Nanocamp: An evaluation of student learning and an elaboration of student thinking

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INTRODUCTION

Summer nanoCamp was designed to introduce middle school students to nanoscale science and technology, and to help them gain an understanding of some of its characteristic concepts, including size and scale and size dependent properties.. Additionally, students wrote their own nanoscience research questions, and created and presented a poster that explored their findings.

RESEARCH QUESTIONS

1. How does student understanding of size and scale, and size dependent properties change during a 2-week summer science camp?
2. What mental models do students have of size and scale and size dependent properties at the end of the camp, and how can these mental models help inform instruction and assessment?

METHODS

Participants:

- 22 students from two diverse, urban, Midwestern middle schools
- Approximately 50% considered economically disadvantaged

Racial background	African American	10
	Biracial/multiracial	5
	Caucasian	7
Gender	Female	12
	Male	10
Grade level	Entering 7th graders	13
	Entering 8th / 9th graders	9

Instruments and coding

Quantitative Assessment:

- Developed questions using evidence-based design
- Administered assessment as a series of activities and problems at the beginning and end of camp
- Assessed students during camp with similar items to track formative ideas
- Further analysis will track learning through the camp

Qualitative assessment:

- Conducted exit interviews, designed to address learning goals
- Analyzed to characterize student understanding
- Further analysis will compare student understanding to our learning goals and quantitative assessments will help evaluate activities, the quality of the assessment questions, and the overall camp experience

QUANTITATIVE ANALYSIS

Learning Goals

Total Pre and Post-Camp assessment scores

- Assessments consisted of a series of inquiry activities. Students had approximately 10 minutes at each activity to address the question or problem presented.

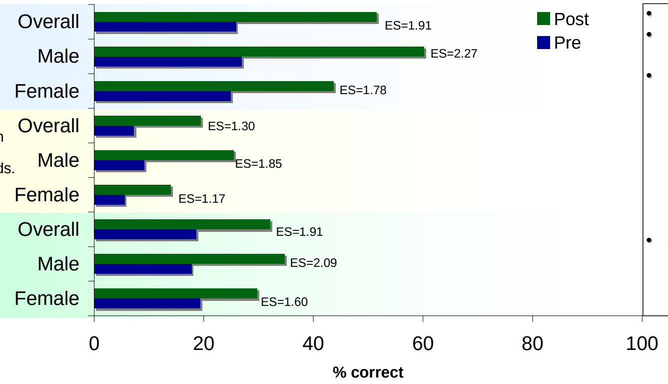
Size and Scale: *Students will be able to:*

- Explain that there worlds that are too small to be seen with the unaided eye, some too small to be seen with a light microscope, including the micrometer and nanometer worlds.
- List several submacroscopic objects, and have an idea of their relative sizes, both qualitatively and quantitatively

Size and Properties:*Students will be able to:*

- Describe and explain how to measure properties that can characterize materials.
- Explain, in general terms, the importance of surface area-to-volume ratio in reactions.

Assessment scores



- Overall mean gain: 25.7%
- No significant difference between different age groups,
- Significant difference between male and female size and scale subset scores (p<0.05)
  - Male mean gain, size and scale subset 32.5 percentage points
  - Female mean gain, size and scale subset 16.85% percentage points
- All overall pre and post-test differences statistically significant (p<,0.001)

QUALITATIVE ANALYSIS

Size-dependent properties:

Student models of Size-dependent properties included ideas in some or all of the following categories. *Examples of student ideas under each category are highlighted in blue. These examples are not intended to depict a correct or ideal model.*

•Reactivity and size:

- General beliefs/observations about size and reactivity
  - *•Ex. Smaller things react more strongly than bigger things.*
- Explanations
  - *Reactions involve breaking things up/interactions*
    - *•Ex. Things have to break into pieces when they react.*
  - *Relationship between access and reactions*
    - *•Ex. Breaking up things exposes the "inside" area.*
  - *Relationship between size and surface area or volume:*
    - *•Ex. Big objects have more surface than small objects.*
  - *Relationship between size and access*
    - *•Ex. The bigger something is, the harder it is to get to the middle.*

•Density, mass, weight, material composition, and size

- General beliefs/observations about size and density, mass, weight, or material composition
  - *• Ex. Things made of the same material have the same density regardless of size.*
- Explanations
  - *Relationship among weight, mass and size*
    - *•Ex. Mass and weight increase with material size - bigger things weigh more.*
  - *Relationship between density and size*
    - *•Ex. Mass and density stay the same regardless of how small you break up a piece of material.*
  - *Relationship among material composition, density and size*
    - *• Ex. Things made of the same material have the same density, regardless of size - a little piece of a sinking material will still sink*

• Size and light interactions

- General beliefs/observations about size and light interactions
  - *• Ex. Color doesn't change, regardless of size.*
- Explanations
  - *• Ex. Materials near the nanoscale are different colors than a larger version of the same material, because they are smaller than some light waves.*

• Other general properties and size

- General beliefs/observations about size and other general properties
  - *•Ex. Properties include physical characteristics (physical features, appearance)*
- Explanations

Size and Scale

Student models of size and scale included ideas in some or all of the following categories.

•Comparing the size of objects

Comparison to hair
Comparison to DNA strand width
Comparison to bacterial size
Comparison to dust
Comparison to light waves
Comparison to the body (lungs, veins)
Comparison of units / measurements
Comparison to other objects

•Seeing the nanoscale

Importance of a SPM
Importance of SEM
Importance of AFM
Things visible with a light microscope
Things that are visible to the unaided eye

•Relative size of nanometers andd other measurement units

•Grouping objects into measurement "worlds": macro, micro, nano.

CONCLUSIONS

- The overall average percent gain for the nanocamp was 25.7%, with an effect size of 1.91 (p<0.001)

Preliminary Implications: Size-dependent properties instruction: Some students equated size and volume - We should address this directly through instruction.

- Focusing on material reactivity may help students develop an understanding of the importance of surface, and the relationship between surface and volume
- Density was *sometimes* conserved regardless of size.
- Light waves could be a good benchmark object- several students mentioned that nanoparticles were smaller than light waves

Preliminary Implications:Size and scale instruction

- Effective benchmarks: hair, dust, cancer cells, veins/bloodstream, bacteria, millimeter,
- Students generally knew that nano things were too small to see unaided or with a light microscope, but did not necessarily connect that information to relative size or comparative size descriptions
- Students who grouped by nano/micro/ macro worlds were generally more successful at comparative size descriptions

NEXT STEPS:

- Comparison of mental models across students
- Comparison of mental models and aptitude
- Interview students and experts to fill in gaps in the model.

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