Exploring Variations in and Developing Typology for Undergraduate Students' Conception of "Size & Scale"

Eun Jung Park, Su Swarat, Greg Light, & Denise Drane Northwestern University

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Abstract

"Size & Scale" is crucial to the understanding of nanoscience, and seems to be a difficult concept for undergraduate students. Yet little is known about how these students conceptualize this concept. An interview study was conducted to identify variations in and typology for students' conception of "Size & Scale", and a subsequent study with a larger population preliminarily confirmed the validity of the typology.

Study design

• Study 1: To identify variations in students' conception of "Size & Scale"

  • Twelve students enrolled in an engineering-major design course and a non-major material science course (Spring 06)

  • Think-aloud interview in which students were required to order and construct scale(s) for objects of different size

• Study 2: To test, using a different assessment tool, whether the variations identified in Study 1 would hold in a larger population

  • Ninety five students enrolled in the same two courses (Spring 07)

  • Four short-answer questions developed based on Study 1 interview results were completed in written form

Rationale of the study

• A firm understanding of "Size & Scale" is the prerequisite for students' learning of advanced nanoscience concepts

• Though seemingly an easy concept, students have difficulty grasp the concept, even after formal instruction (Drane, et al., Accepted)

• Students of different age groups have shown difficulty understanding the concept, particularly with the indirectly-experienced ends of size spectrum (Tretter, et. al., 2006)

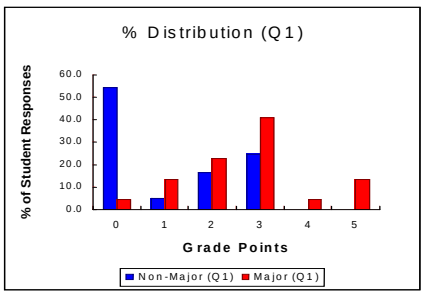
• Little is known about undergraduate students' conception of "Size & Scale"

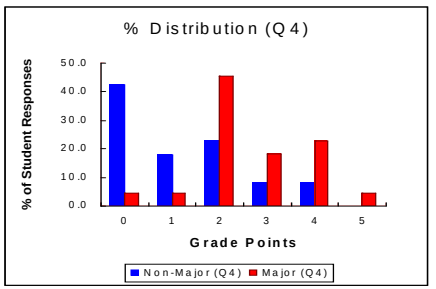
Results

• Study 1: Interviews revealed 3 major types of students' conception, and 2 dimensions along which students' conceptions vary

Type	Type-1		Type-2	Type-3	
Sub-type	1a	1b	2	3a	3b
Nature of Continuum	Continuous			Fragmented	
Categories of scale used	Logarithmic		Hybrid	Linear	
Main characteristics	1. Applied the logarithmic scale across the macro – sub-macro continuum. 2 Provide correct explanation for the log scale's construction	1. Applied the logarithmic scale across the macro – sub-macro continuum. 2. Log scale as a "scientific" way of scaling, 3. Relied on memorization to construct it.	1. A scale could be applied across all sizes. 2. Applied a hybrid scale that included logarithmic and linear scales. 3. Provide primitive explanation; But unable to explain the log scale's.	1. Fragmented conception of scale across all sizes 2. Applied the linear scale based on actual sizes. 3. Attempted to assign numbers to the scale	1. Fragmented conception of scale across all sizes 2. Applied the linear scale based on actual sizes. 3. No attempt to assign numbers to the scale

• Study 2: Student responses were graded on a 0-5 scale* reflecting the dimensions of the typology identified in Study 1; The distribution of students' grades suggested that the short-answer questions were effective in capturing the variations in students' conceptions (see graphs below for sample grade distributions)





* Higher score indicates a more sophisticated understanding (i.e. logarithmic)

Conclusion

Our efforts, both the interviews and short-answer questions, seemed to be effective in identifying variations in students' conceptions of "Size and Scale". The next step might include exploring pedagogical approaches to address the learning barriers preventing students from developing the sophisticated type of conception, applying this typology to students of other age groups (e.g. high school), and testing the possibility of including the short-answer questions in a nanoconcept inventory.