

# Analogies and metaphors for scaffolding middle school students' scale cognition

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**Learning goal:** conveying the difference in relative sizes between microscale and nanoscale objects

## Theoretical Framework

Learning theory



Behaviorist roots that brings together a cognitive information processing perspective. (e.g. Evaluating analogical comparisons facilitates noticing and comprehending the critical attributes of a concept.)

Gagne's theory



Planning instruction incorporates:  
-defining a taxonomy of learning outcomes (e.g. concrete concepts, defined concepts,.)  
-specific learning conditions, and  
-the nine events of instruction.

Theory of concept development

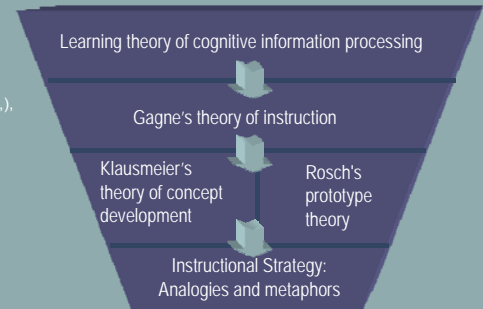


To specify:  
- the level of concept attainment and  
- the mental processes involved in attaining each higher level of the concept  
- the instructional conditions

Prototype theory



For the design of the learning strategy: analogies and metaphors.



## Instructional strategy

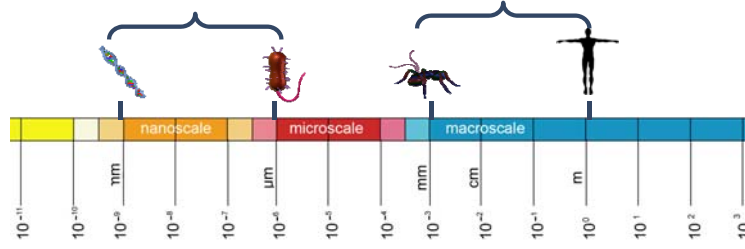
Comparison processes foster insight

Analogies and metaphors mediate between the vague, intangible attributes of abstract concepts and those of a more concrete nature.

The result is the transformation of the concept into an integrated concrete familiar image

The more frequent use of approximate sizes in everyday life may strengthen those neural connections that will enhance the students' ability to indicate more accurately the relative size over absolute size.

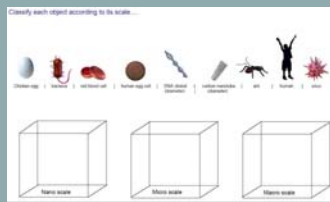
*The difference in sizes between the height of a human and the length of an ant is approximately the same as the difference in sizes between the length of a bacterium and the diameter of a DNA double strand.*



## Levels of scale cognition

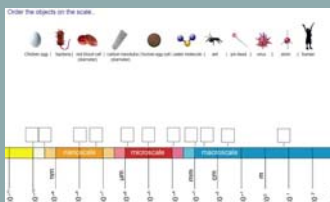
**Class inclusion:**

Ability to sort objects into specific categories of scale



**Serial ordering:**

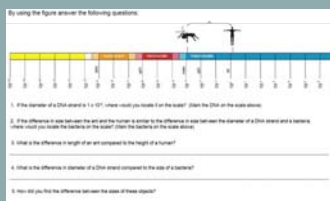
Ability to order objects by relative size along a linear scale



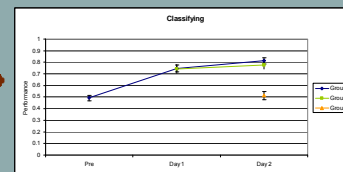
**Proportional schema:**

Ability to compare relative size between categories of scale.

This can involve both *logical* and *mathematical* abilities. Logical proceeds mathematical and is defined by equating the relationship between two attributes  $\alpha$  and  $\beta$  with a second set of terms  $\delta$  and  $\gamma$  based on some property. In mathematics the ratio of quantity is compared.



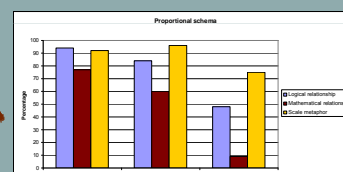
## Students' performance



Group 1 are the 59% of students who classified the objects by size. Group 2 are students that did not classified by size. Group 3 are students who did not receive the instruction based on analogies and metaphors, but were exposed to an informal learning environment.



After instruction, students exposed to analogies and metaphors improved their performance in classifying objects and ordering objects.



Analogies and metaphors may serve as an adequate scaffold to student's cognitive processes for attaining scale cognition.

The majority of the students exposed to analogies and metaphors understood the proportional relationship demonstrated in the analogies and were able to identify in numerical terms the difference between them by using the scale metaphor.

The students that were not exposed to the proportional analogies recognized the metaphor represented with the scale.