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Transitioning into a discipline – exemplars as cognitive resources in learning physics

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Introduction

Thomas Kuhn: Normal research activity guided by disciplinary matrix and **exemplars**. [1]

Exemplars are “concrete problem solutions, accepted by the group as, in a quite usual sense, paradigmatic” [2, p. 298]

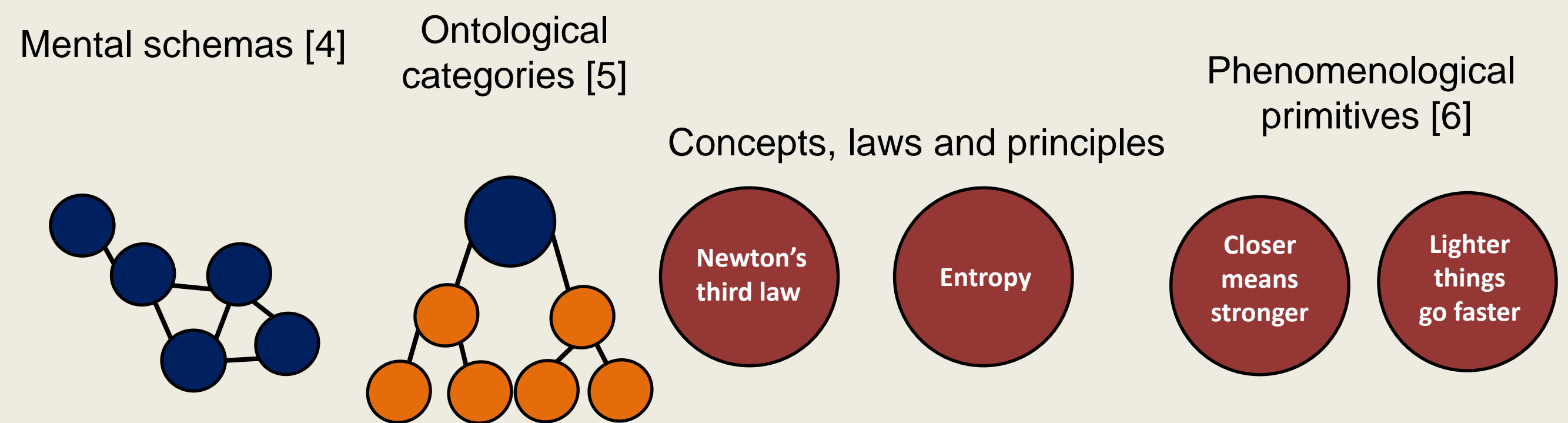
Given their important role in the scientific community, we aim to understand the relevance of exemplars for the individual learner.

Our definition: An exemplar is a specific, but representative, phenomenon, together with its explanation. It is both **paradigmatic within the discipline** and a **cognitive resource** for the individual.

Examples: *Teacher demonstration + explanation, Historical/thought experiment, Lab exercise + discussion, Worked example.*

The resources framework

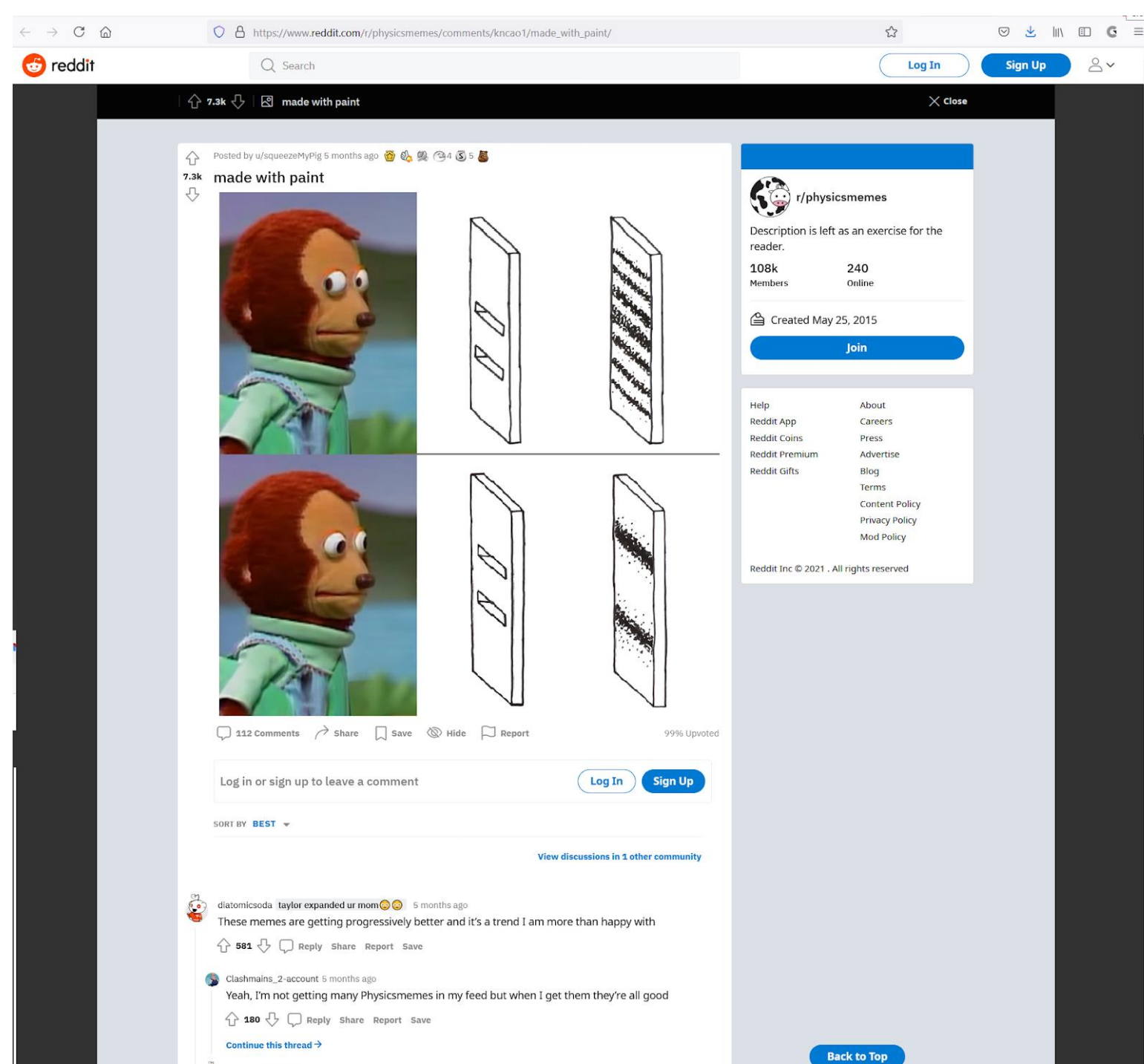
”Resource – a compiled knowledge element [...] [D]ifferent levels of structure may be used as resources by different individuals”. [3, p. 58]



Resources may be exposed through talk. However, full structure is probably not made visible through talk or any other externalisation.

What associations might a student make?

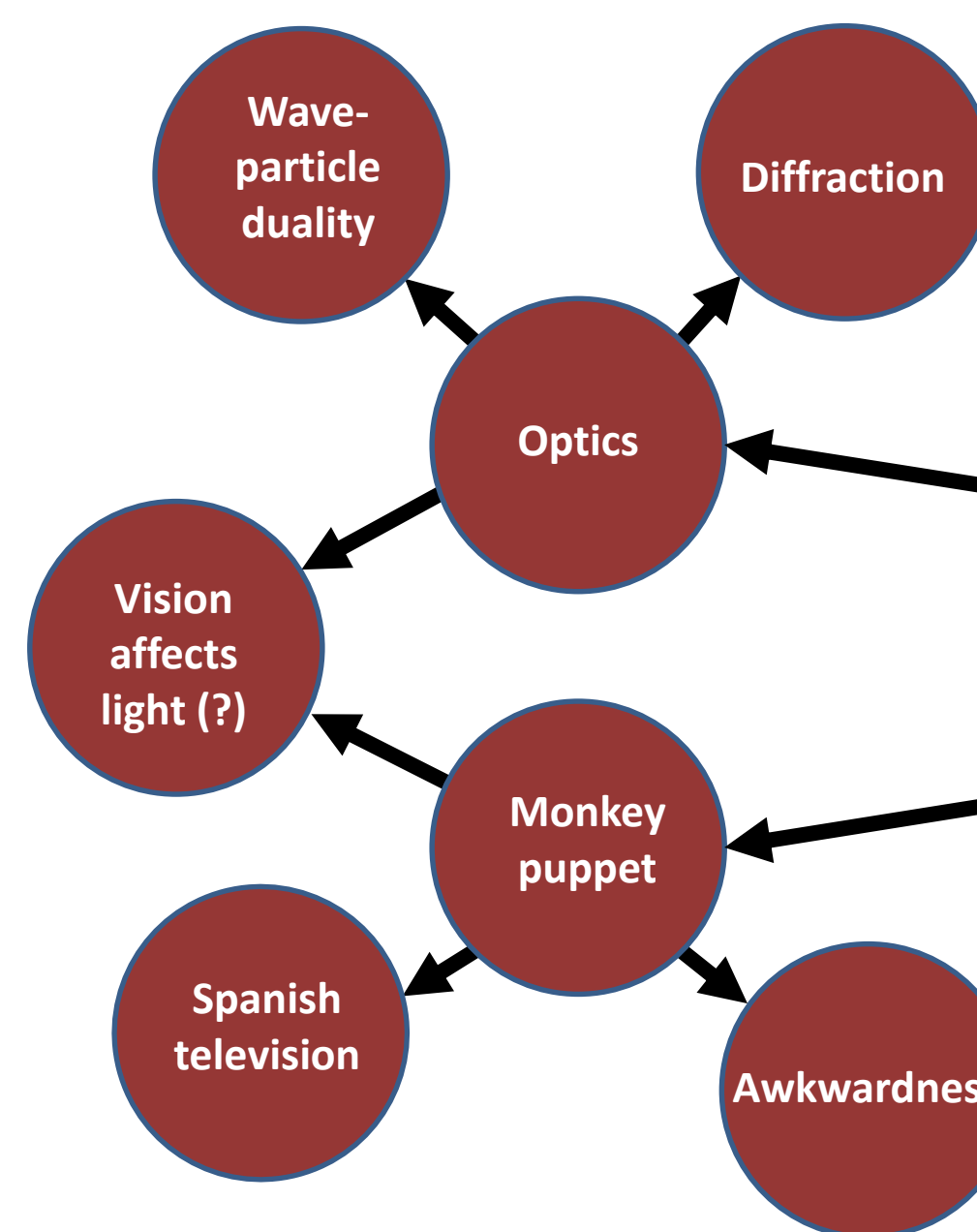
A popular physics meme on Reddit [7]



The exemplar: Quantum measurement in the double slit experiment

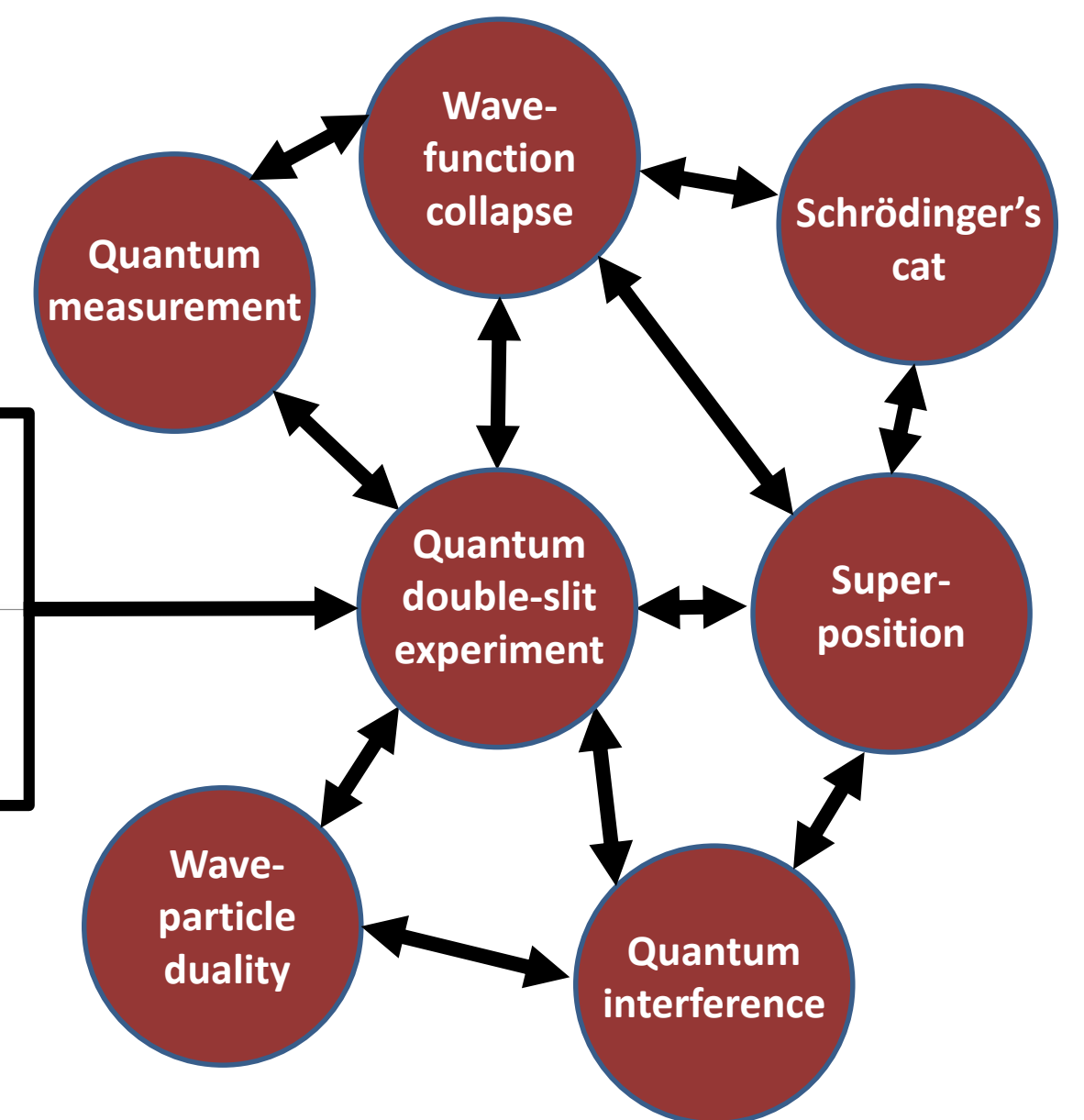
Electrons are sent towards a double slit. The monkey puppet represents an observer making measurements. No measurement: interference pattern. Measurement: wave function collapse, no interference.

Unproductive association without the exemplar



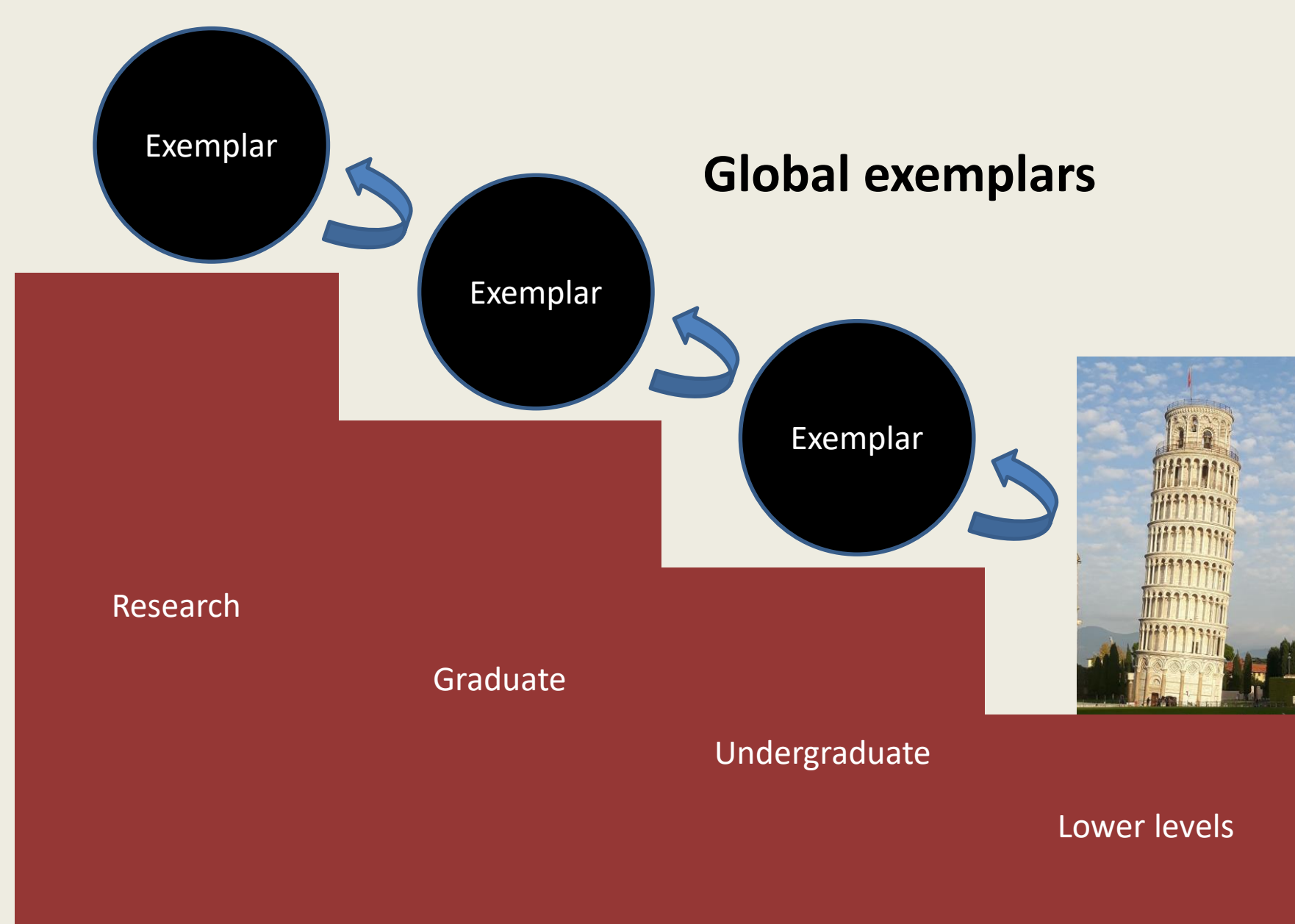
- Loosely connected associations.
- Discrete incoherent schemas.
- Unproductive reasoning.

Productive association with the exemplar



- Activates exemplar as cognitive resource.
- Coherent schema.
- Productive reasoning.

Local exemplars



Exemplars are used as stepping stones in order to transition into the discipline. Global exemplars are refined toward the local exemplars. [8]

“All physicists [...] begin by learning the same exemplars: problems such as the inclined plane [...]; instruments such as the vernier, the calorimeter, and the Wheatstone bridge. As their training develops, however, the symbolic generalizations they share are increasingly illustrated by different exemplars. Though both solid-state and field-theoretic physicists share the Schrödinger equation, only its more elementary applications are common to both groups.” [1, p. 187]

Future directions

Studying exemplars within Physics Education Research may inform us about

- How exemplars are used by learners and experts.
- Construction of curriculum and syllabus.
- How to facilitate smooth transitions between educational levels.
- How learning works at the highest levels of education.

Exemplars may be studied through

- Observation studies.
- Metacognition/problem solving strategies.
- Interviews with teachers and experts.

Exemplars may provide a bridge between disciplinary knowledge and educational research.

References

- [1] Kuhn, T. S. *The Structure of Scientific Revolutions* (Second ed.). University of Chicago Press, 1970.
- [2] Kuhn, T. S. *The essential tension*. University of Chicago Press, 1977.
- [3] Redish, E. *Proceedings of the International School of Physics “Enrico Fermi” Course CLVI: Research on Physics Education* (2004) 1–56. [[physics/0411149](https://arxiv.org/abs/physics/0411149)].
- [4] Piaget, J. *The Origins of Intelligence in Children*. International University Press, 1952.
- [5] Chi, M. *et al. Learning and Instruction* **4** (1994) 27–43.
- [6] diSessa, A. A. *Cognition and Instruction* **10(2)** (1993) 105–225.
- [7] https://www.reddit.com/r/physicsmemes/comments/kncao1/made_with_paint/ (screenshot 15 June 2021).
- [8] Klang, P. *Språk och stil* **NF 29** (2019) 233–260.