

Categorizing Concepts and Concept-Links to Examine Student Understanding

DYAN L. MCBRIDE
ADVISOR: DEAN A. ZOLLMAN

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Types of Concepts – Original works

- **Original Concepts Categorizations – Northrop³**
 - Concepts by intuition
 - Concepts by postulation
- **Original works by Lawson⁴**
 - Concepts by Apprehension
 - ✦ Immediately sensed – hot, cold, sharp, hunger
 - Descriptive Concepts
 - ✦ Learned but basic and deeply engrained – table, eat, beside, above
 - Theoretical Concepts
 - ✦ Highest level, for causal events – magic, ghosts, imaginations

3. Northrop, 1947 4. Lawson & Renner, 1975 and Lawson & Thompson, 1988

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Recent Categorizations

- **Newer works by Lawson, et. al.⁵ – Biology context**
 - Descriptive Concepts
 - ✦ Easily observed
 - food chain, carnivore, nocturnal
 - Hypothetical Concepts
 - ✦ Could be observed if given enough time
 - fossils, natural selection, and evolution
 - Theoretical Concepts
 - ✦ Impossible to observe
 - Molecules, air pressure, genes, osmosis


5. Lawson, et al., 2000

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Meaningful Understanding

Nieswandt and Bellomo⁶: Concept Links matter

- **Single-level links – two concepts at same level**
 - Descriptive-descriptive, hypothetical-hypothetical
- **Cross-level links – two concepts at different levels**
 - Descriptive-hypothetical, hypothetical-theoretical
- **Multi-level links – all three levels together**
 - Descriptive-hypothetical-theoretical



Increasing Difficulty

6. Nieswandt & Bellomo, 2008

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Drawbacks of Prior Schemes

Prior Studies - Biology	Our Context - Physics
<ul style="list-style-type: none"> • Dependence on Time <ul style="list-style-type: none"> ○ Defining characteristic of observability • Expertise Irrelevant <ul style="list-style-type: none"> ○ Student answers compared to an "expert" response <ul style="list-style-type: none"> ✦ Example: fossils 	<ul style="list-style-type: none"> • No time-dependence <ul style="list-style-type: none"> ○ Observability depends on other factors • Expertise Level Matters <ul style="list-style-type: none"> ○ Want to focus on the perspective of the students <ul style="list-style-type: none"> ✦ Examples: temperature, wavefronts

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Categorization based on Observability

Retain essence of Observability-based categorization

- **Descriptive Concepts**
 - Concepts that can be *directly observed*
 - ✦ Speed, magnification, period of oscillation
- **Hypothetical Concepts**
 - Concepts that *could be observed*, given appropriate set-up
 - ✦ Atomic spectra, center of mass, infrared light
- **Theoretical Concepts**
 - Concepts that *cannot be observed*, regardless of set-up
 - ✦ Thermal conduction, entropy, gravitational force

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Concept Links

- **Single-level Links**
 - Involve concepts at only one level
- **Cross-level Links**
 - Involve concepts at any two levels
- **Multi-level Links**
 - Involve concepts from each level

Can include any number of concepts

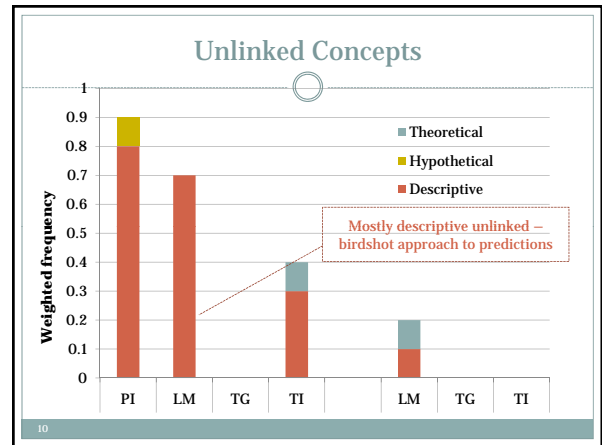
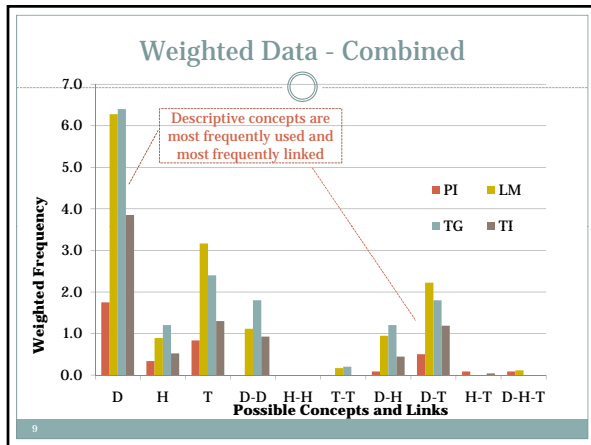
Must be all part of the same idea or "thought"

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Example Analysis

- *Interviewer: So what do you think would happen to the grid pattern if the lens of the eye had some sort of defect?*
- *Student 1: I think instead of being like, right now you have one of these shapes [hexagon], like, I think that one of the points would move in toward center. Because it would, like instead of light going uniformly through [the lens] and creating this pattern, one would kind of like warp in this direction.*
- *Student 2: Yeah, well, I think light would be hitting the smaller [array] lenses at a different angle because of the increased or decreased focal length of the lens [at the site of the defect]*

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Conclusions and Future Works

- Concept categorization technique can be a valuable tool for assessing what types of concepts use, and how they link those concepts together.
- Small modifications to the original works of Lawson *et al.* and Nieswandt and Bellomo in the field of biology have provided a scheme which can be easily applied to many physics contexts while still preserving and even extending the essence of the original method.
- Next: tie to other physics learning theories, such as Hammer's resources, diSessa's theories of p-prims, and the causal net, and our ideas of transfer.

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