Understanding Undergraduate Students' Conceptions of A Core Nanoscience Concept: Size and Scale

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Abstract:

The rapidly growing field of nanoscience and nanotechnology calls for the inclusion of general nano-education in our educational agenda. Student understanding of one of the key concepts in nanoscience, *size and scale*, serves as a prerequisite for students' learning of more advanced nanoscale science and technology. This paper presents the findings of a small-scale qualitative study with students studying nanoscale science aimed at exploring the ways they understand the idea of "size and scale". Results suggest wide variation in the way students understand this concept. The study identifies a preliminary typology of student conceptions of *size and scale* as it relates to macro and sub-macro phenomena along three key dimensions. In addition, the research identified a critical paradigmatic experience which appears to play a role in hindering the development of more complex and sophisticated understanding at each level of conception.

Rationale of the study:

• *Size & Scale* has been identified as one of the "big ideas" of nanoscience (Stevens et al., 2006).

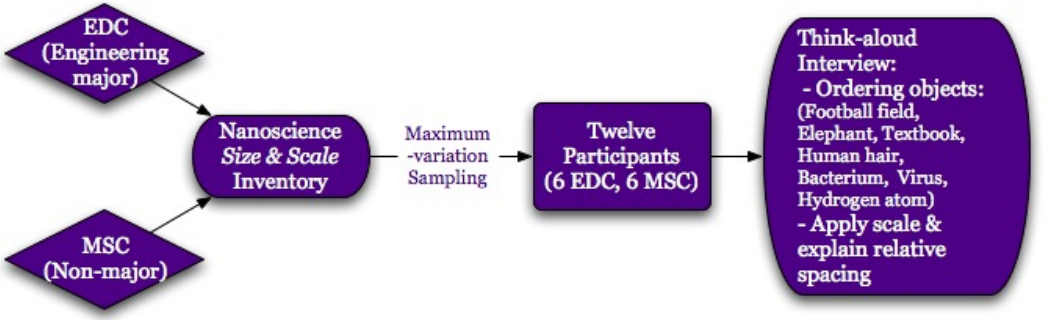
• Undergraduate students are reported to have difficulty in mastering this concept (Drane et al., 2007).

• Previous research on *size & scale* has not examined undergraduates' conception of this big idea (Tretter et al., 2006).

Research goal:

To identify undergraduate students' conceptions of *size & scale*, and to explore barriers that prevent them from fully grasping this idea.

Methods:



Results:

A preliminary typology of students' conception of *size & scale:*

Type	Type-1		Type-2	Type-3	
Sub-type	1a	1b	2	3a	3b
Nature of continuum	Continuous			Fragmented	
Category of scale used	Logarithmic		Hybrid	Linear	
Main characteristics	1.Understood that the logarithmic scale is a "real scale that can be applied across the macro – sub-macro continuum. 2.Able to provide correct explanation for the log scale's construction (e.g. even spacing) and the advantage of using it.	1. Applied the logarithmic scale across the macro – sub-macro continuum. 2. Viewed the log scale as a "scientific" way of scaling, not a "real" scale. 3.Relied on memorization to construct it.	1. Understood that a scale could be applied across all sizes. 2. Applied a hybrid scale that included elements of both logarithmic and linear scales. 3.Able to provide primitive explanation for the advantage of using it; But unable to explain the log scale's construction (e.g. even spacing).	1. Held fragmented conception of scale across all sizes; Viewed the macro and sub-macro worlds as divided. 2. Applied the linear scale based on actual sizes. 3. Attempted to assign numbers to the scale	1. Held fragmented conception of scale across all sizes; Viewed the macro and sub-macro worlds as divided. 2. Applied the linear scale based on actual sizes. 3. No attempt to assign numbers to the scale

Discussion & Conclusion:

• Despite the small sample size, this study successfully delineates a preliminary typology of undergraduate students' conception of *Size & Scale*. In particular, the typology can be viewed in terms of increasing understanding with respect to three dimensions:

- Nature of continuum
- Nature of scale type used
- Nature of understanding of the particular scale used

• Students' choice and explanation of their scale revealed a strong reliance on visual experience.

• Some students hold the belief of a separation of the "two worlds", i.e. the Macro/visible vs. Sub-macro/invisible world.

• Confusions over Imperial vs. Metric unit system poses particular barriers for American students to grasp the idea of *Size & Scale*.