

The **Big Ideas** in **Physics** and How to Teach Them

TEACHING PHYSICS 11–18



A David Fulton Book

BEN ROGERS

Visible Physics

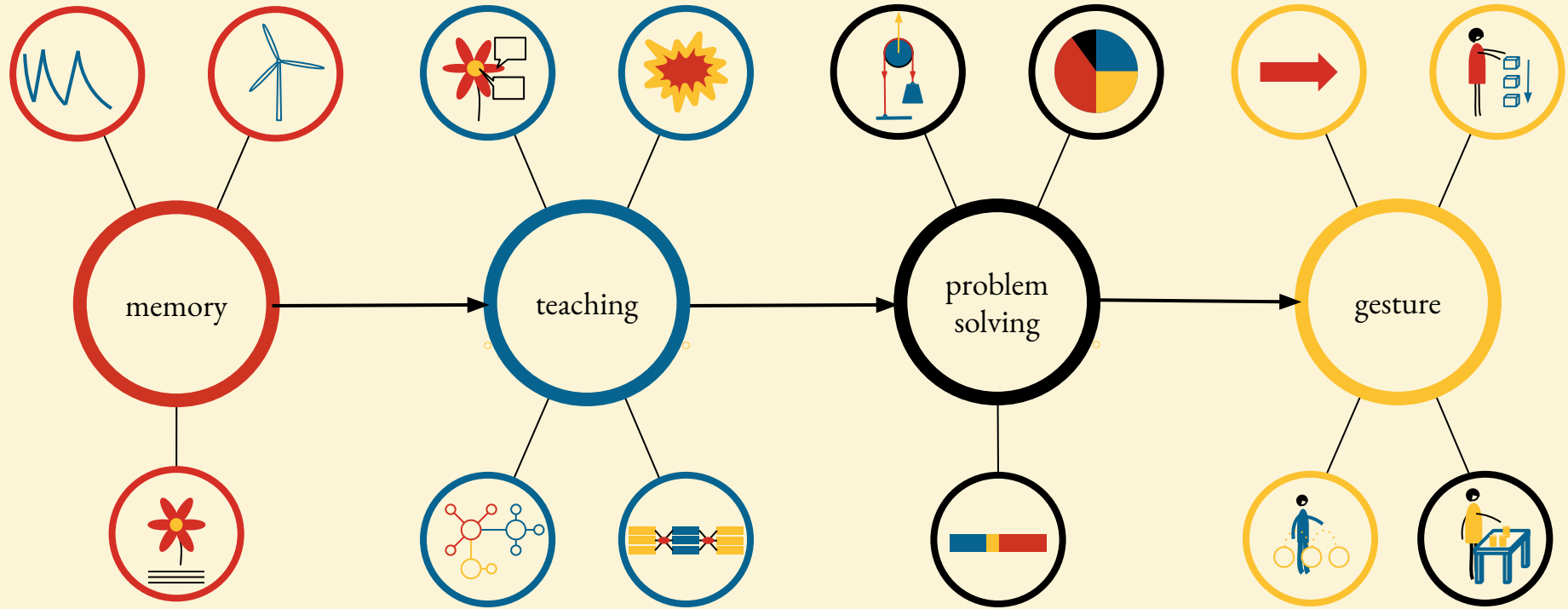
Ben Rogers

*Director of Curriculum and Pedagogy:
Paradigm Trust*

Paradigm
TRUST

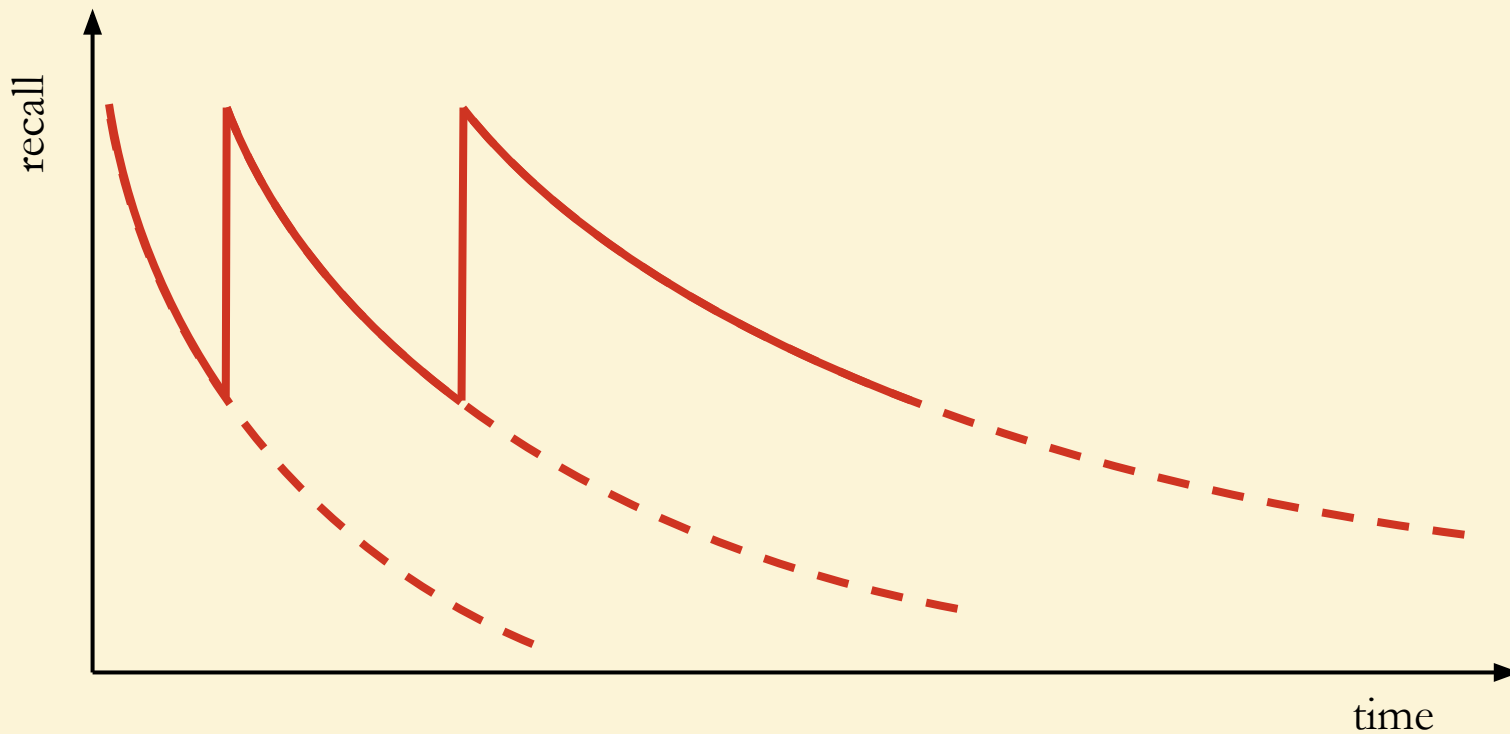
Visible Physics

Ben Rogers - Director of Curriculum and Pedagogy: Paradigm Trust



Memory

The Ebbinghaus Forgetting Curve - 1885



The Surprisingly Powerful Influence of Drawing on Learning

The Picture Superiority Effect

kinetic energy
kinetic energy
kinetic energy

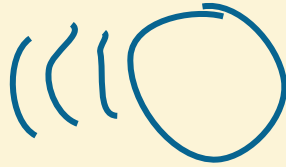
gravitational potential
gravitational potential
gravitational potential

thermal
thermal
thermal

The Surprisingly Powerful Influence of Drawing on Learning

The Picture Superiority Effect

kinetic energy
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gravitational potential
gravitational potential
gravitational potential

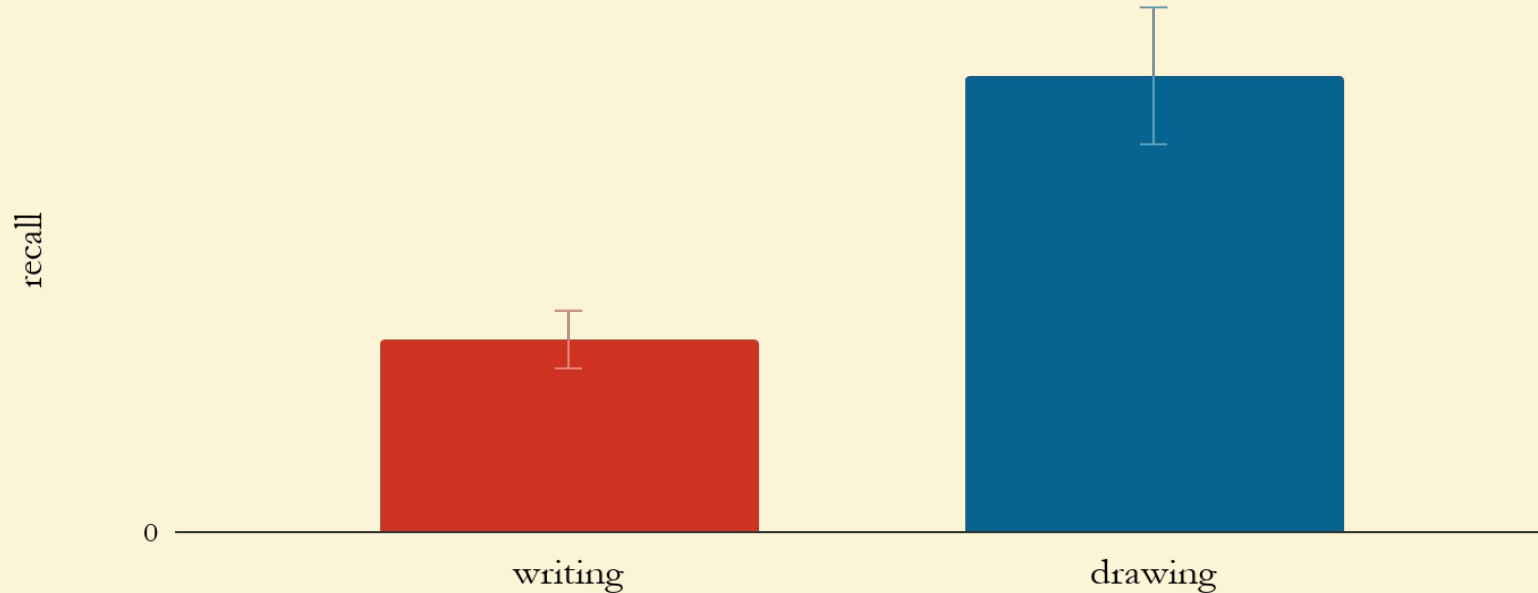


thermal
thermal
thermal



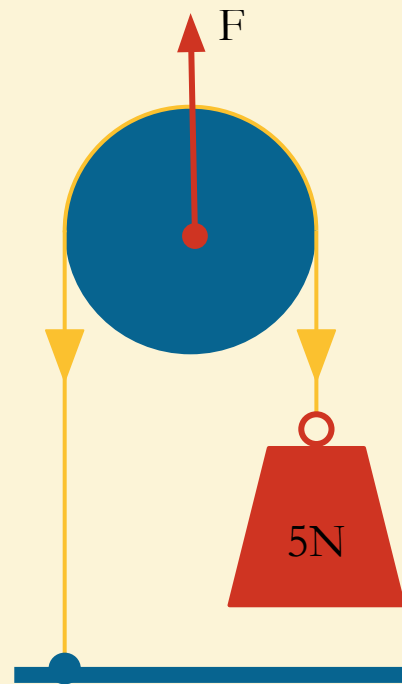
The Surprisingly Powerful Influence of Drawing on Learning

The Picture Superiority Effect

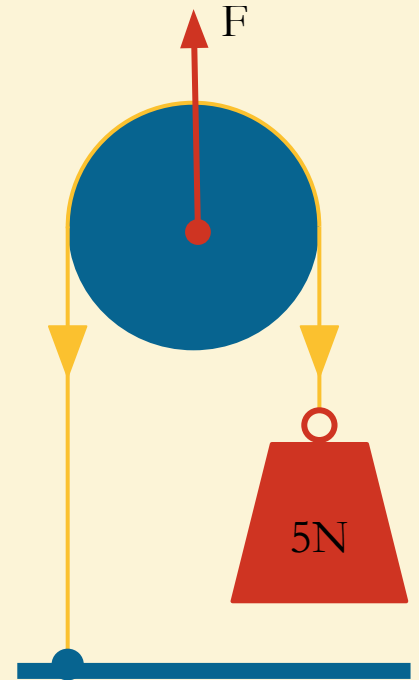
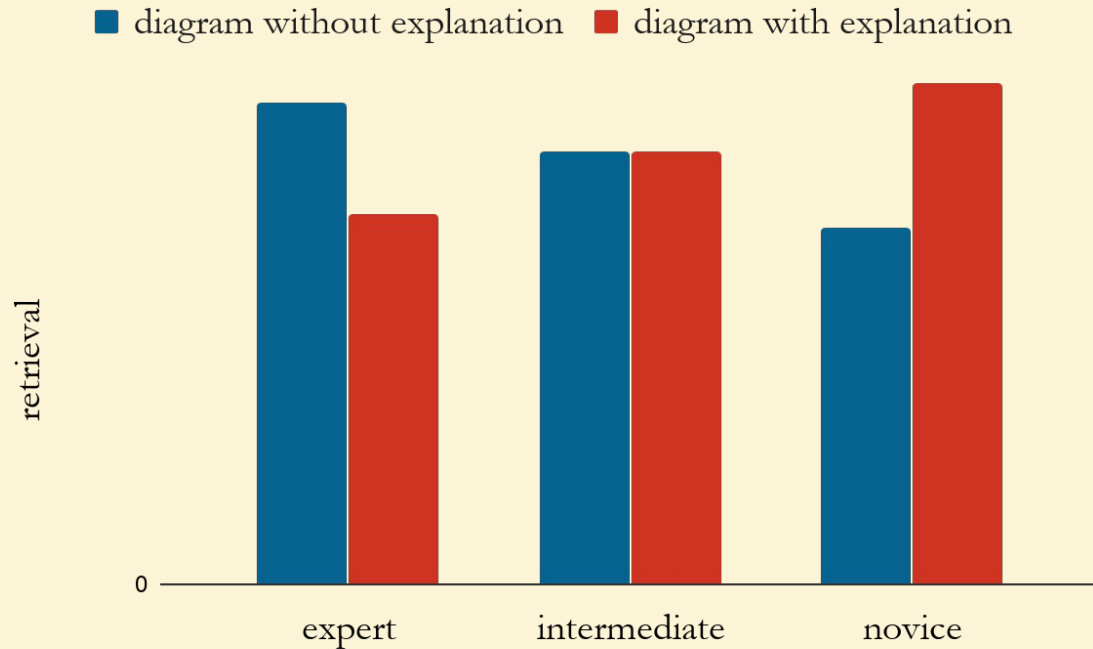


Teaching

Should I explain a visual?



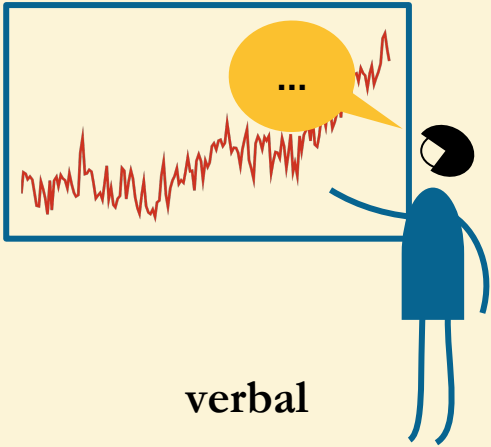
Should I explain a visual?



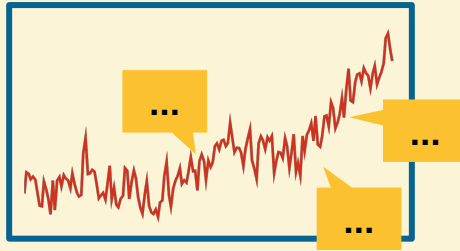
How should I explain my visual?



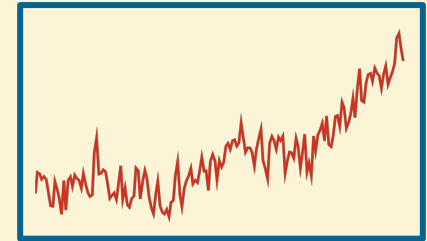
How should I explain my visual?



verbal



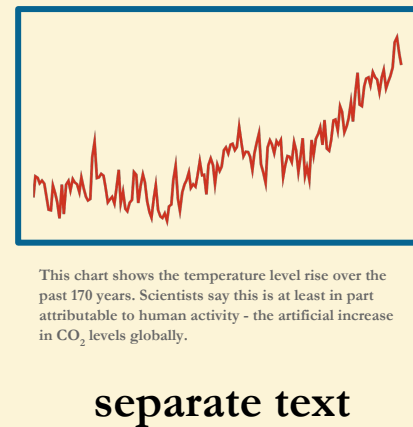
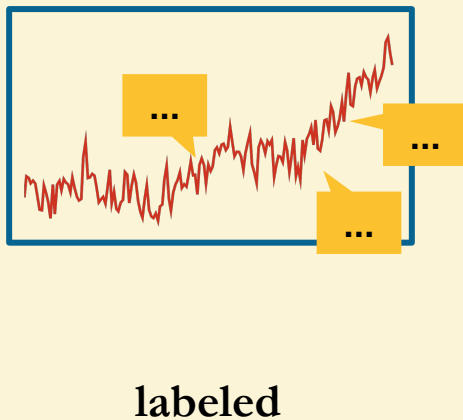
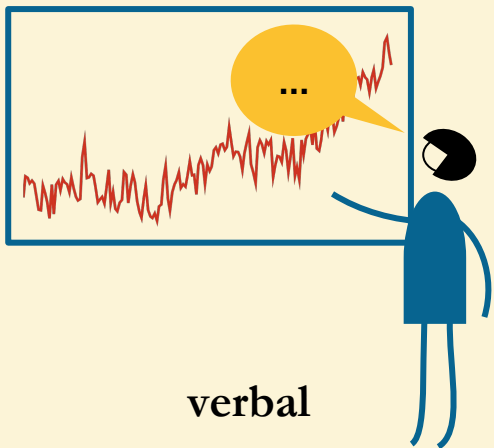
labeled



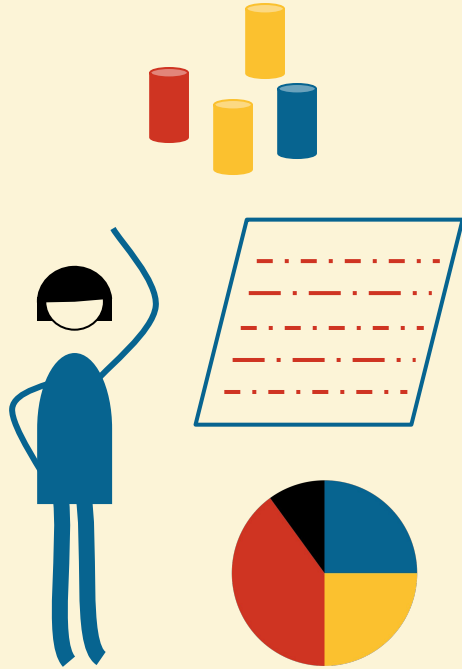
This chart shows the temperature level rise over the past 170 years. Scientists say this is at least in part attributable to human activity - the artificial increase in CO₂ levels globally.

separate text

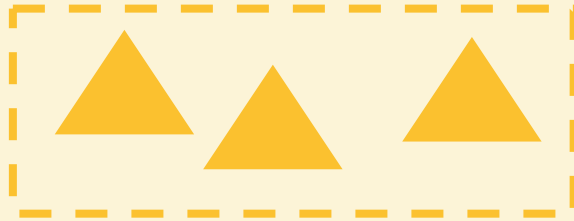
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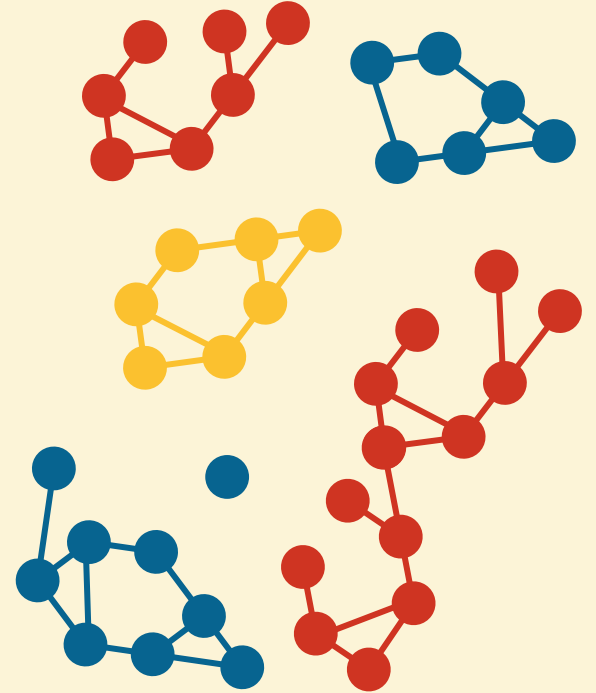
External Memory



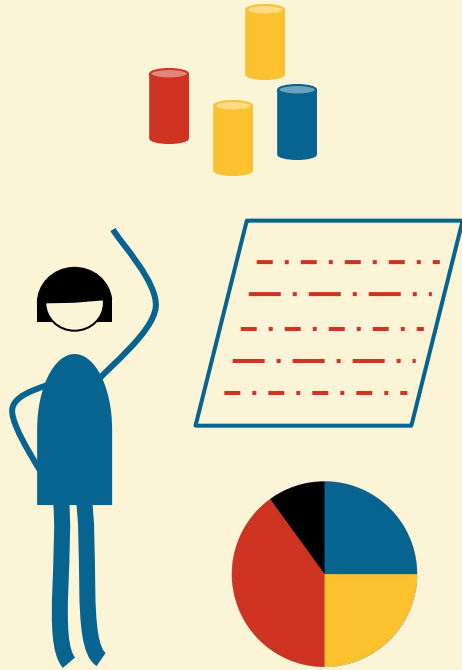
Working Memory



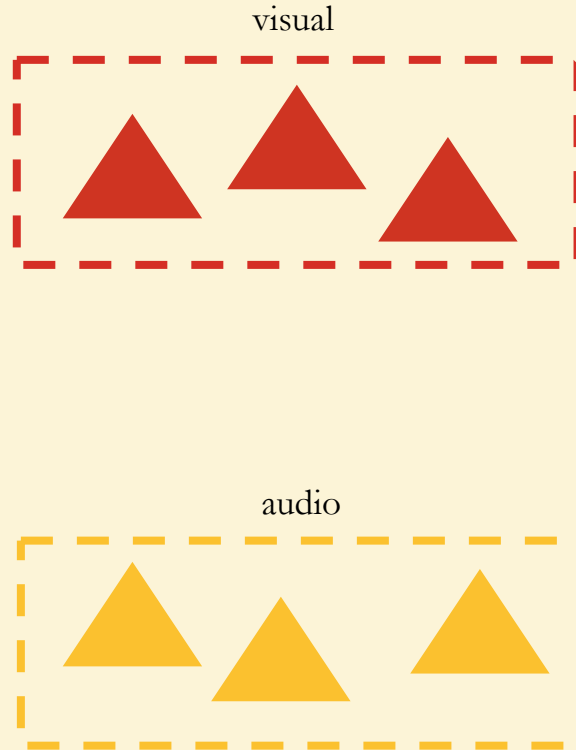
Long Term Memory



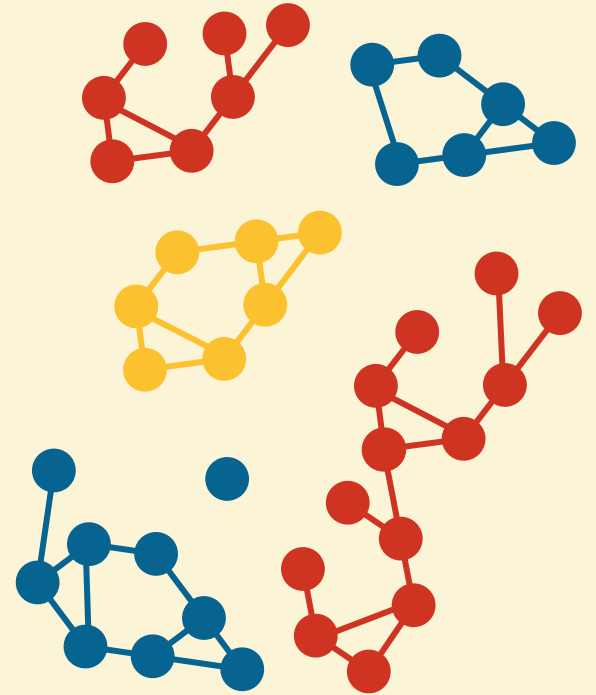
External Memory



Working Memory



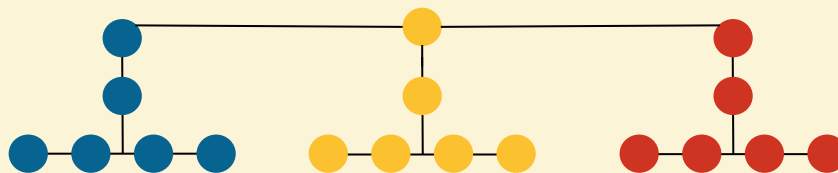
Long Term Memory



Teaching

Organising Knowledge

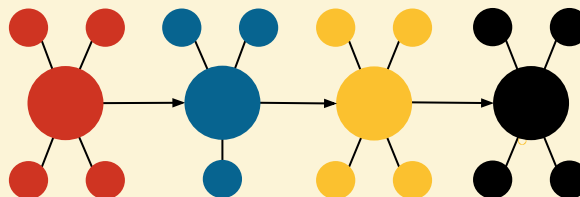
Group



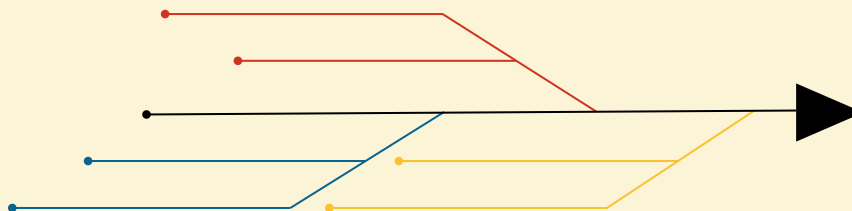
Compare

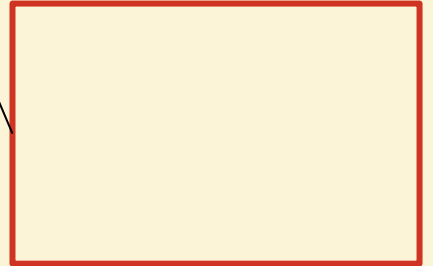
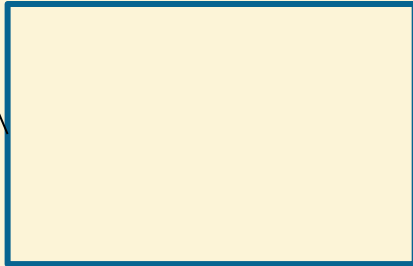
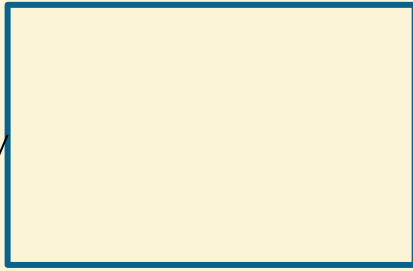
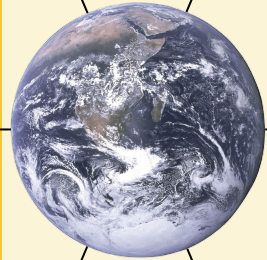
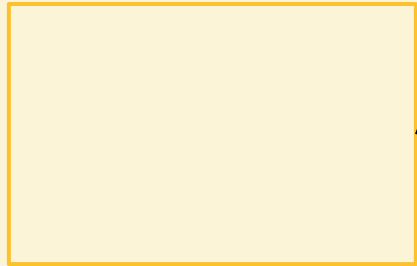
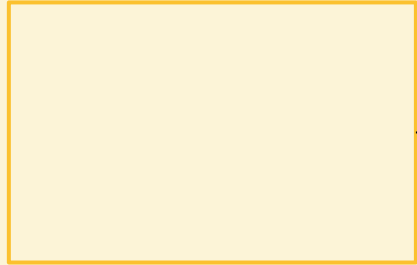


Sequence



Cause and Effect





Different

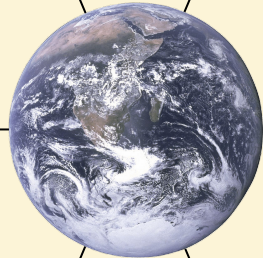
Similar

Different

The Earth orbits the Sun.

The Earth has liquid oceans.

The Earth has an atmosphere.



Both are approximately spherical.

Both rotate.

Both have gravity.



The Moon orbits the Earth.

The Moon has no atmosphere.

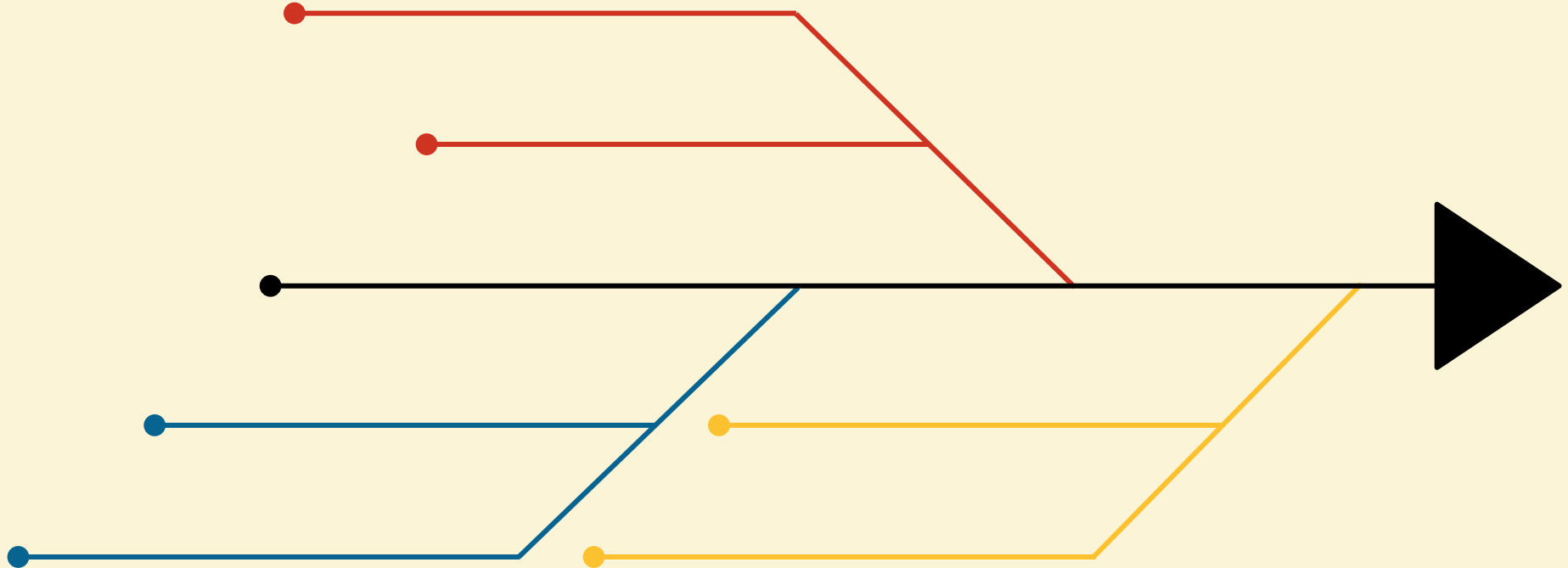
The Moon's orbital period is the same as its rotation period.

Different

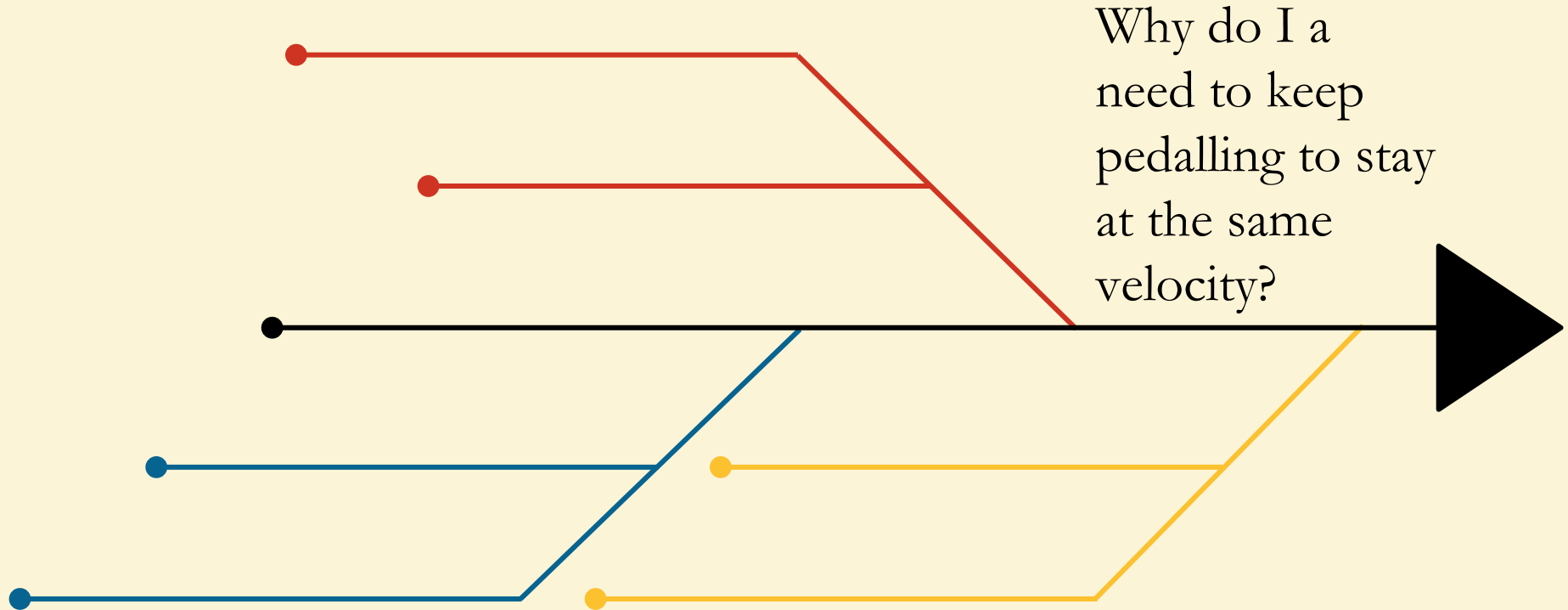
Similar

Different

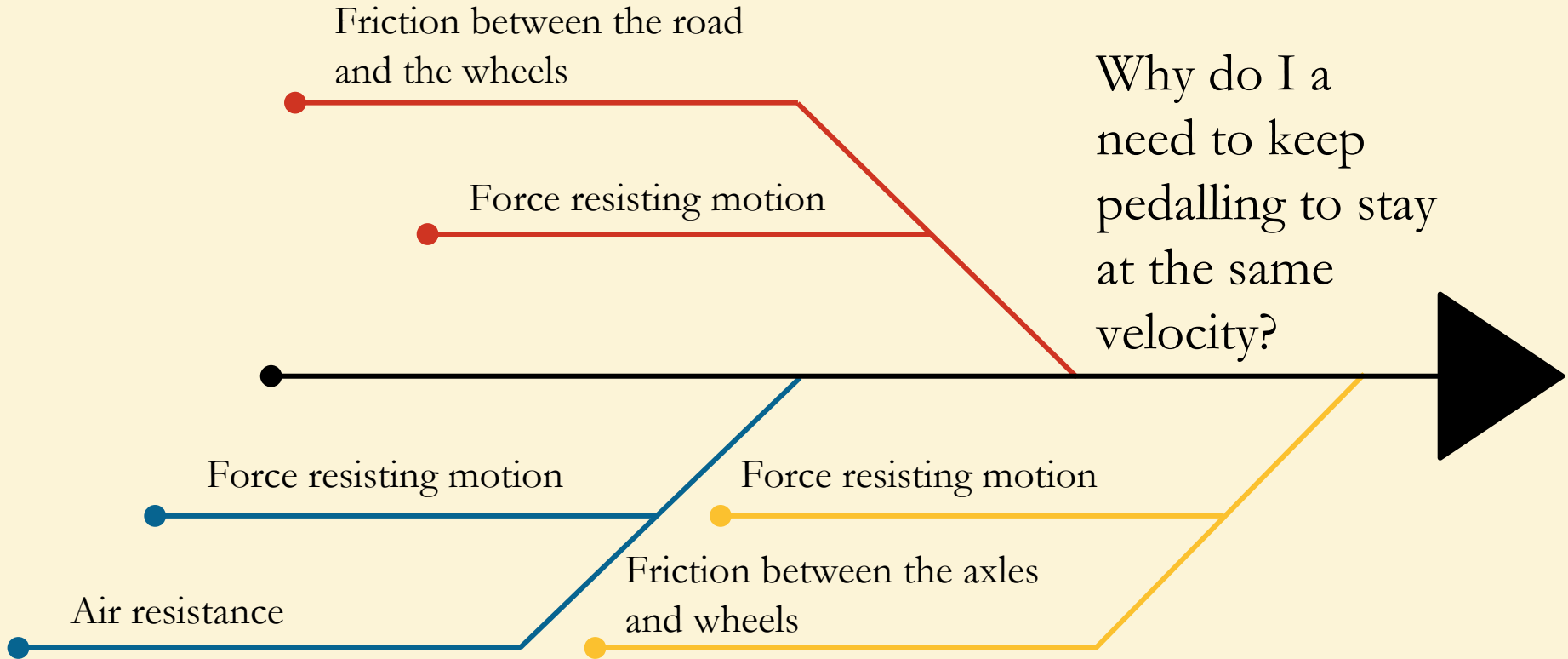
Ishikawa Diagram - Cause and Effect



Ishikawa Diagram - Cause and Effect

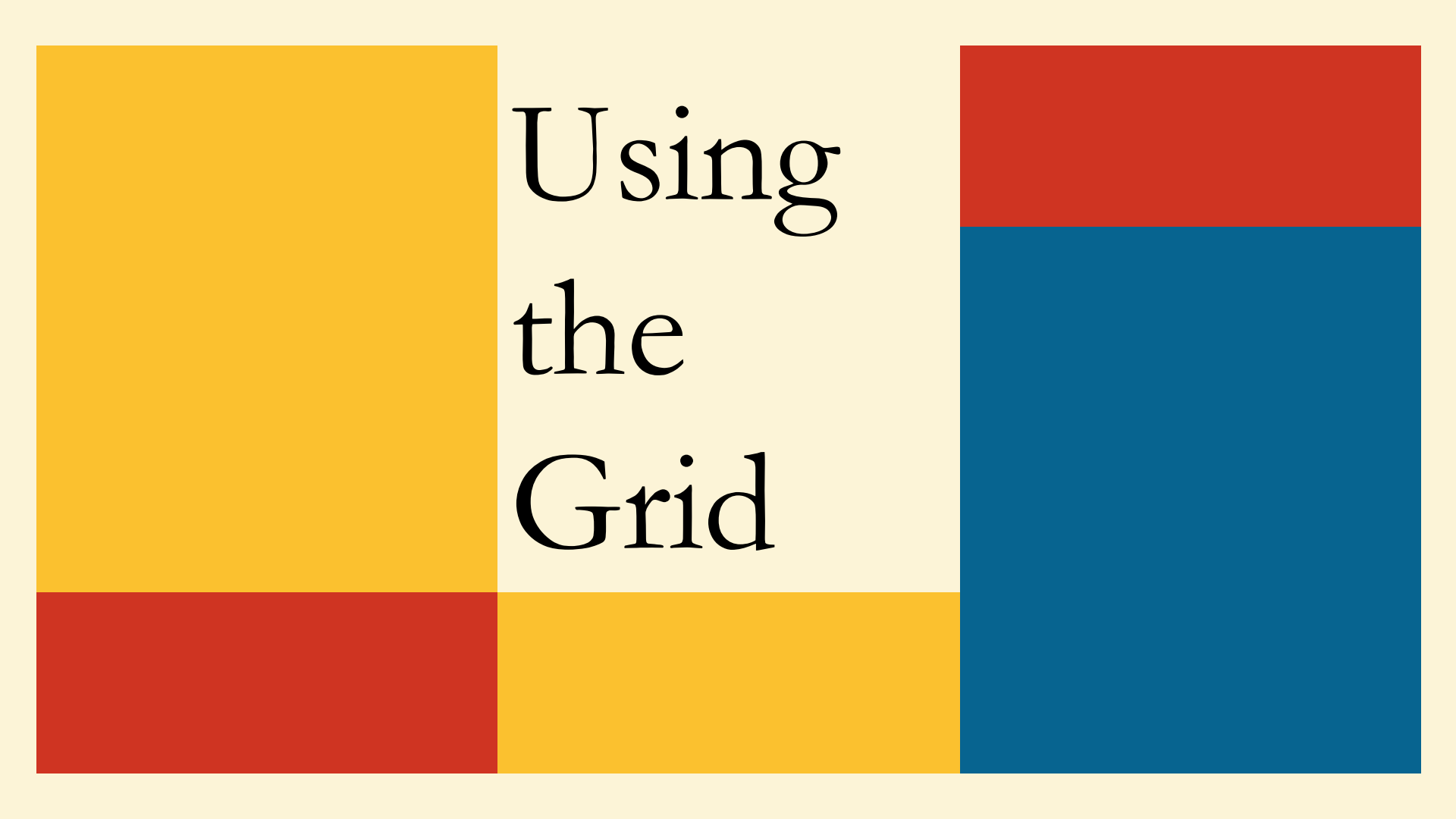


Ishikawa Diagram - Cause and Effect



Teaching

Tidy Layouts Reduce Cognitive Load



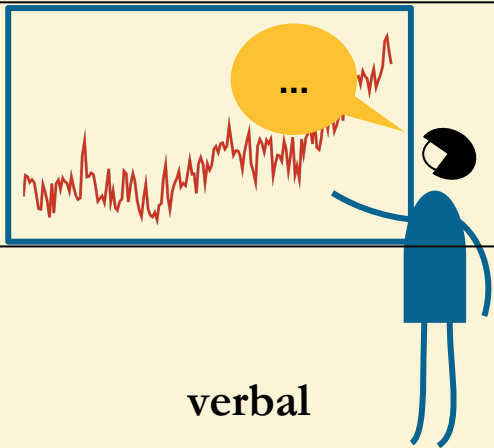
Using
the
Grid

Using

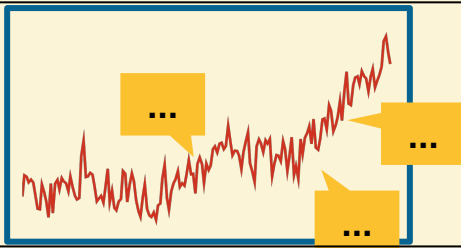
the

Grid

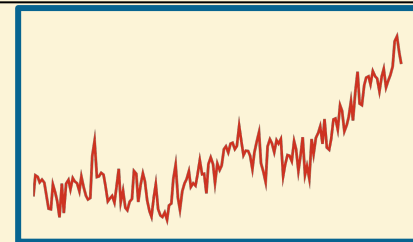
How should I explain my visual?



verbal



labeled

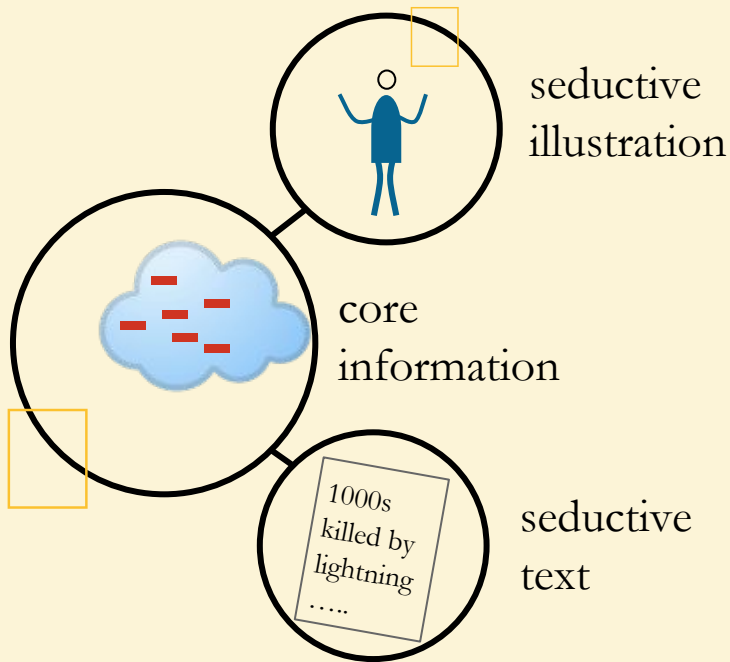


This chart shows the temperature level rise over the past 170 years. Scientists say this is at least in part attributable to human activity - the artificial increase in CO₂ levels globally.

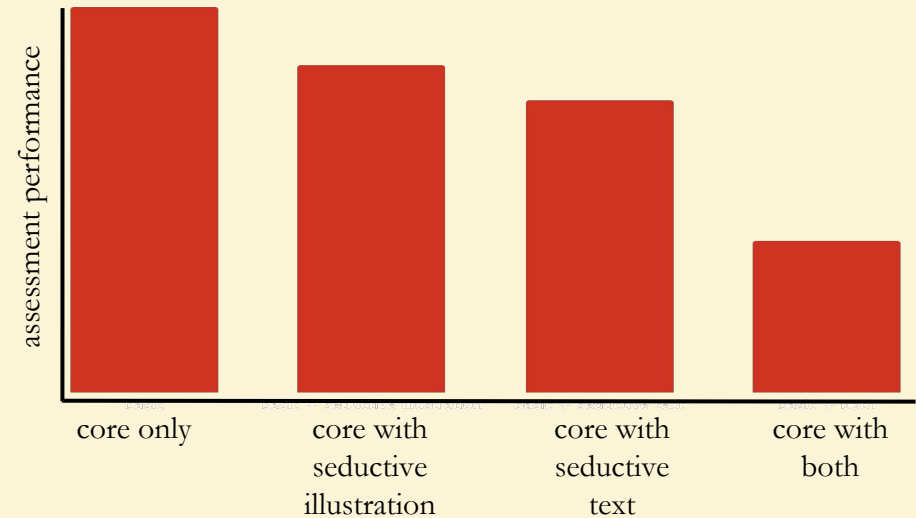
separate text

retrieval

Should I add 'seductive' details?



Adding detail intended to motivate and engage has a detrimental effect on learning.



Summary

Explaining Images

- Explain images to novices (not to experts)
- Verbal beats labeled

Labelling Images

- Dual coding increases retention
- Avoid the Split Attention Effect

Tidiness Matters

- Use ‘the grid’ to design slides
- Insist on tidy working

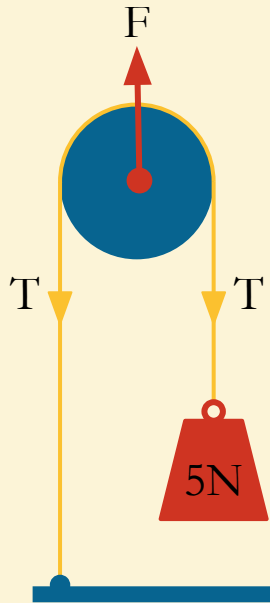
Problem Solving

Computational Efficiency: Search and Inference

One end of a rope is secured to the floor while the other end is passed through a pulley directly above. The free end of the rope is attached to a 5N weight. The weight is suspended by the rope.

What is the size of the force required to suspend the pulley?

Computational Efficiency: Search and Inference



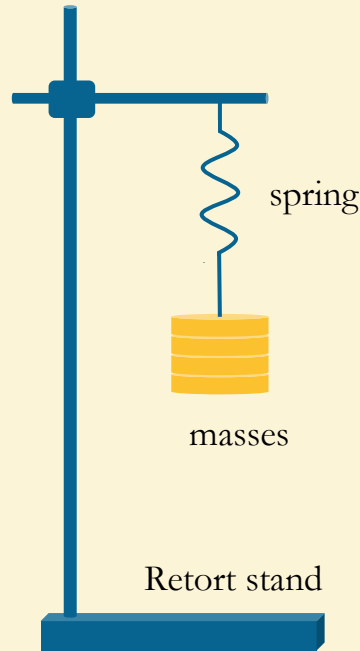
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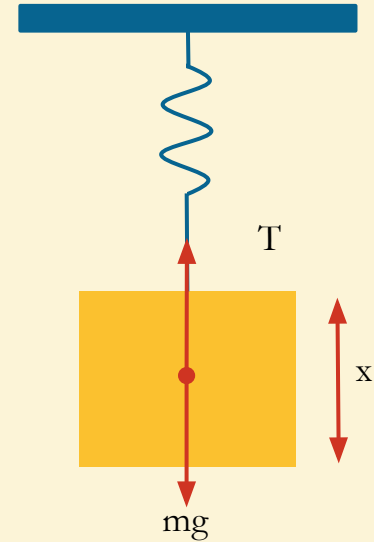
How much detail?



A demonstration, photo or video often shows too much detail for a novice.

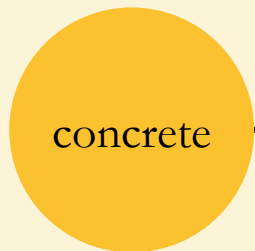
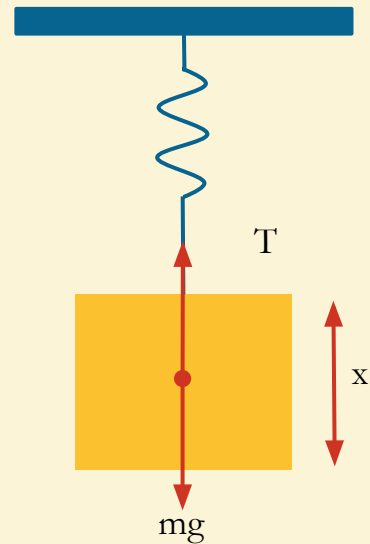
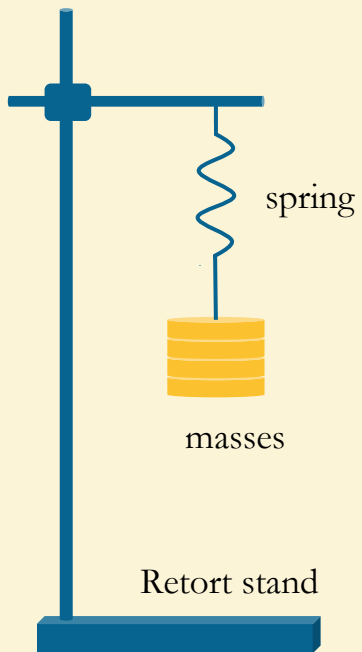


This is a **representational visual**: it shows where the parts go.

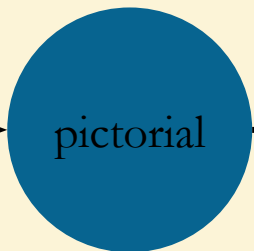


This is an **explanatory visual**: it shows the relationship between parts.

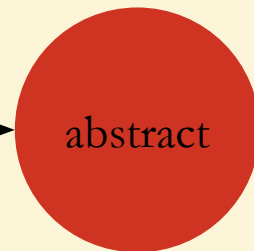
How much detail?



concrete

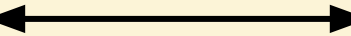
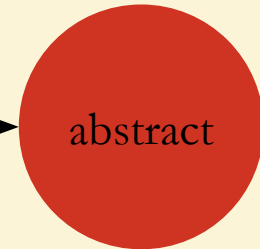
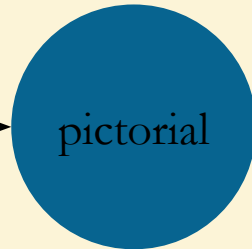
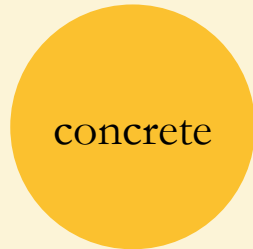
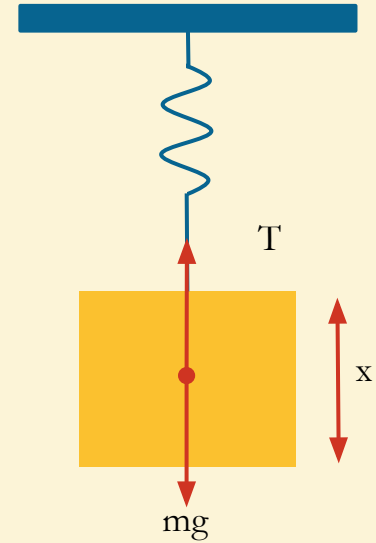
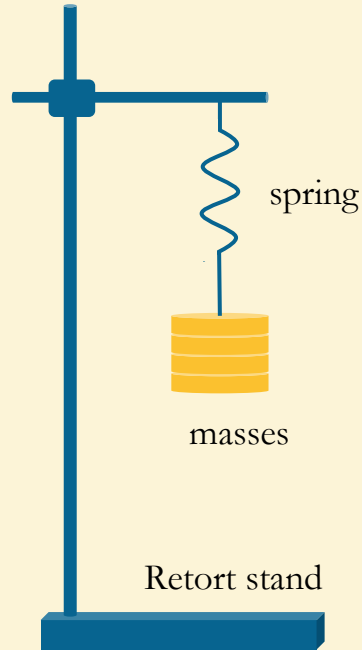


pictorial

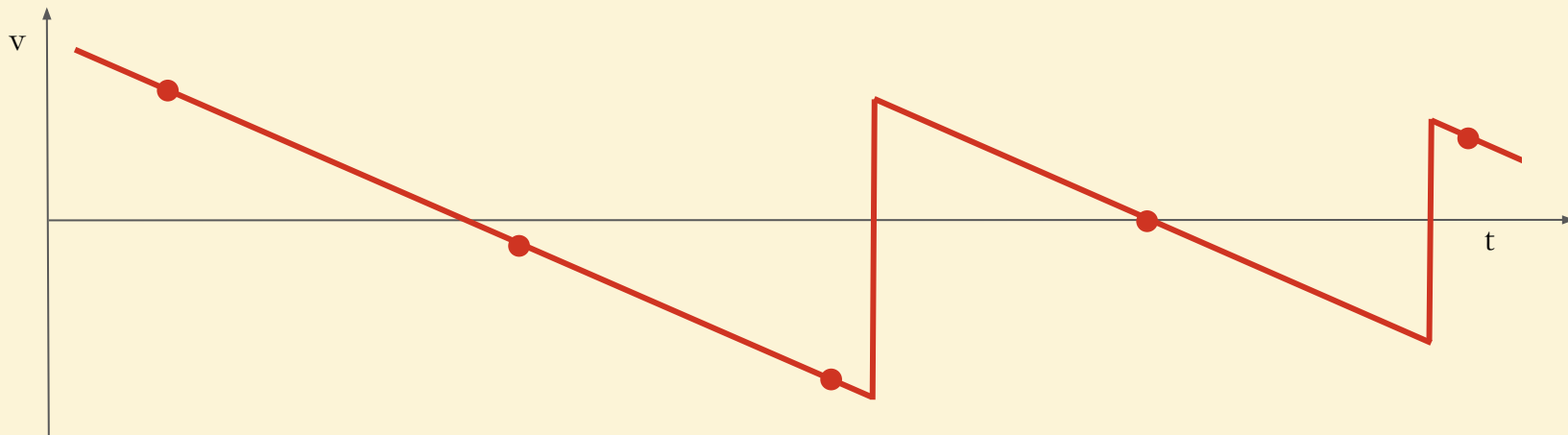


abstract

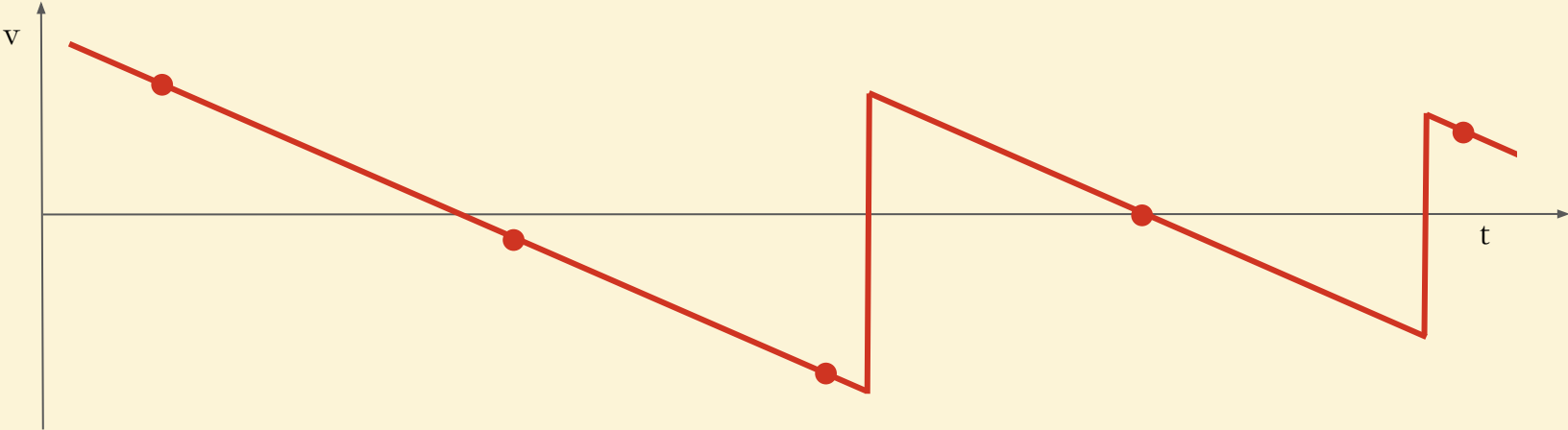
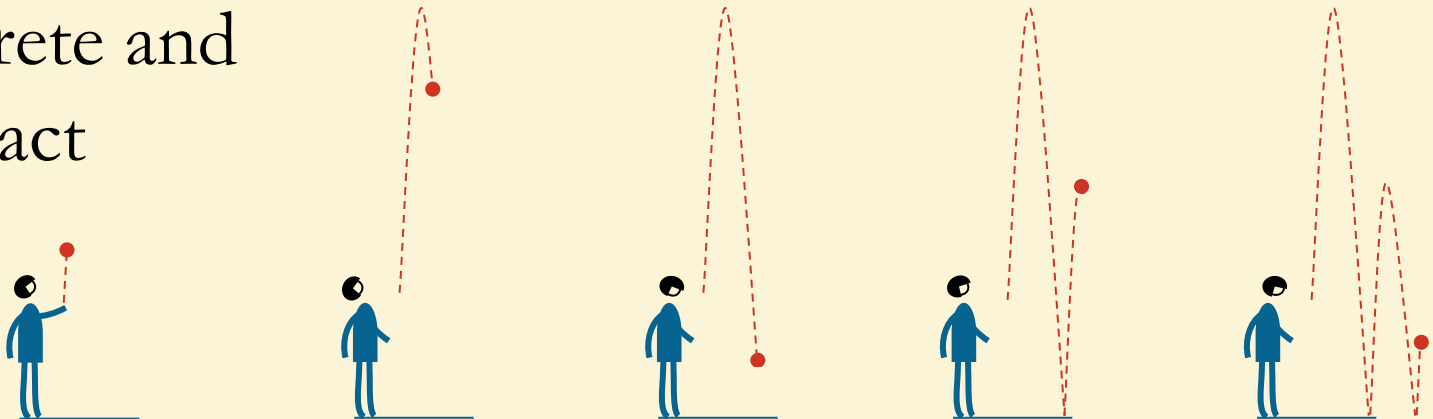
How much detail?



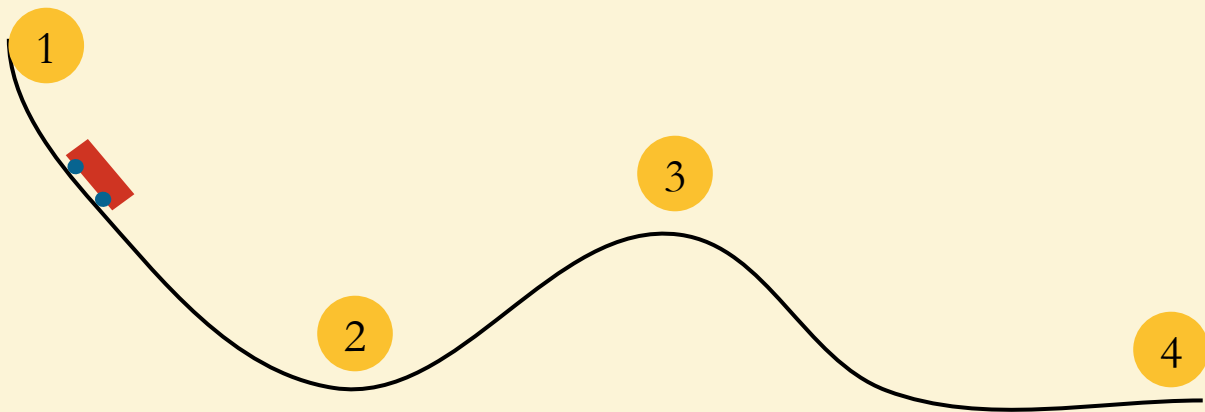
Concrete and Abstract



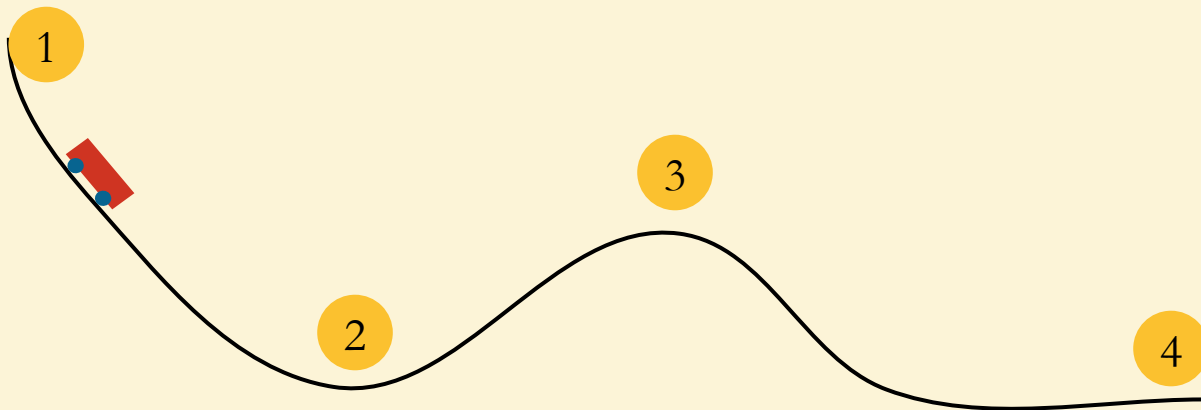
Concrete and Abstract



Concrete



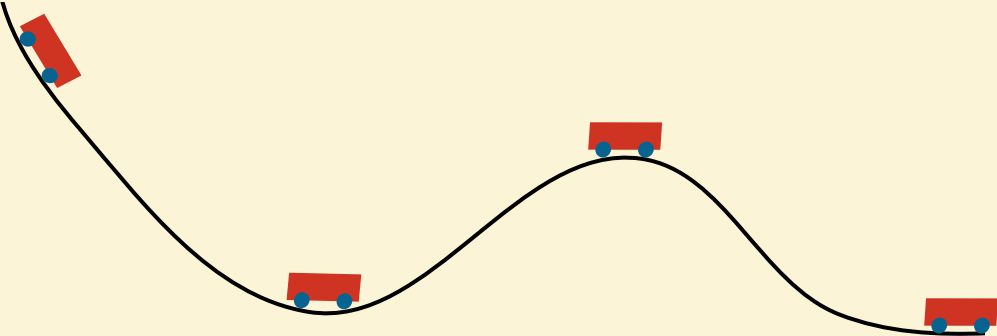
Concrete



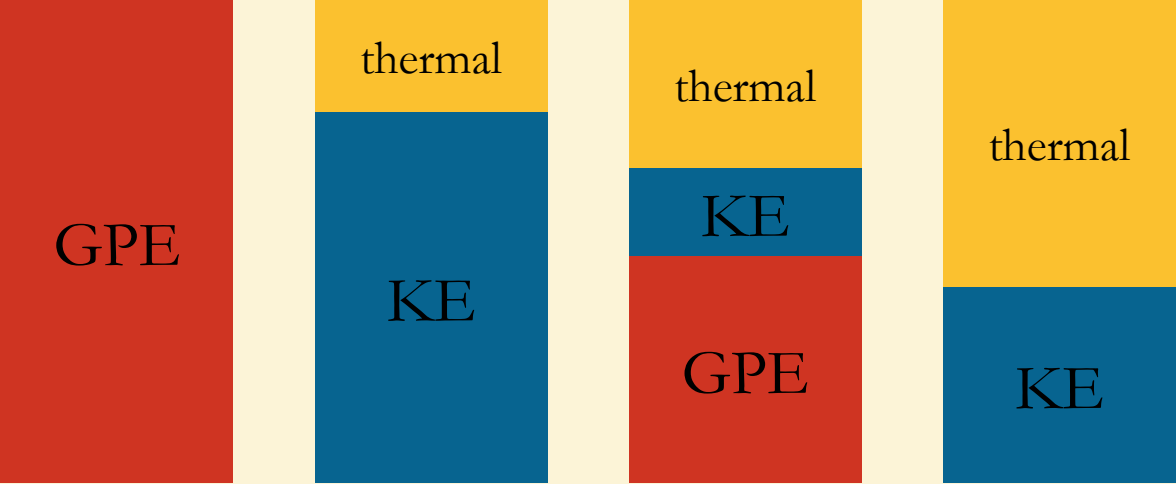
Abstract



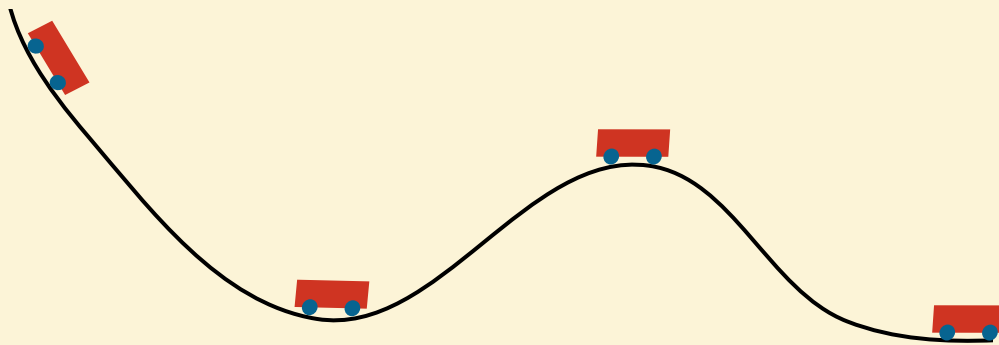
Concrete



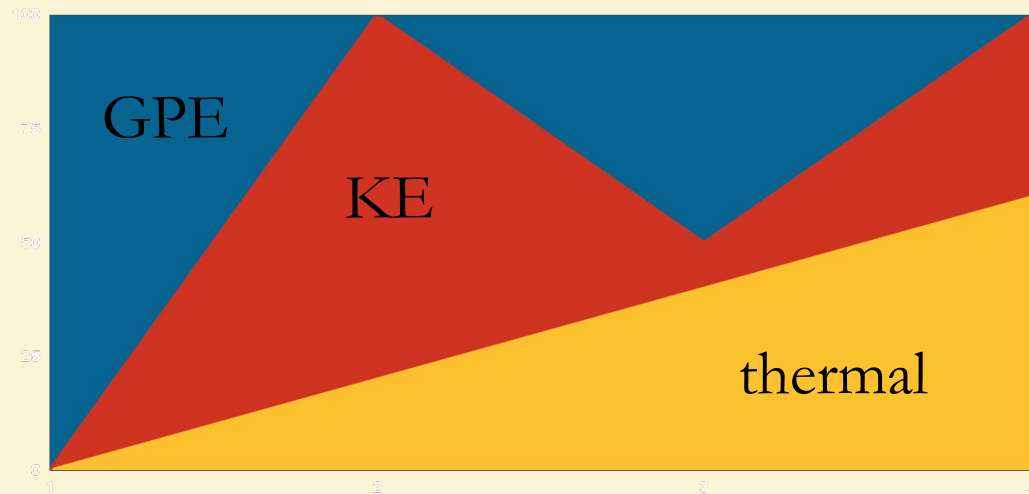
Abstract



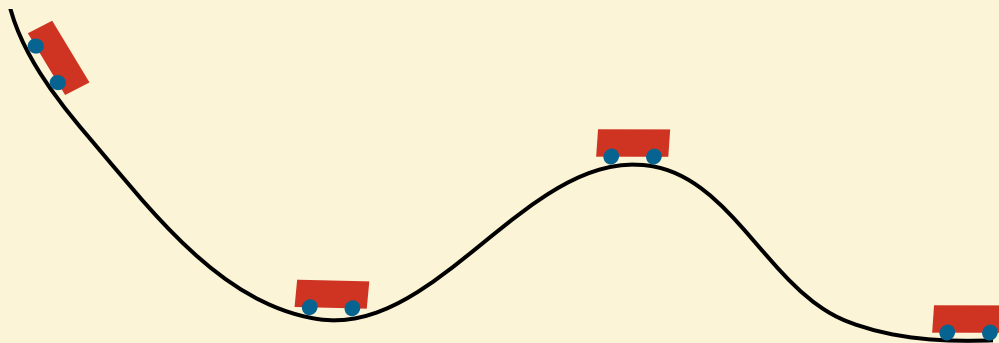
Concrete



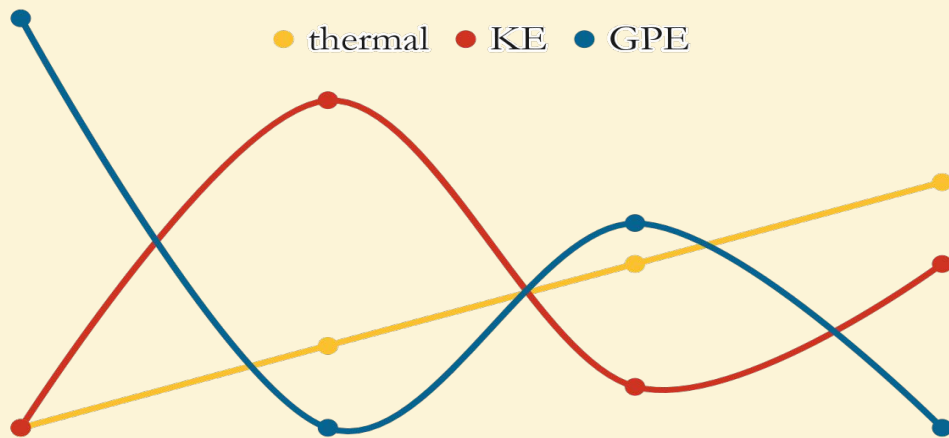
Abstract



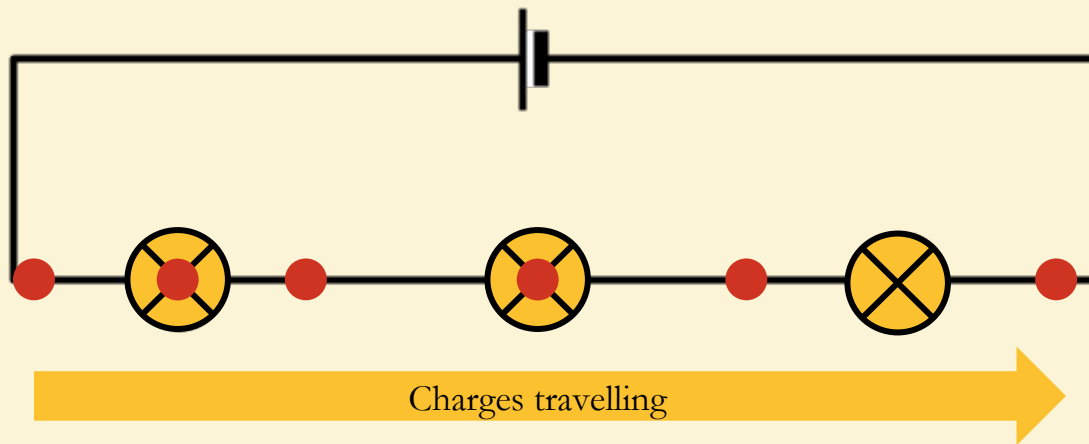
Concrete



Abstract



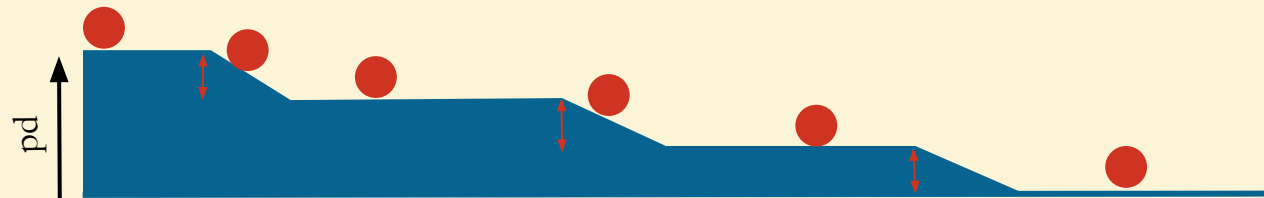
Potential Difference



Concrete



Abstract



Summary

Computational Efficiency

- Design diagrams and visuals to reduce search and inference.

Concrete Pictorial Abstract

- Move up and down the ladder of abstraction.

Drawing with the Body

“When thought overflows the mind, the mind puts it back into the world.”

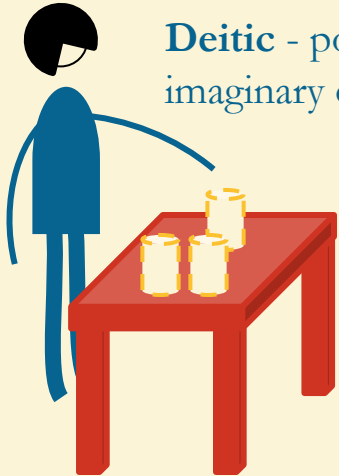
Tversky 2018

Gestures for Thinking

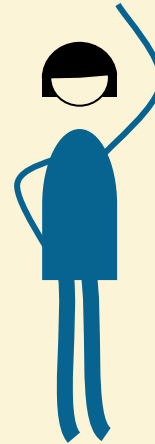
Iconic - representing an action through gesture.



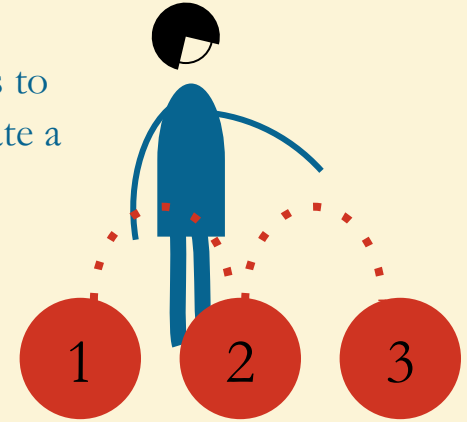
Deitic - pointing at imaginary objects.



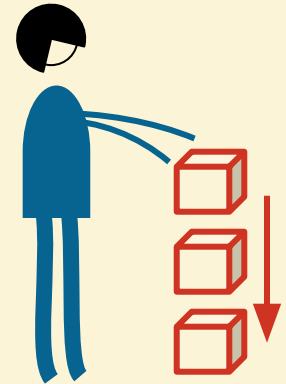
Emblem - classroom gestures with agreed meaning.



Beats - gestures to punctuate a list.



Metaphoric - hand signals which represent abstract ideas.

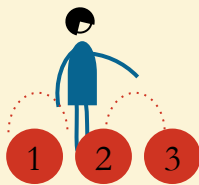


Gestures for Explaining

representational



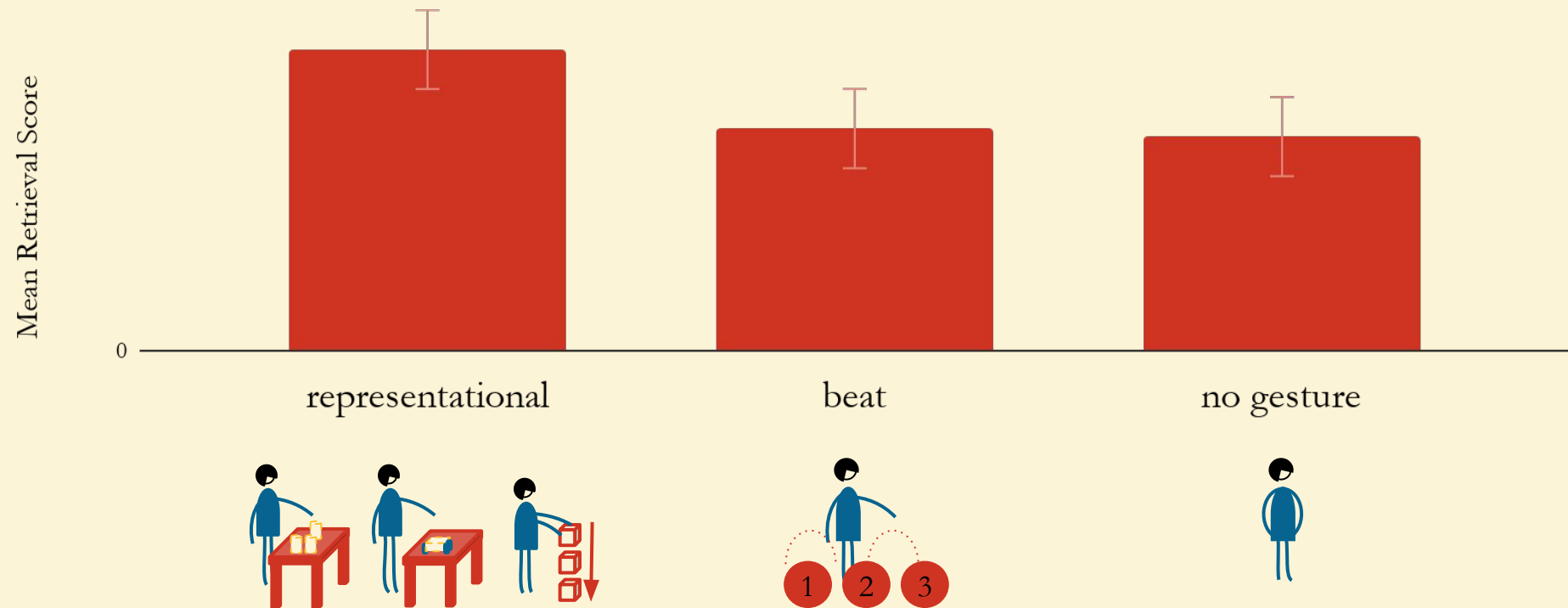
beat



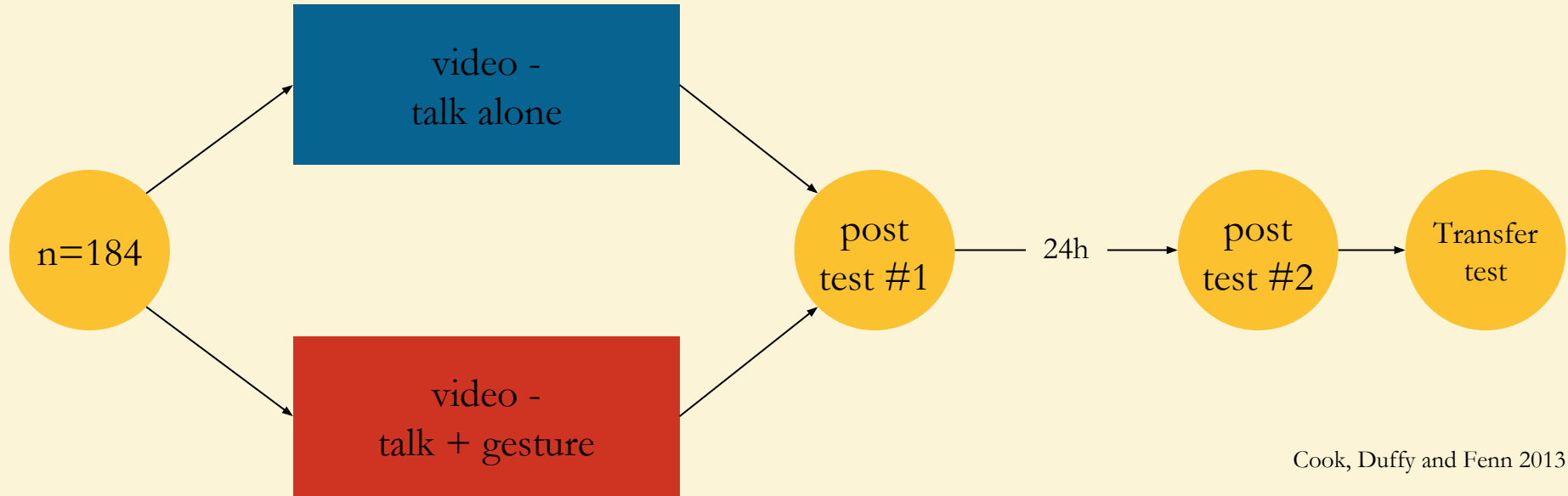
no gesture



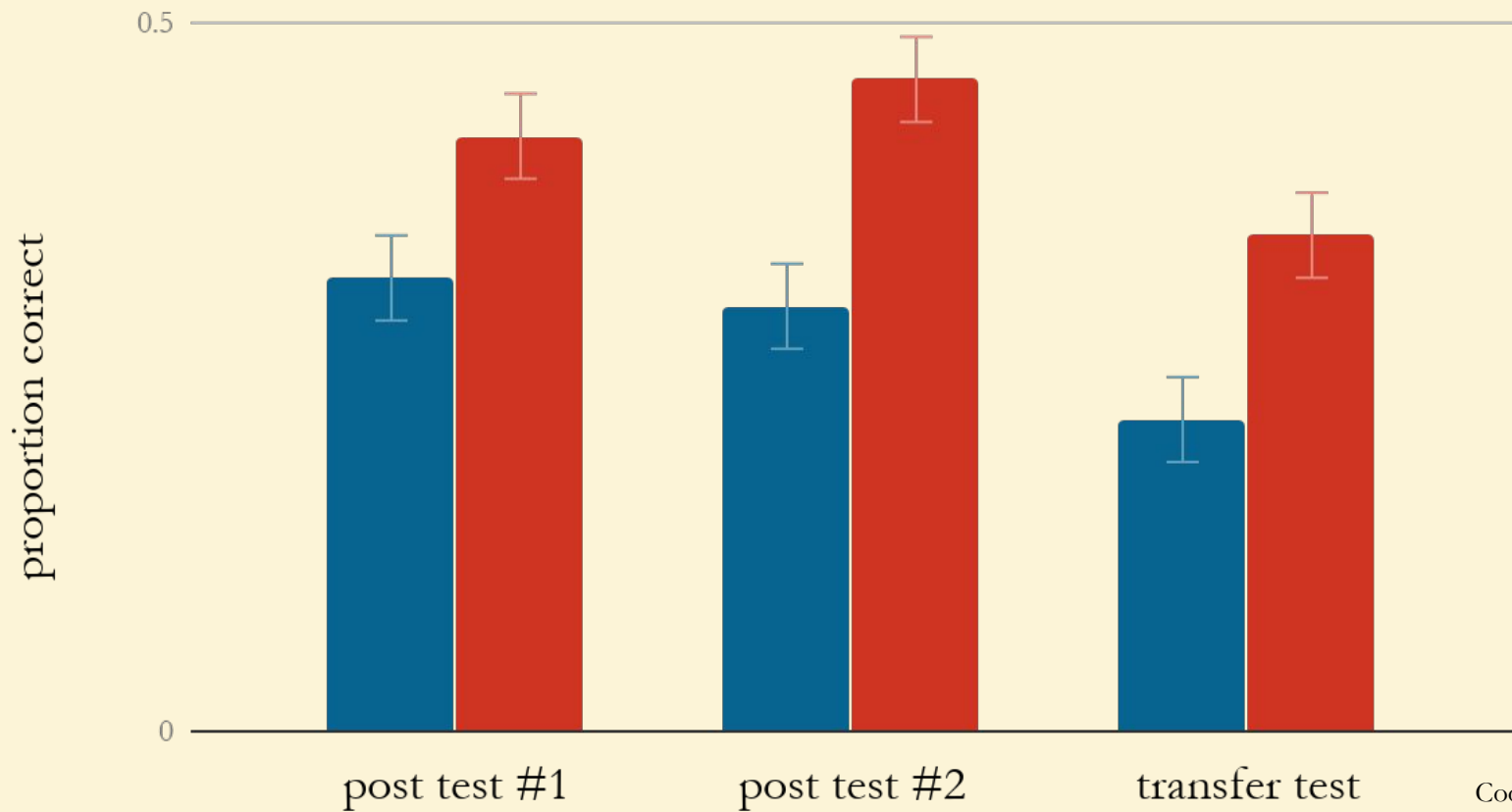
Gestures for Explaining



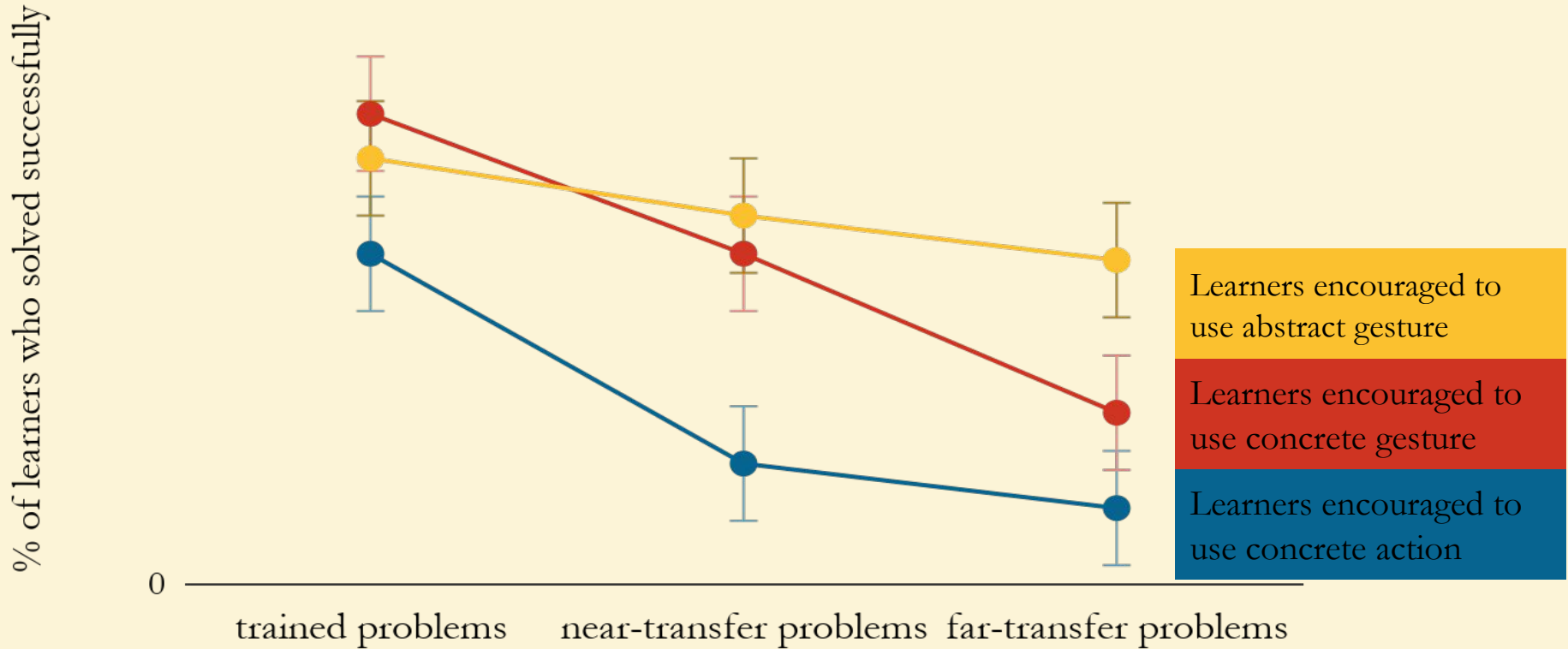
Does Teacher Gesture Improve Learning?



■ speech alone ■ speech + gesture



Should we encourage learners to use gesture?



Summary

Gestures Support Memory

- When learners use gesture, retrieval is enhanced.

Gestures Support Teaching

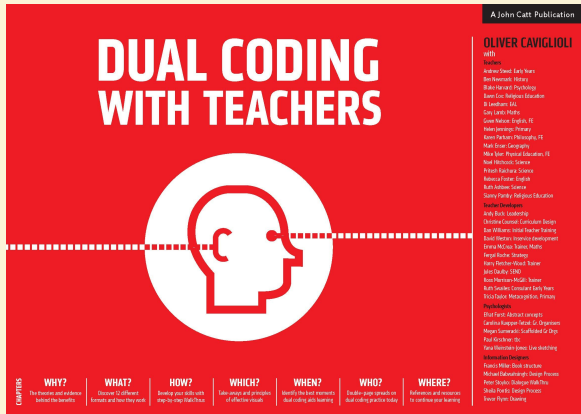
- When teachers use gesture, learning is enhanced.

Gestures Support Problem Solving

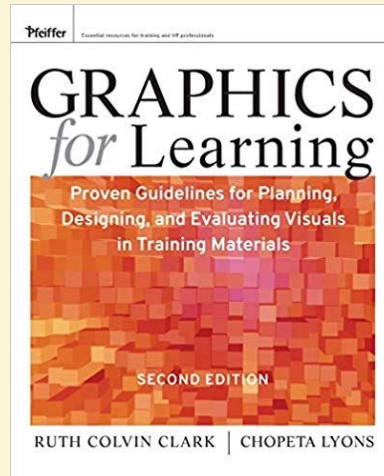
- When learners are encouraged to use gesture, problem solving is enhanced.

Theoretical Influences in this Presentation

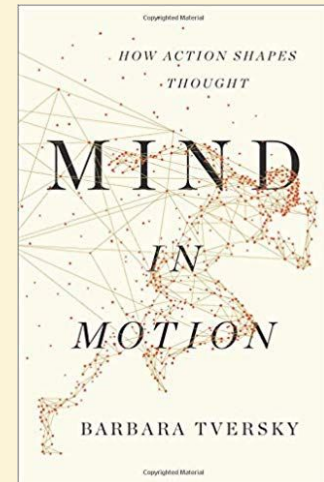
Oliver Caviglioli



Clark and Lyons

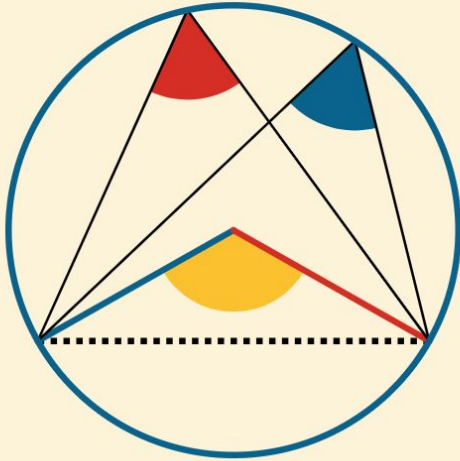


Barbara Tversky



Graphical Influences in this Presentation

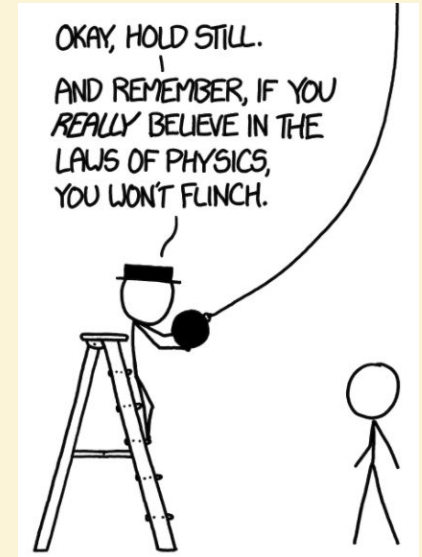
Byrne's Euclid



Grid System



xkcd





The end!