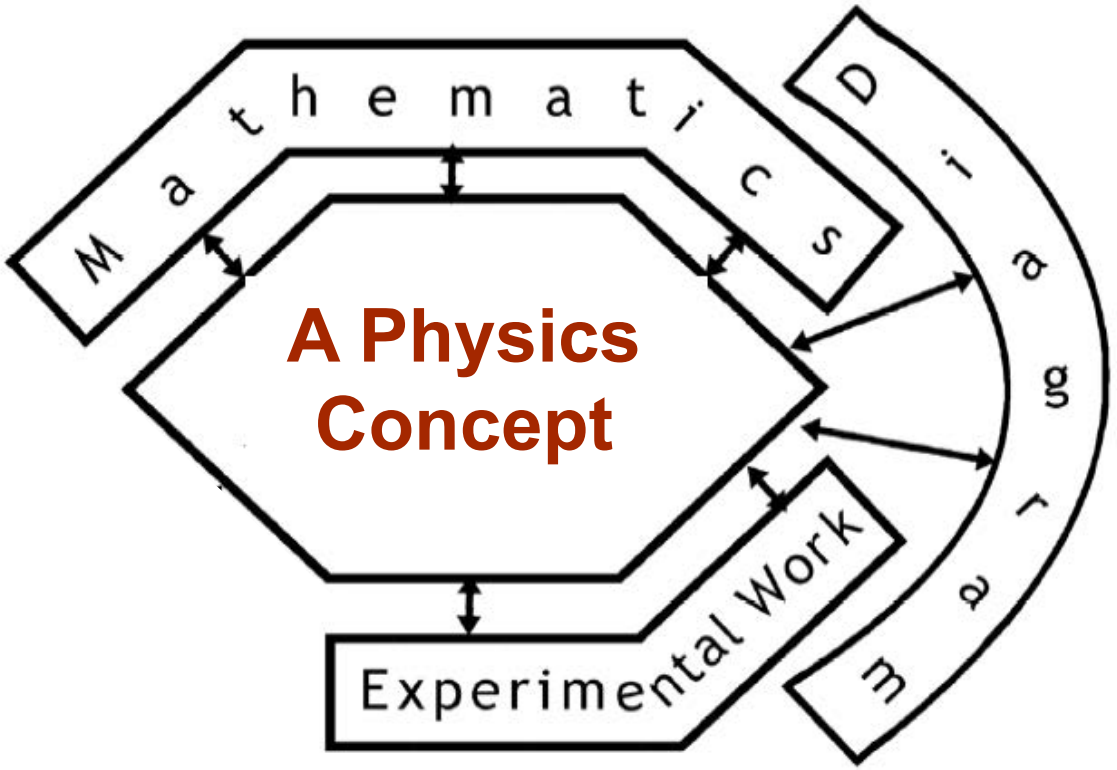
Theoretical constructs

Learning a particular physics concept is dependent on becoming *fluent* in a *critical constellation of semiotic resources.*

(Airey 2009, Airey & Linder 2009)

UPPSALA
UNIVERSITET

Critical constellations



Airey & Linder (2009)

UPPSALA UNIVERSITET

Theoretical constructs

Discourse imitation **is when students use semiotic resources appropriately 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)

UPPSALA UNIVERSITET

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**

UPPSALA UNIVERSITET

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

UPPSALA UNIVERSITET

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

UPPSALA UNIVERSITET

Disciplinary affordance

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

Fredlund *et al* (2012:658)

UPPSALA UNIVERSITET

Pedagogical affordance

Pedagogical affordance Wu & Puntembekar (2012)

However offer no definition…

For our purposes, pedagogical affordance

Usefulness for learning the discipline

Airey (2015)

UPPSALA UNIVERSITET

Two related affordances

Pedagogical affordance

Usefulness for learning the discipline

Disciplinary affordance

Usefulness in the discipline

UPPSALA UNIVERSITET

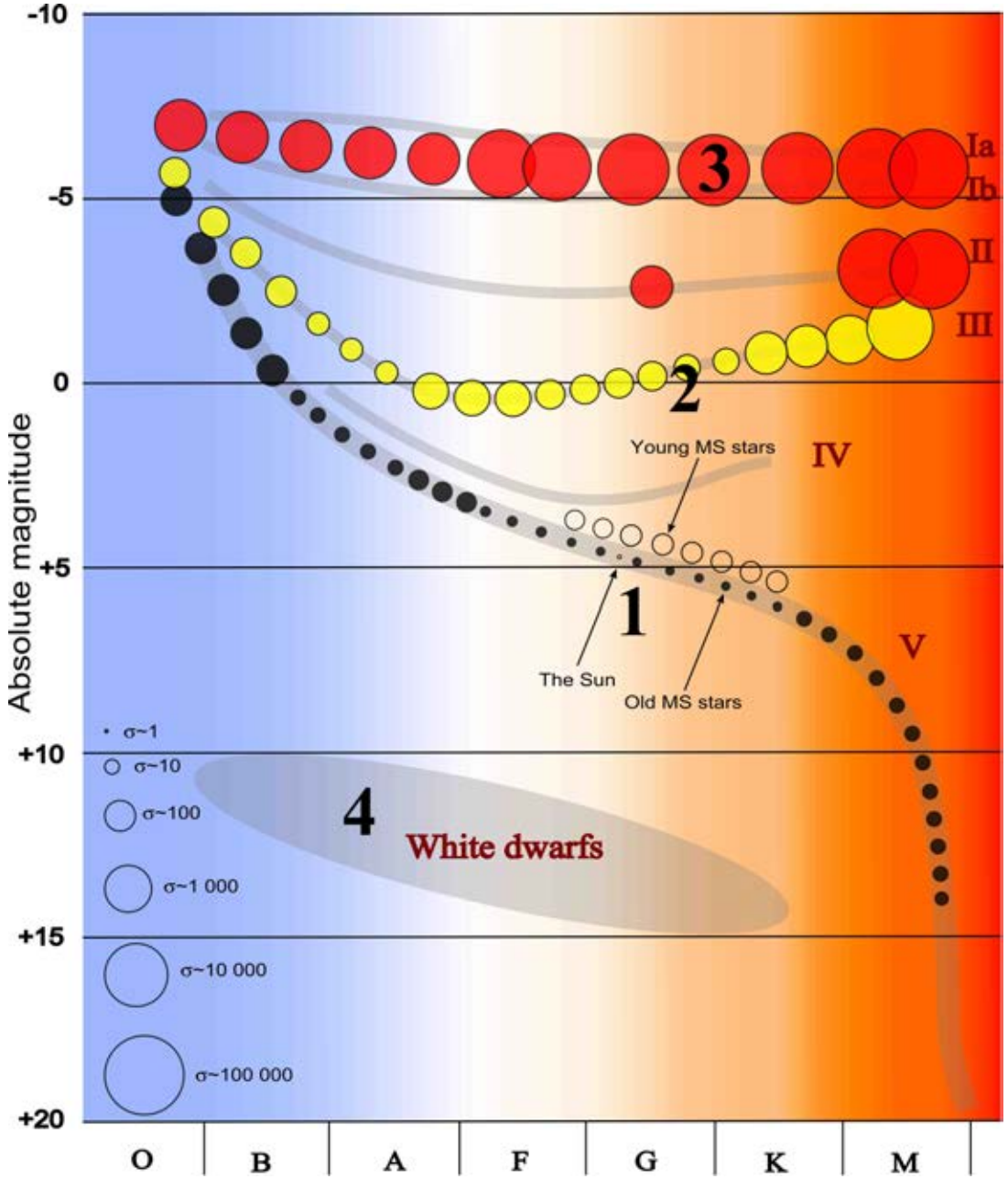
Two related affordances

Pedagogical affordance

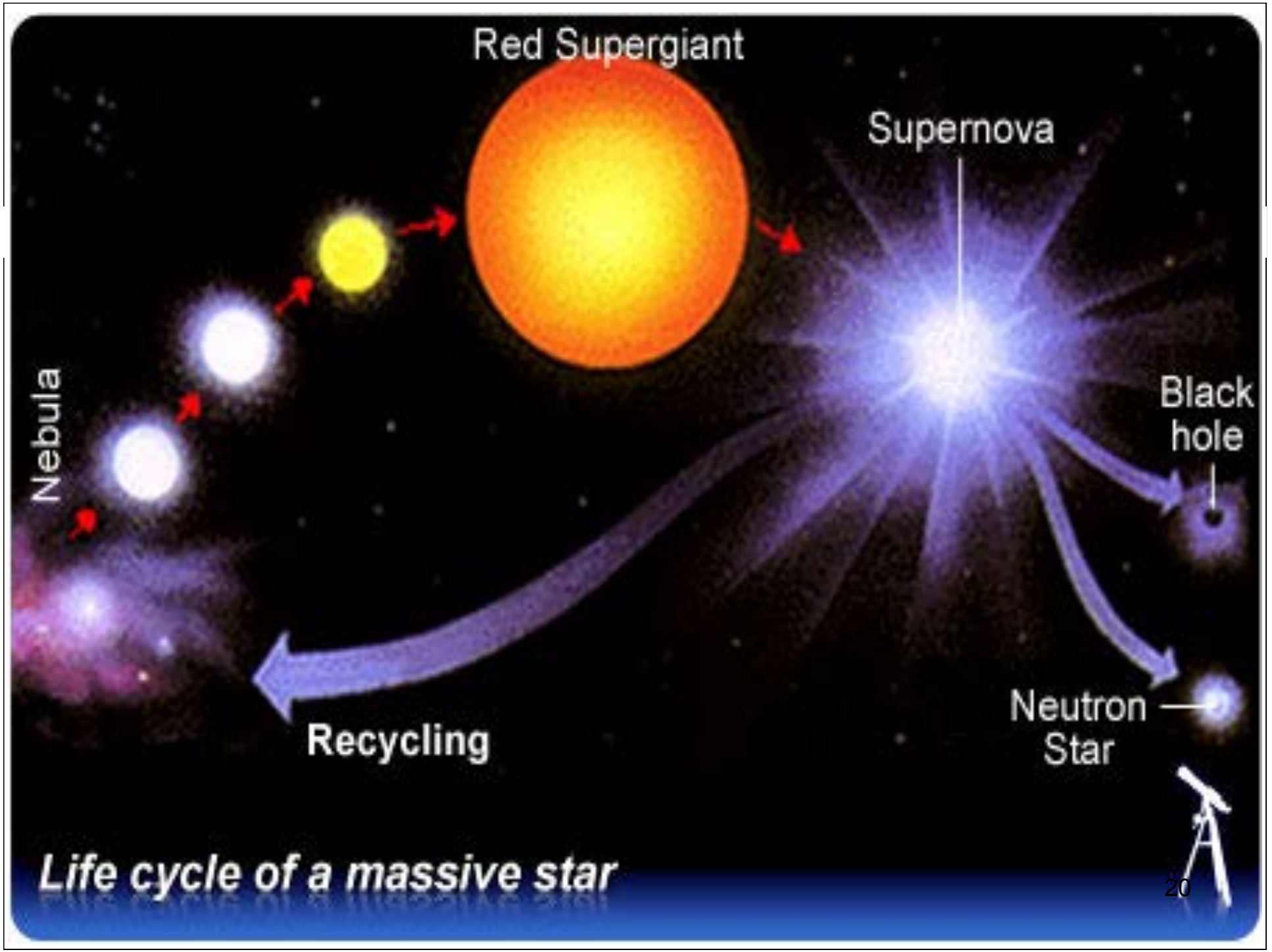
Usefulness for learning physics

Disciplinary affordance

Usefulness in physics

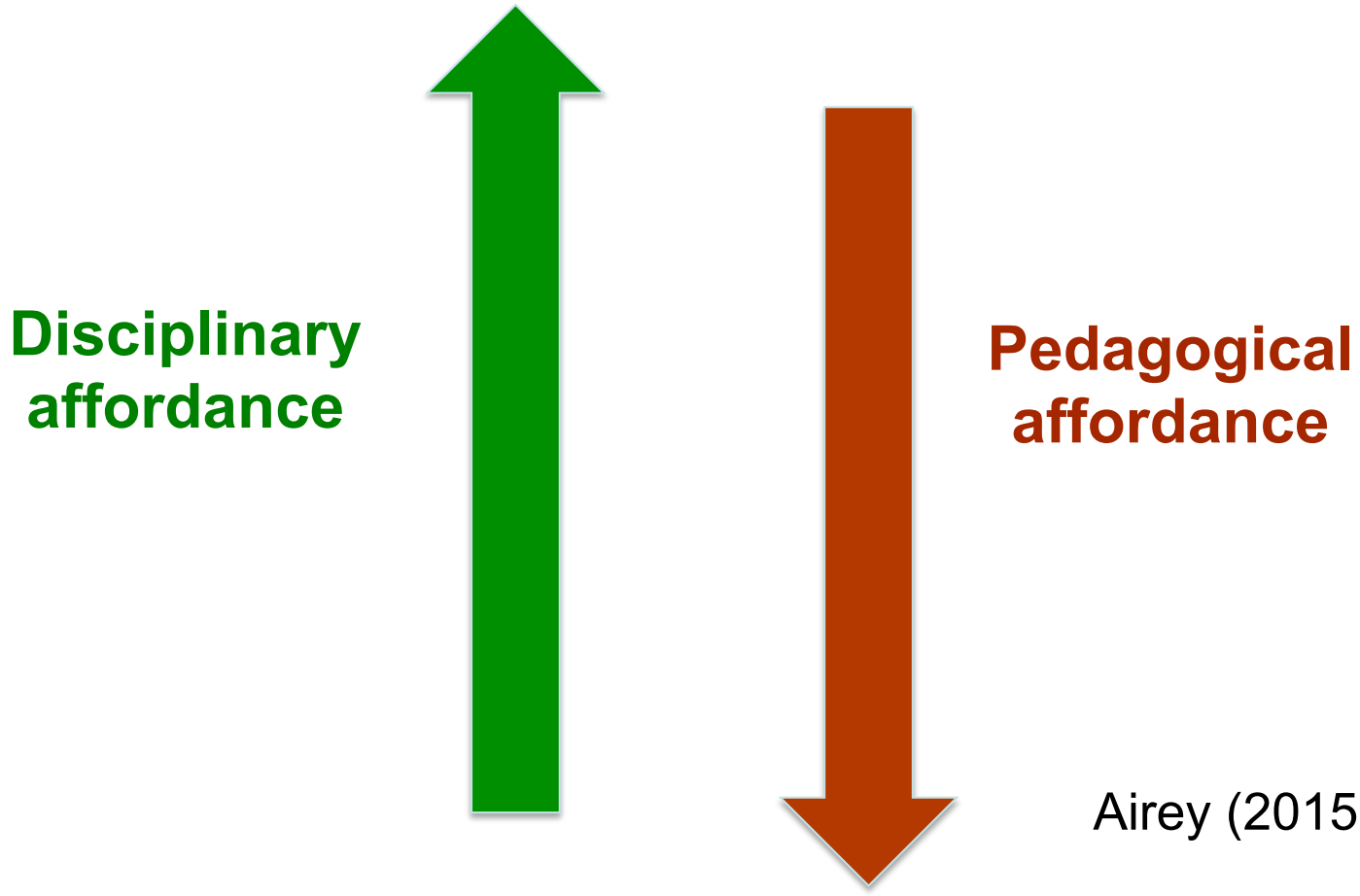


Airey & Eriksson 2014


Red Supergiant
Supernova
Nebula
Black hole
Recycling
Neutron Star
Life cycle of a massive star

UPPSALA UNIVERSITET

Pedagogical vs disciplinary affordance



Airey (2015)

UPPSALA UNIVERSITET

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)

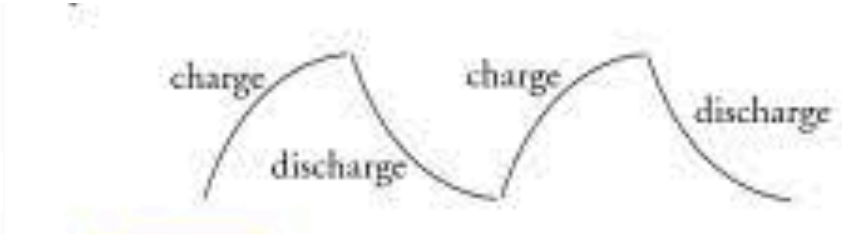
UPPSALA UNIVERSITET

Unpacking disciplinary affordance

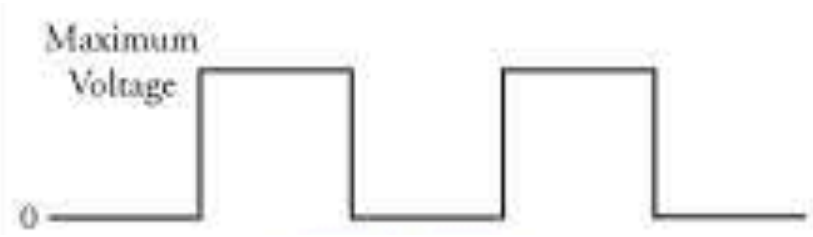
RC-circuits

Fredlund et al (2014)

Channel 1:



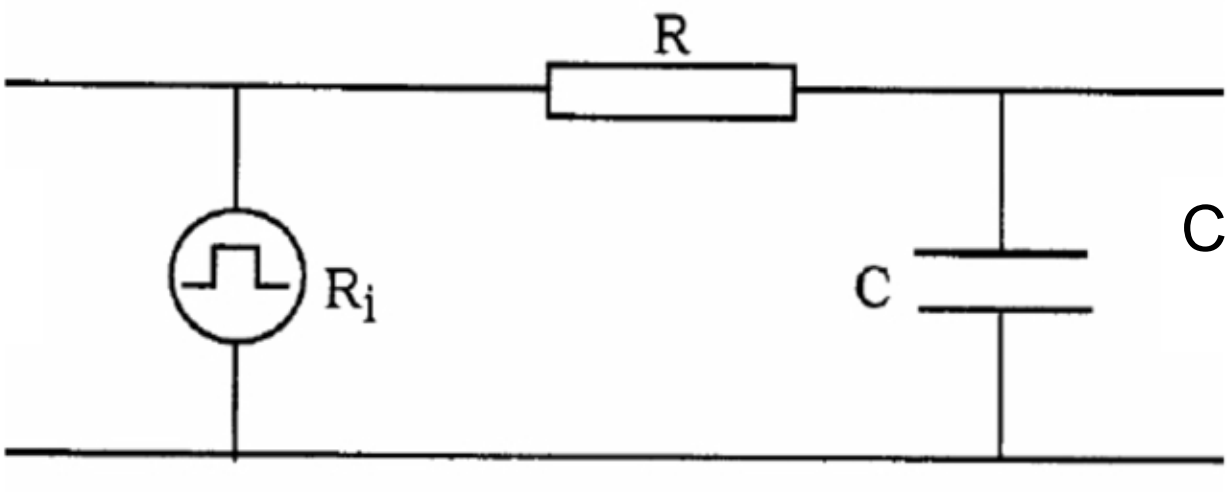
Channel 2:



UPPSALA UNIVERSITET

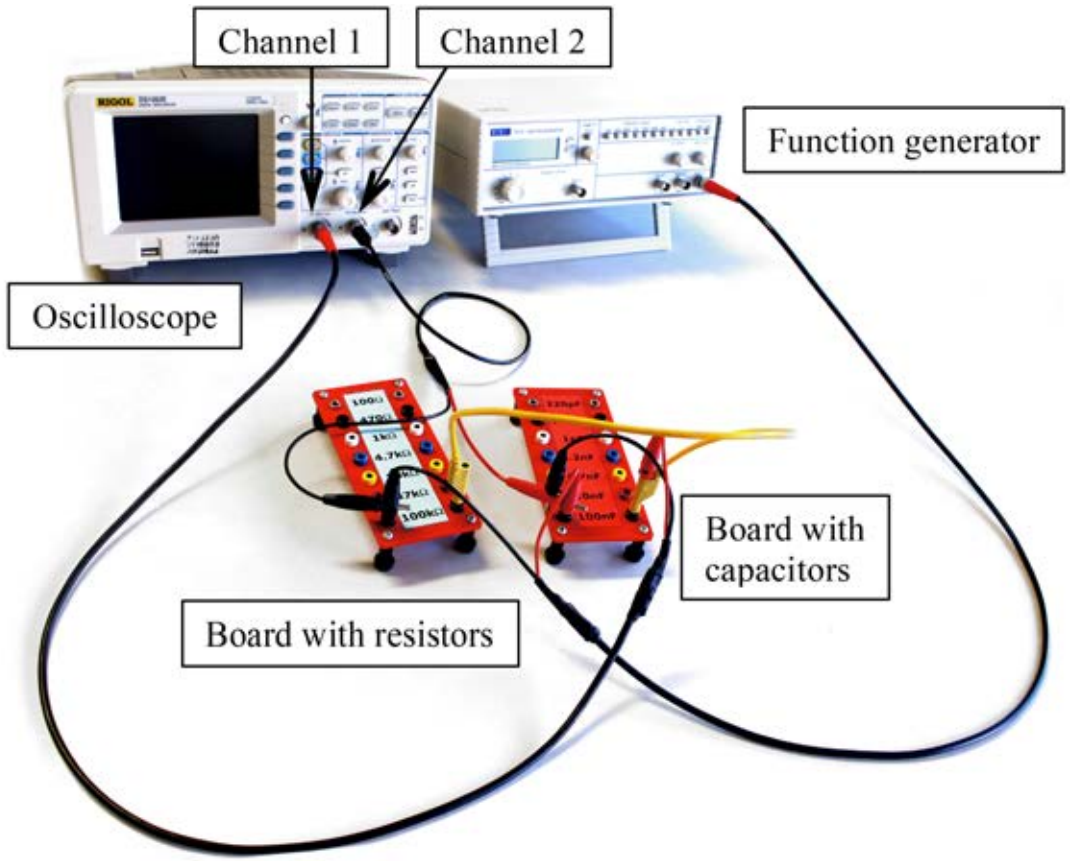
Unpacking disciplinary affordance

Channel 2

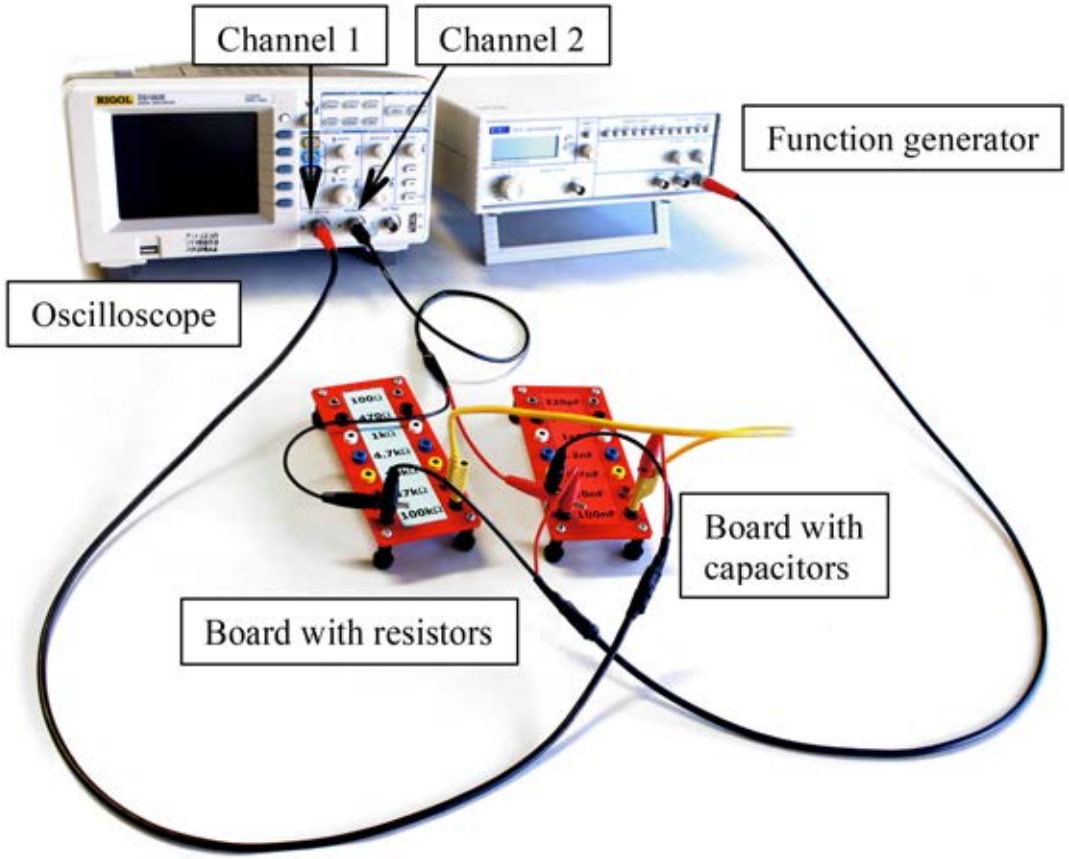


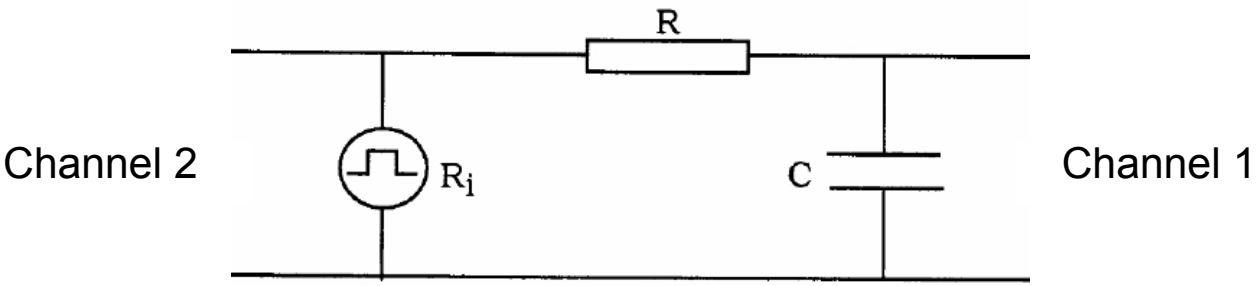
Channel 1

UPPSALA
UNIVERSITET

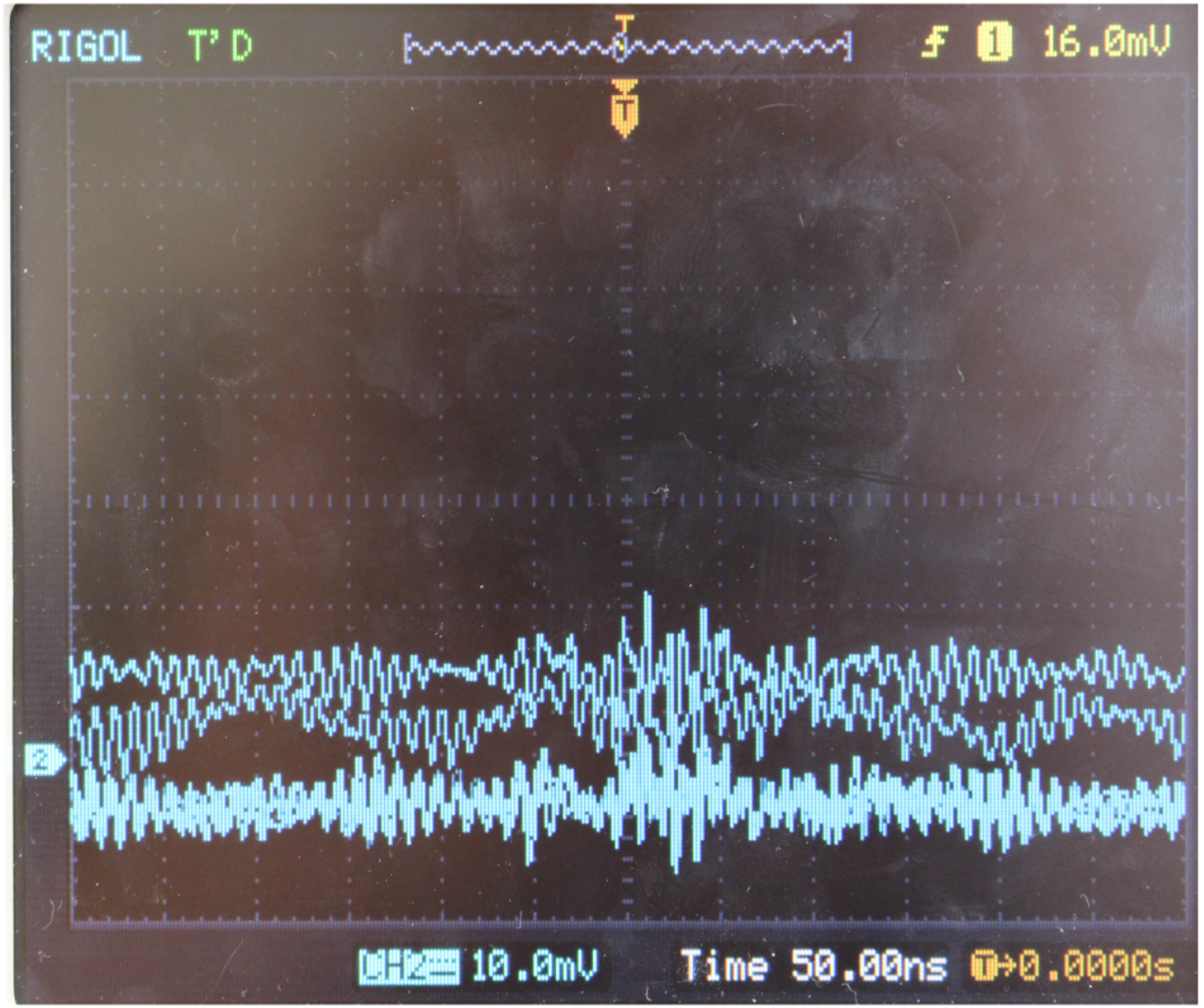


UPPSALA UNIVERSITET





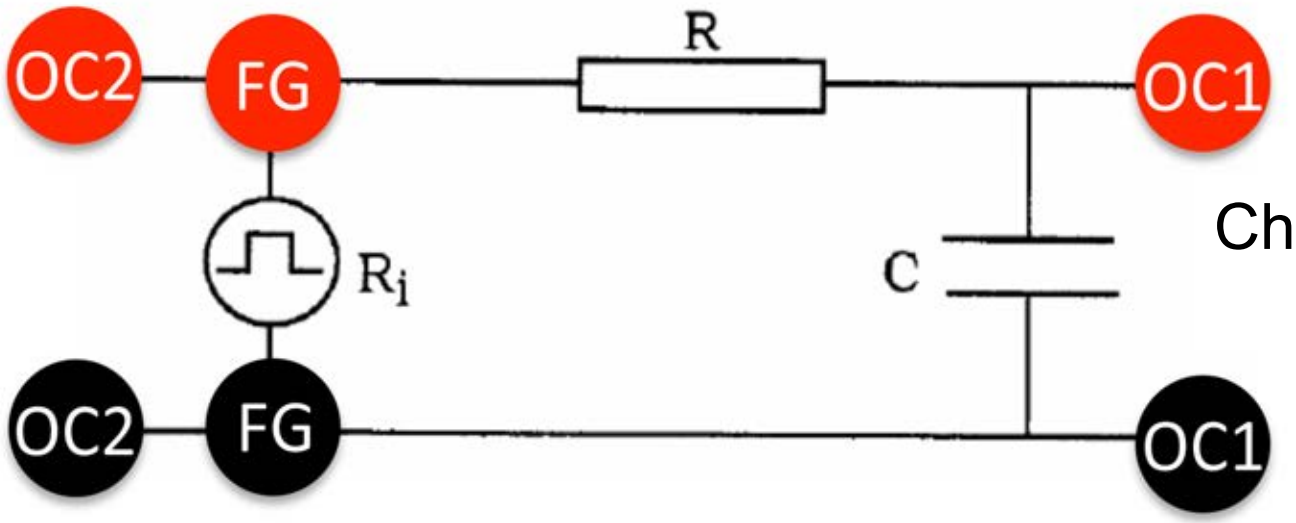
UPPSALA
UNIVERSITET



UPPSALA UNIVERSITET

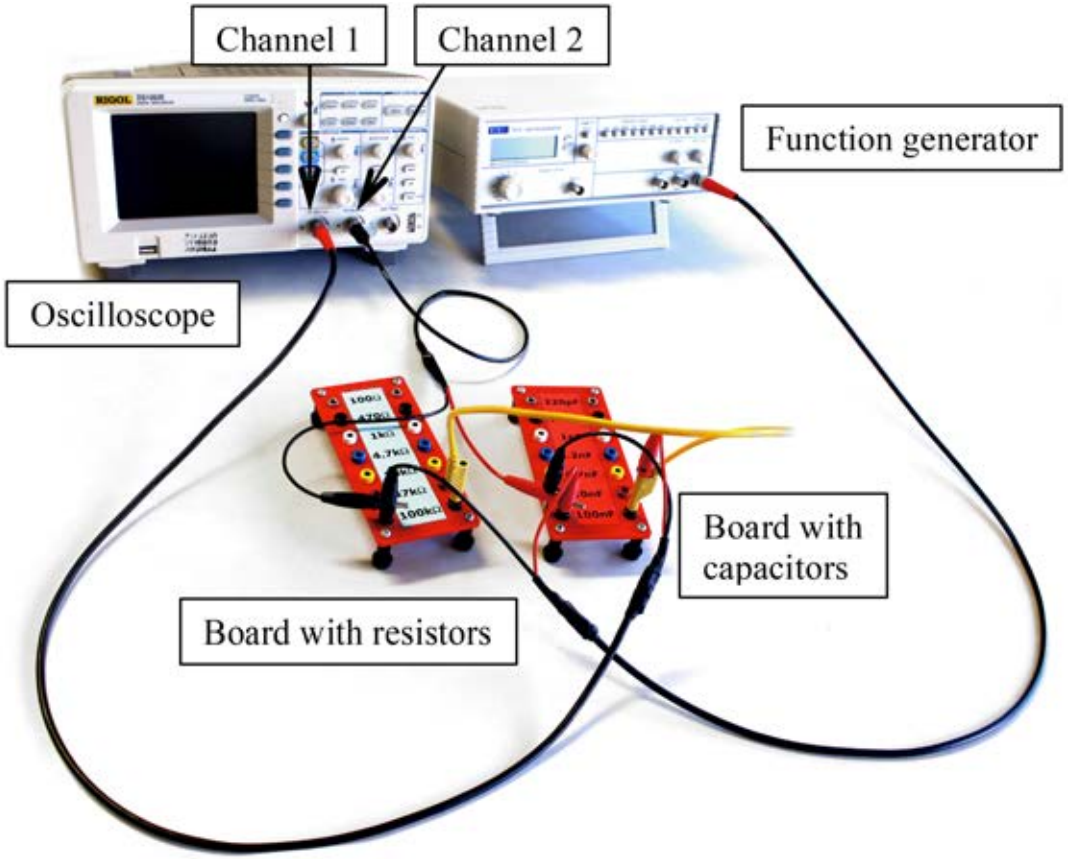
Unpacking disciplinary affordance

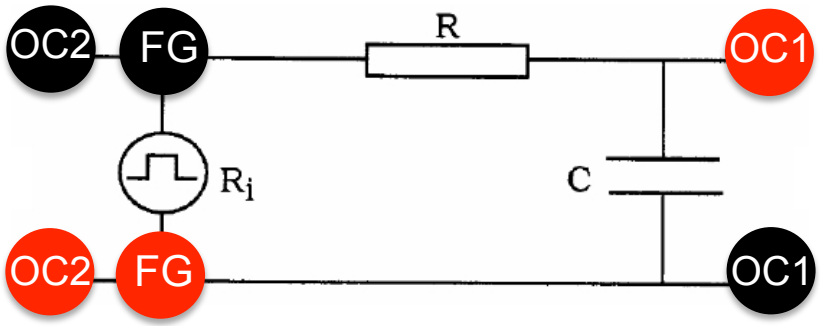
Channel 2



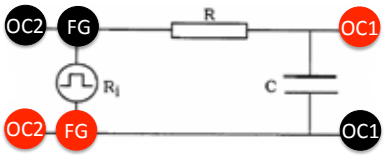
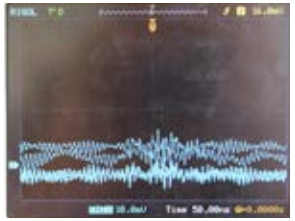
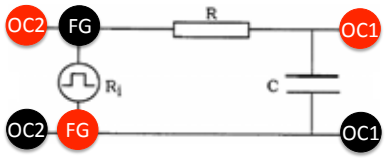
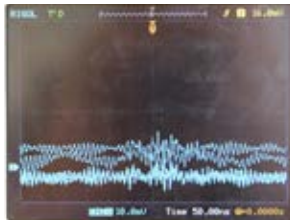
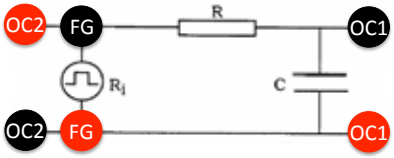
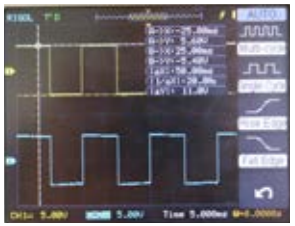
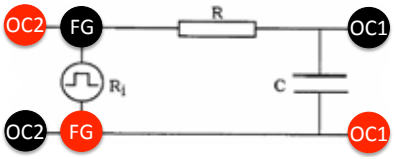
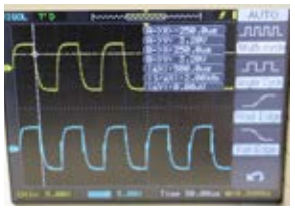
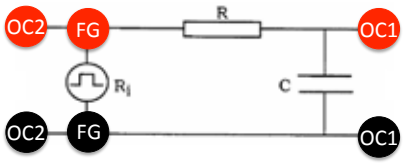
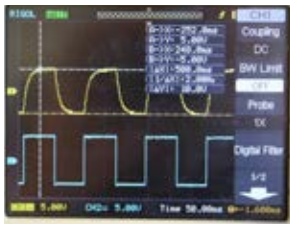
Channel 1

UPPSALA UNIVERSITET





UPPSALA UNIVERSITET

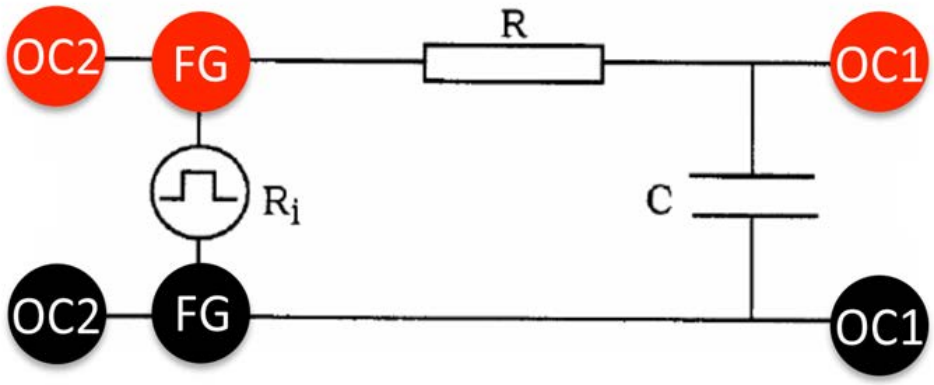
Description	Circuit connection	Image on the oscilloscope screen
(a) The students' first connection		
(b) The students' simplified connection		
(c) The circuit after the TA's first intervention		
(d) The same circuit after having increased the frequency		
(e) The circuit after the TA's second intervention		

UPPSALA UNIVERSITET

Unpacking

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

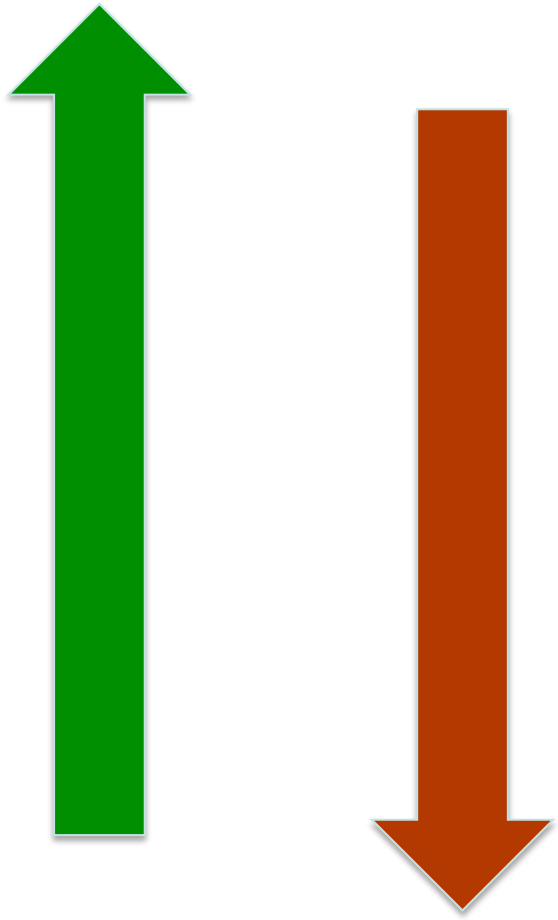
Airey (2015)



UPPSALA UNIVERSITET

Pedagogical vs disciplinary affordance

Disciplinary affordance



Pedagogical affordance

Airey (2015)

UPPSALA UNIVERSITET

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…

UPPSALA
UNIVERSITET

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

See Fredlund, Airey & Linder (2015a)

UPPSALA UNIVERSITET

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

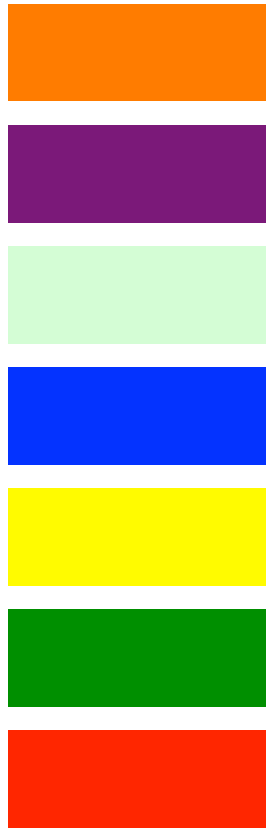
Disciplinary Affordance

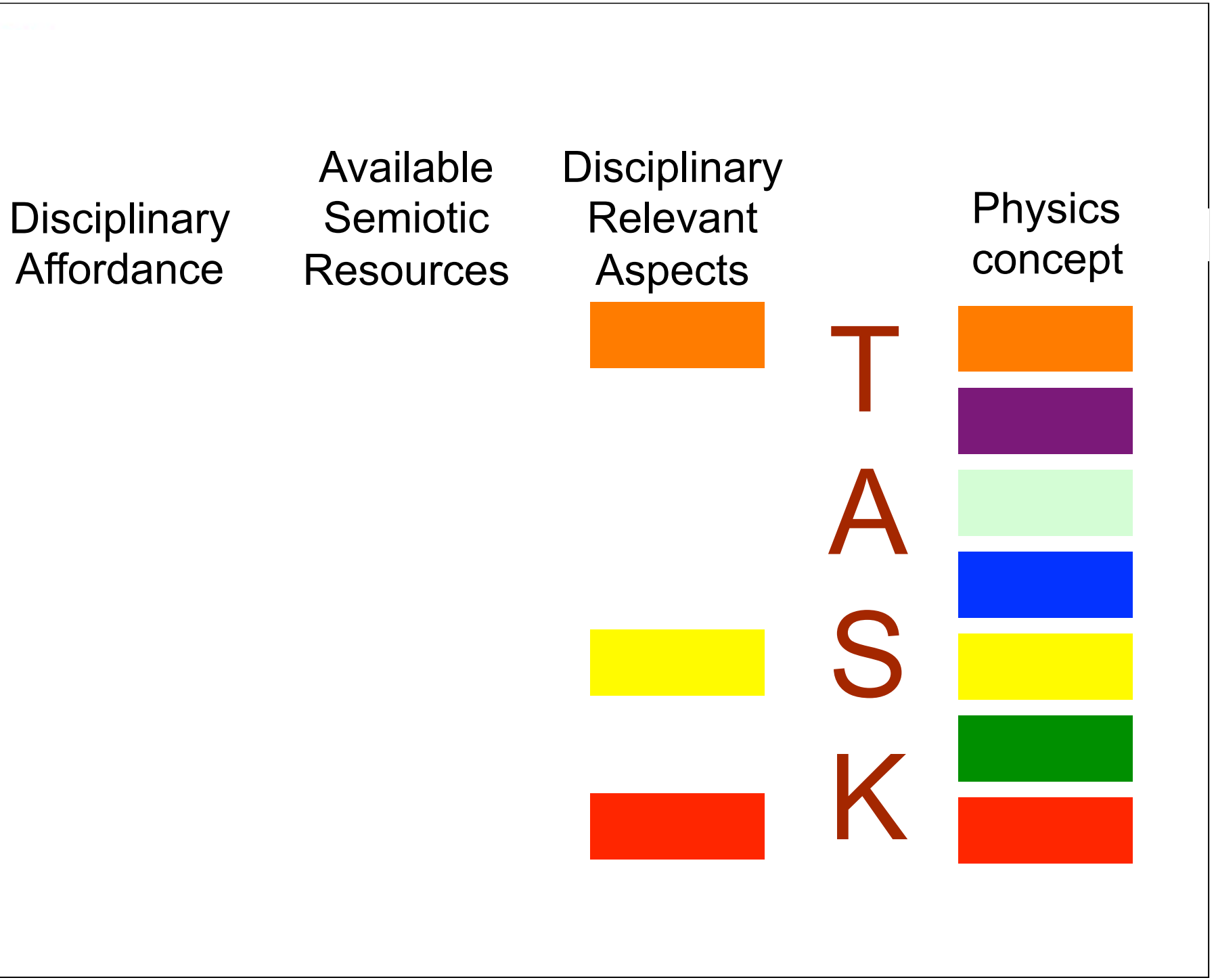
Available Semiotic Resources

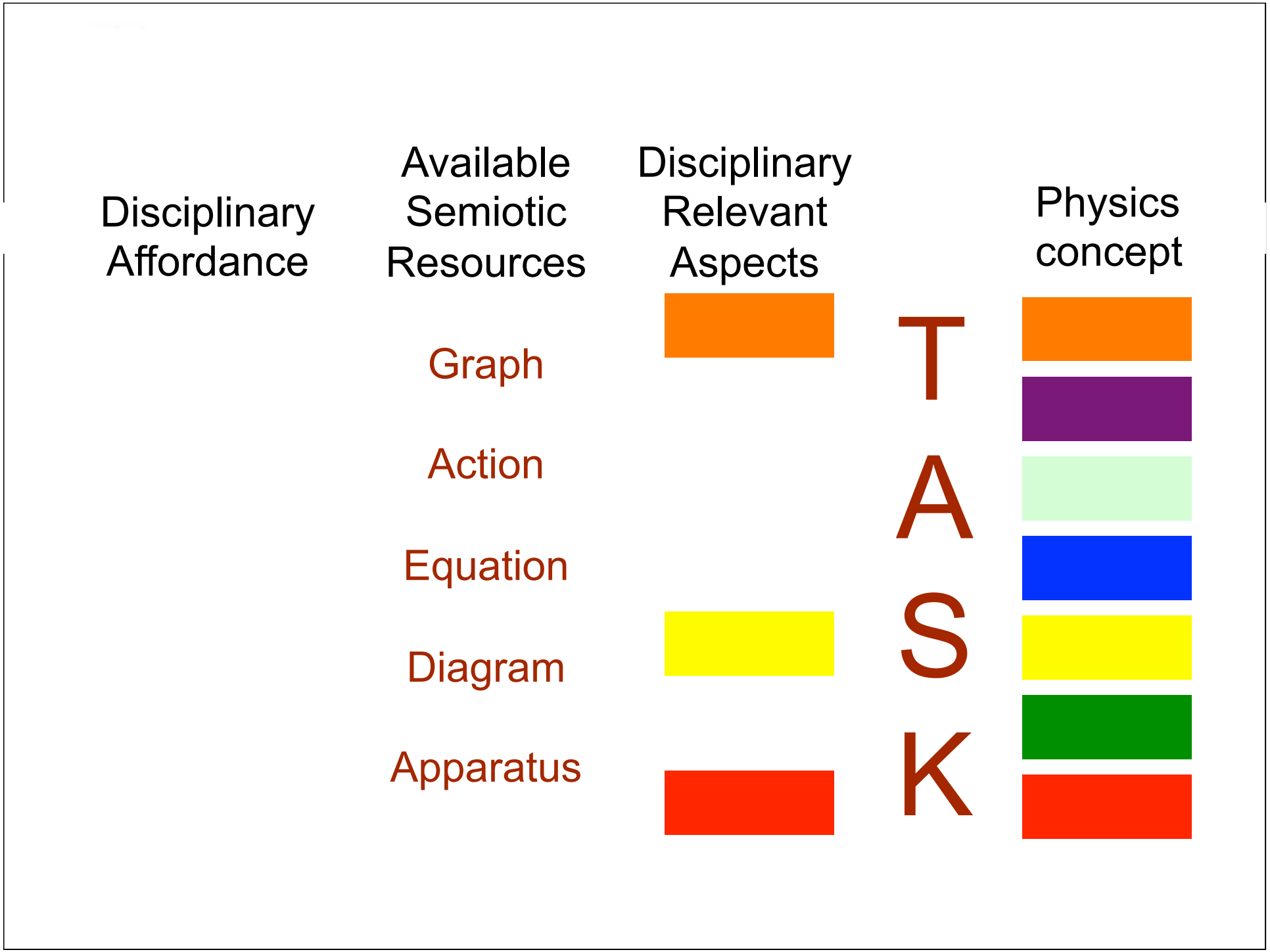
Disciplinary Relevant Aspects

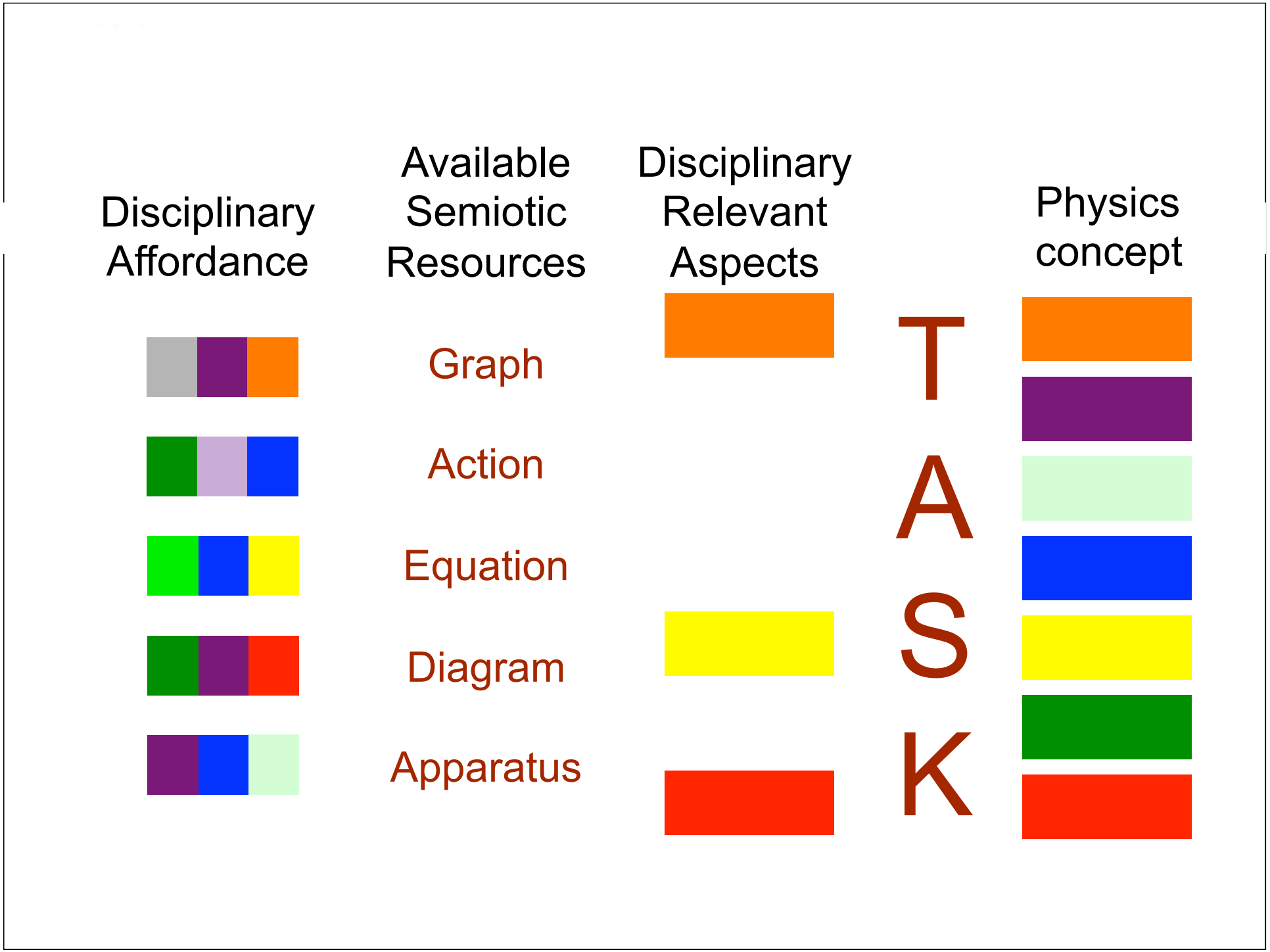
TASK

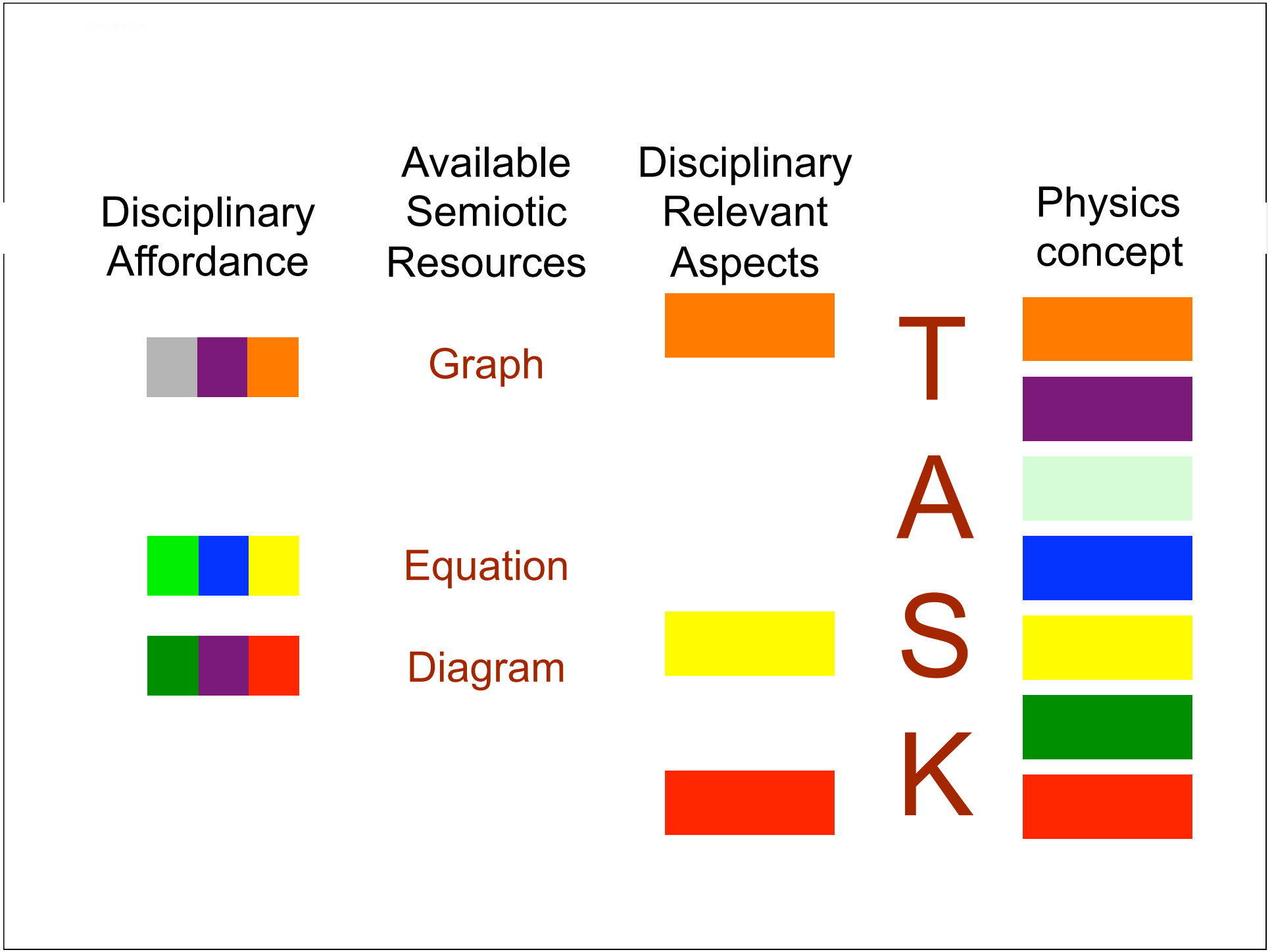
Physics concept

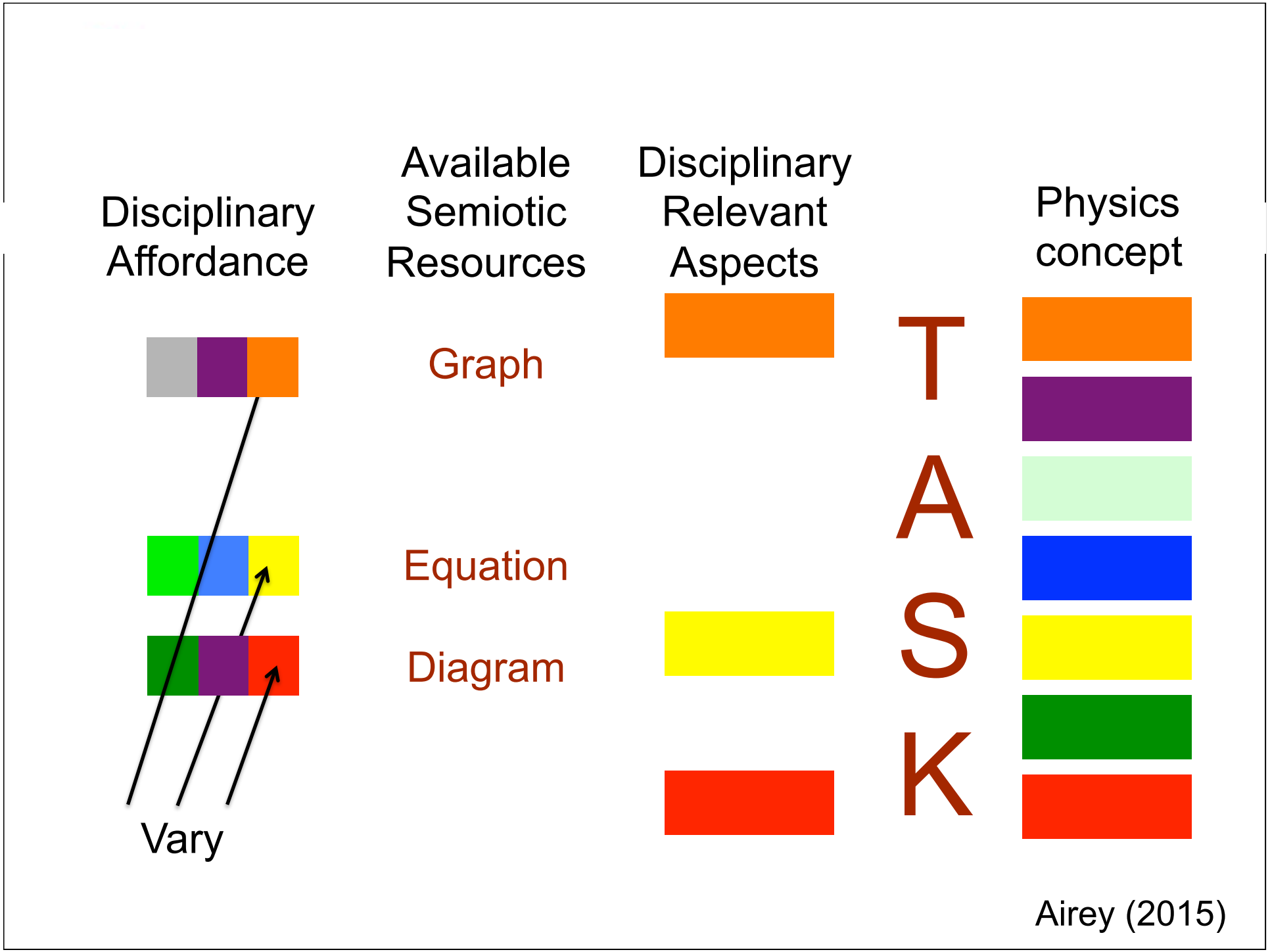



Disciplinary Affordance
Available Semiotic Resources
Disciplinary Relevant Aspects
TASK
Physics concept


Disciplinary Affordance
Available Semiotic Resources
Disciplinary Relevant Aspects
Physics concept
Graph
Action
Equation
Diagram
Apparatus
T
A
S
K


Disciplinary Affordance
Available Semiotic Resources
Disciplinary Relevant Aspects
Physics concept
Graph
Action
Equation
Diagram
Apparatus
T
A
S
K


Disciplinary Affordance
Available Semiotic Resources
Disciplinary Relevant Aspects
Physics concept
Graph
Equation
Diagram
T
A
S
K


Disciplinary Affordance
Available Semiotic Resources
Disciplinary Relevant Aspects
Physics concept
Graph
Equation
Diagram
Vary
T
A
S
K
Airey (2015)

UPPSALA
UNIVERSITET

Patterns of variation

Identify disciplinary-relevant aspects

Select appropriate semiotic resources

Create systematic pattern of variation

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

UPPSALA UNIVERSITET

Patterns of variation

Clearly better if required disciplinary affordance is in available in one single semiotic resource

e.g.

A qualitative description of refraction

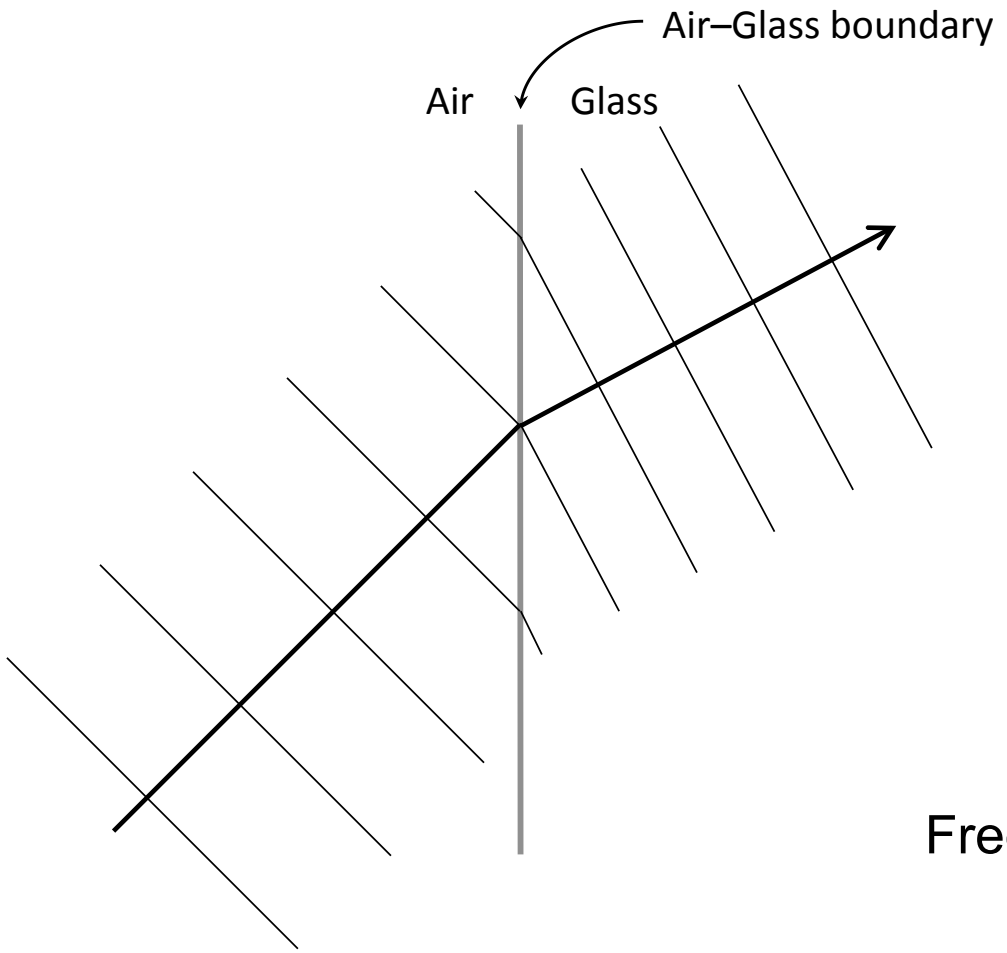
requires 3 disciplinary relevant aspects:

medium, speed, direction

(Fredlund *et al* 2012, Kryjevskaia *et al* 2012).

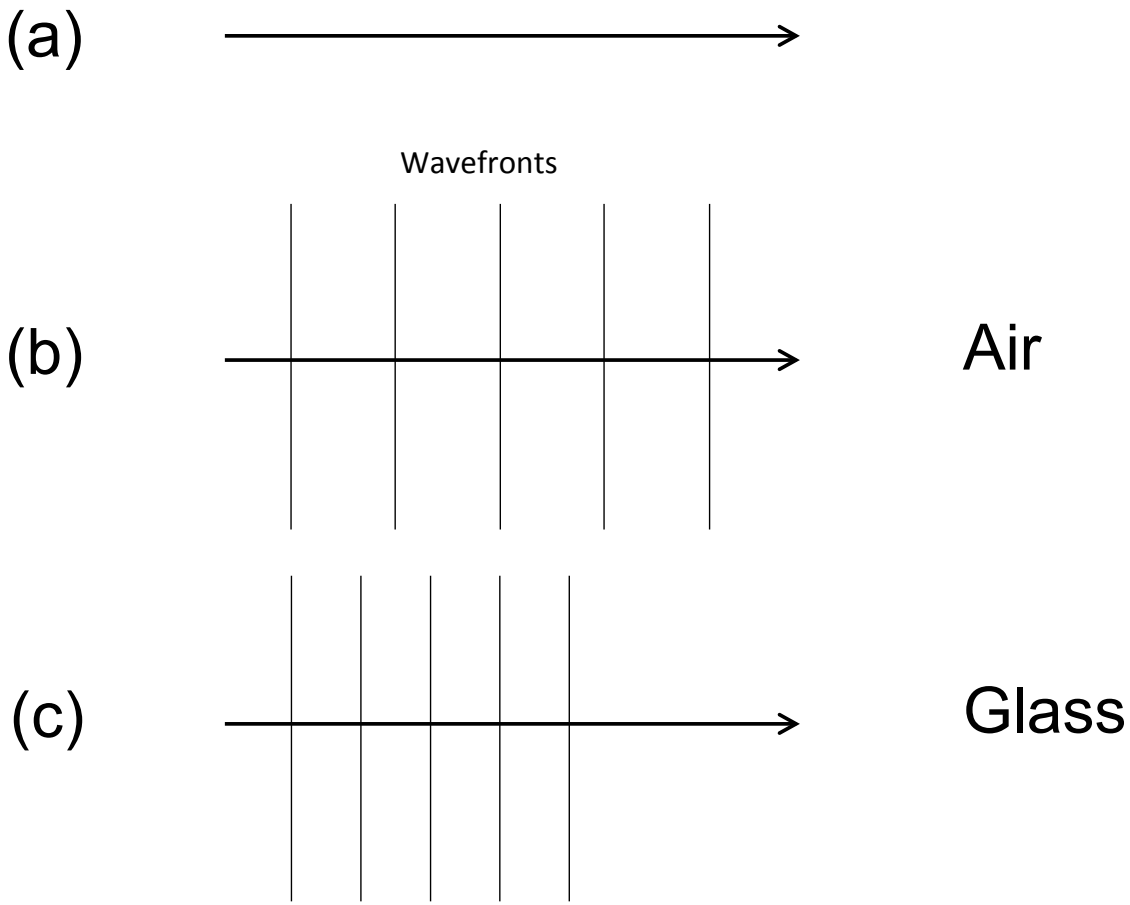
UPPSALA UNIVERSITET

All three are present in a wavefront diagram



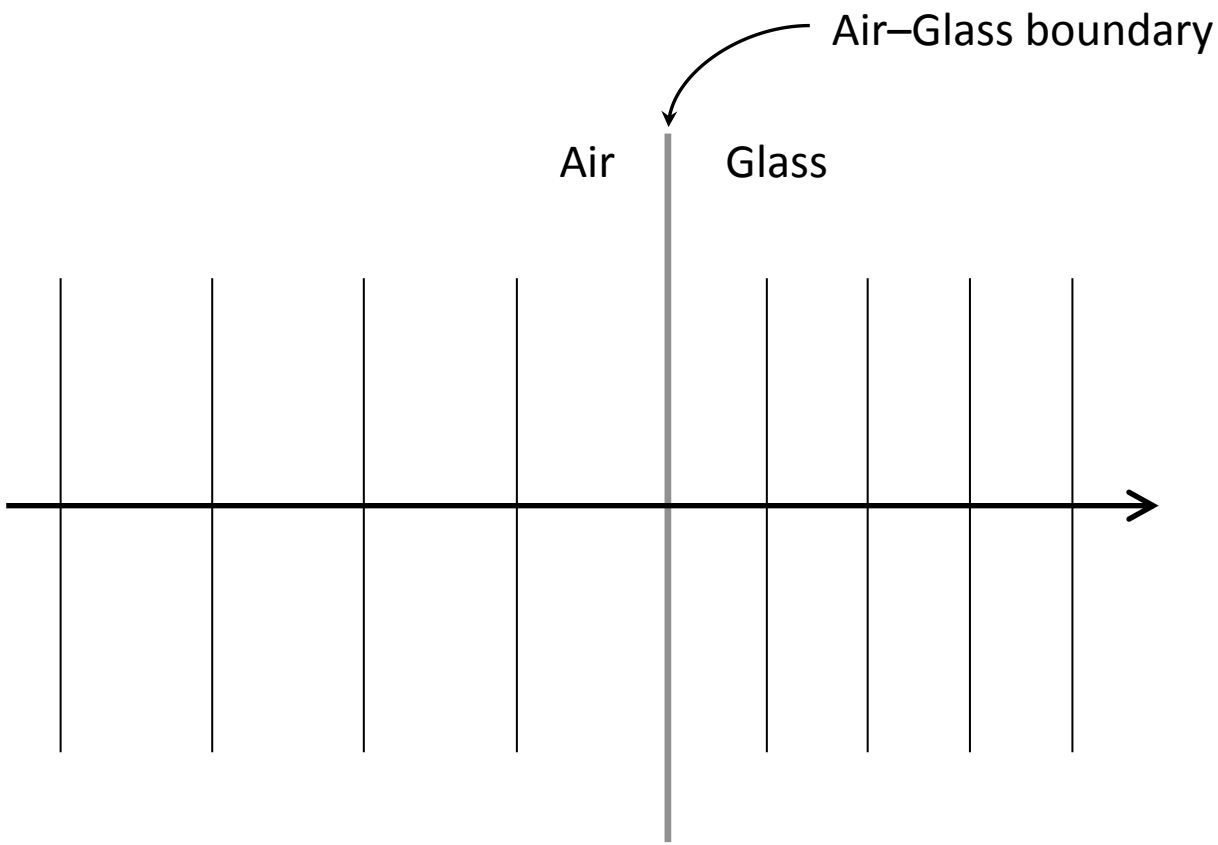
Fredlund *et al* (2015a)

UPPSALA UNIVERSITET



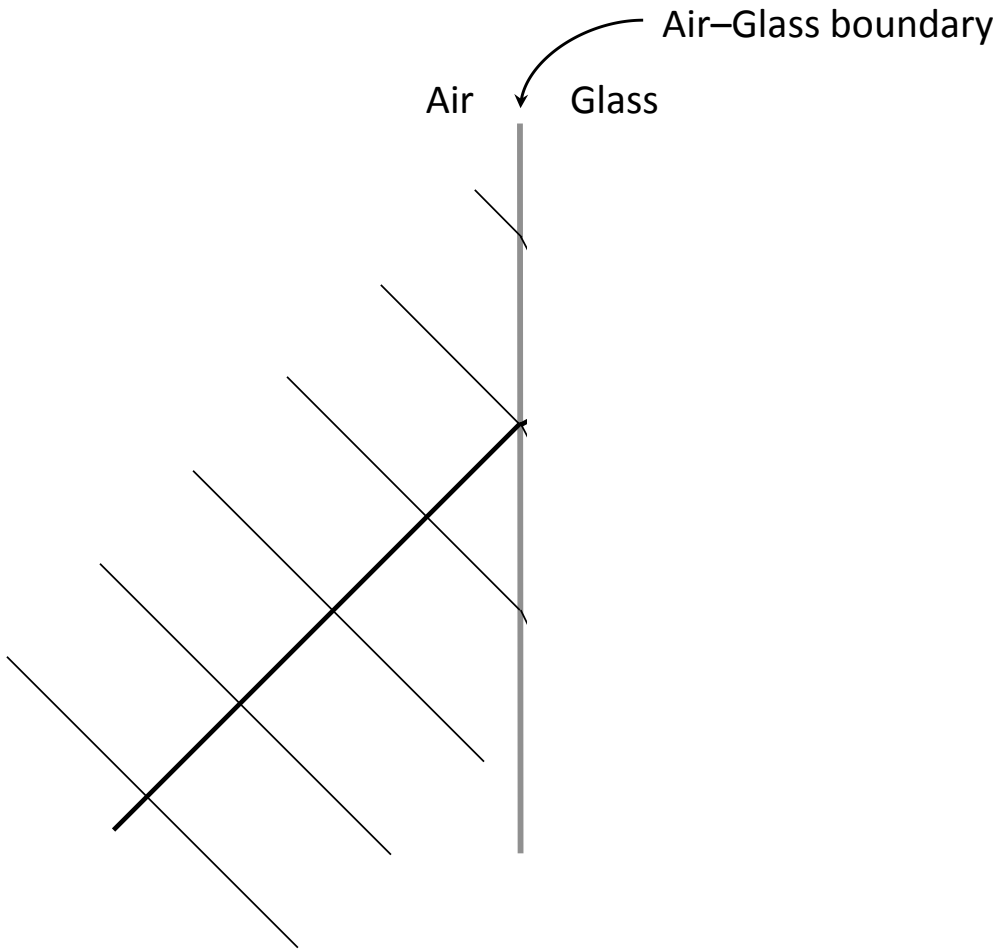
Fredlund *et al* (2015a)

UPPSALA
UNIVERSITET



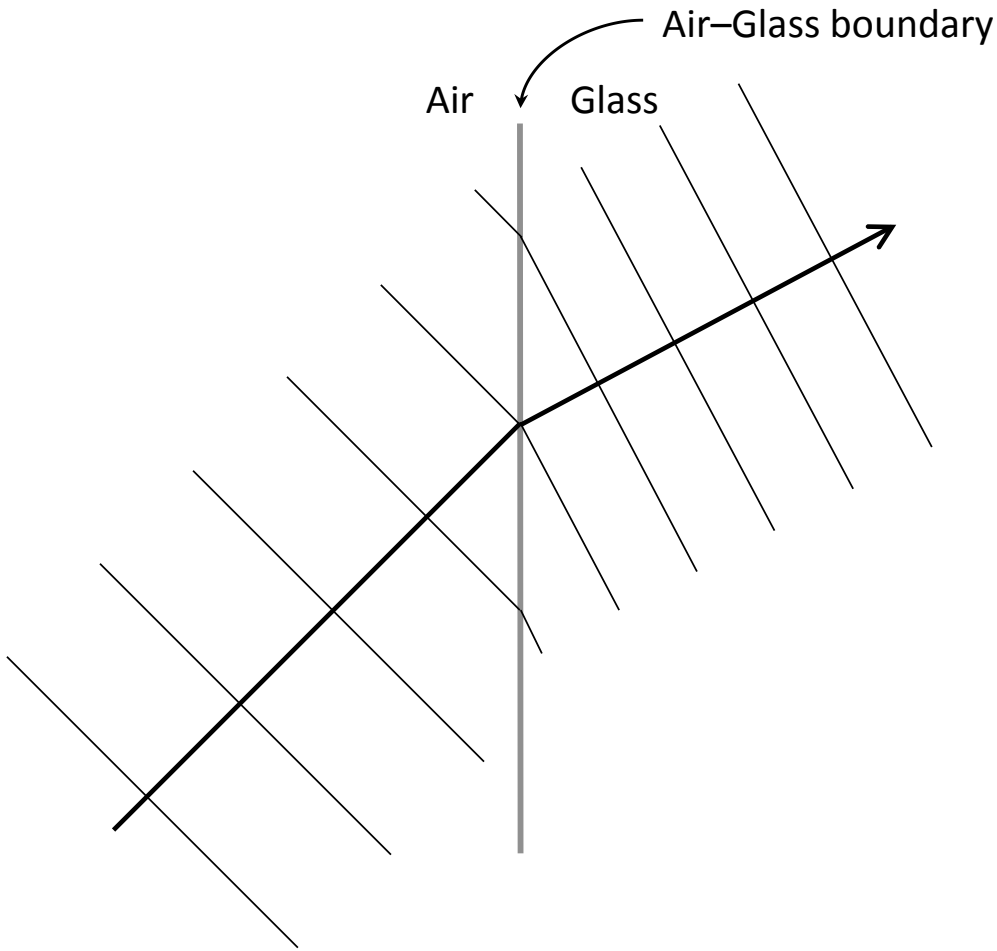
Fredlund *et al* (2015a)

UPPSALA
UNIVERSITET



Fredlund *et al* (2015a)

UPPSALA
UNIVERSITET



Fredlund *et al* (2015a)

UPPSALA
UNIVERSITET

Shown how this could be applied in Electrostatics

Fredlund (2015); Fredlund et al (2015b)

UPPSALA
UNIVERSITET

Summary

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

UPPSALA
UNIVERSITET

Thanks for listening!

UPPSALA UNIVERSITET

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. & 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. (in production) 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.

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.

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.