

Breaking The Whole
Into Its Parts:
Categorizing Items on a
Survey of
Student Ideas About
Quantization.

Physics Education Research
Group

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Supported by NSF GER 9553460
and NSF DUE 9653145

Outline

for the two talks:

1. Goals of Project
2. Methodology
3. Focus on the Photon
4. Theoretical Model
5. Focus on Atomic Transitions
and the Electron
6. Future Work

1. Goals of Project

Primary goal: Discover students' conceptions of *QUANTIZATION* before explicit instruction.

Secondary goals:

- Learn how these conceptions change as a result of instruction.
- Create diagnostic survey
- Identify or create appropriate curricular materials
- Discover students' ideas about light and atoms

2. Methodology

- Interviews
- Written surveys

Intention: let students themselves guide our inquiry.

Procedure: to find out what students think about *quantization*, ask them about:

- Photons
- Electrons
- Atomic transitions

3. Focus on the Photon

3a. Interviews and written surveys

focus on:

- The nature of photons and quantization
- Mental images of photons
- Properties of photons
- Interpretations of simple situations involving light sources.

3a. Interviews and Surveys (continued)

Interviews were open-ended.

Survey included:

- 5 multiple-choice questions, and
- 41 Likert-scale (agree-disagree) items.

Survey item content was taken from interview transcripts.

Example Likert scale items:

- A photon is a particle that carries light.
- Photons are spherically shaped, like protons or neutrons.

3a. Interviews and Surveys (continued)

Interviews (73) and surveys (374)
generally show that:

- Many students have heard the word “photon,” but few have clear mental images of photons and their properties.
- Those images they do have are diverse.
- Graduate students and physicists also struggle with mental images, but the images they have are generally more elaborate than those of high school students and undergraduates.

3b. Grouping Survey Items by topic

- Quantization (2 categories)
- * Photon vs. light
- Photons are not real
- * Size of photons
- Shape of photons
- Producing photons
- Color/frequency
- Wave-particle duality
- Observing/detecting photons
- Photons as a force between objects
- Slit experiments and “chopping off”
- Shadows
- Photons are protons (or another part of the atom)

3b. Grouping Survey Items (continued): Size of photons

Likert-scale items relating to photon size			
N = 374			
			major difference
	disagree	agree	agree-disagree
A photon is much smaller than an electron.	16%	48%	32%
A photon is a few nanometers across.	23%	17%	-6%
A photon is about the same size as a proton.	38%	11%	-26%
A photon is a point. It doesn't really have a size.	36%	23%	-13%

4. Developing a Theoretical Model Minstrell's *Facets**

Facets are specific student ideas, misconceptions, or errors that pertain to a particular physics idea or physical situation.

E.g., “Heavier objects fall faster.”

Facets relating to each idea are grouped together, and are ordered according to their “correctness.”

* J. Minstrell, “Facets of students’ knowledge and relevant instruction,” in R. Duit, F. Goldberg, and H. Niedderer, eds., *Research in Physics Learning: Theoretical Issues and Empirical Studies* (IPN: Kiel, Germany, 1992);

J. Minstrell, “Building Facet-Based Learning Environments,” *AAPT Announcer* **29**(2), 131 (1999).

4. Developing a Theoretical Model (continued)

- “*Conceptinos*:” dividing survey items and interview transcripts into small ideas. E.g.:

A photon {is a particle} [that carries light].

- *Concept tree*: listing and arranging the ideas fundamental to quantization.

Change of focus:

See BB9