Exploring Students' Patterns of Reasoning

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Supported by National Science Foundation Grant ESI-055494

Introduction and Research Goal

- NSEUS[1] (National Study of Education in Undergraduate Science) investigates the effect of interactive engagement teaching-learning strategies in treatment courses in compare to traditional courses
- As a part of NSEUS, we are comparing students' (Elementary Education majors) reasoning skills in a scientific context across disciplines (treatment and traditional courses)

Content Question Design

- Designed to elicit students' reasoning patterns as they apply recently scientific concepts to a new context
- Structured with defined levels of abstraction
- Developed from concepts and procedures and the manner that these are cognitively processed
- Constructed to include a reasoning type such as cause-effect chain of reasoning, compare and contrast, analogical reasoning, etc

Bloom's revised taxonomy for classifying the components of reasoning [1]

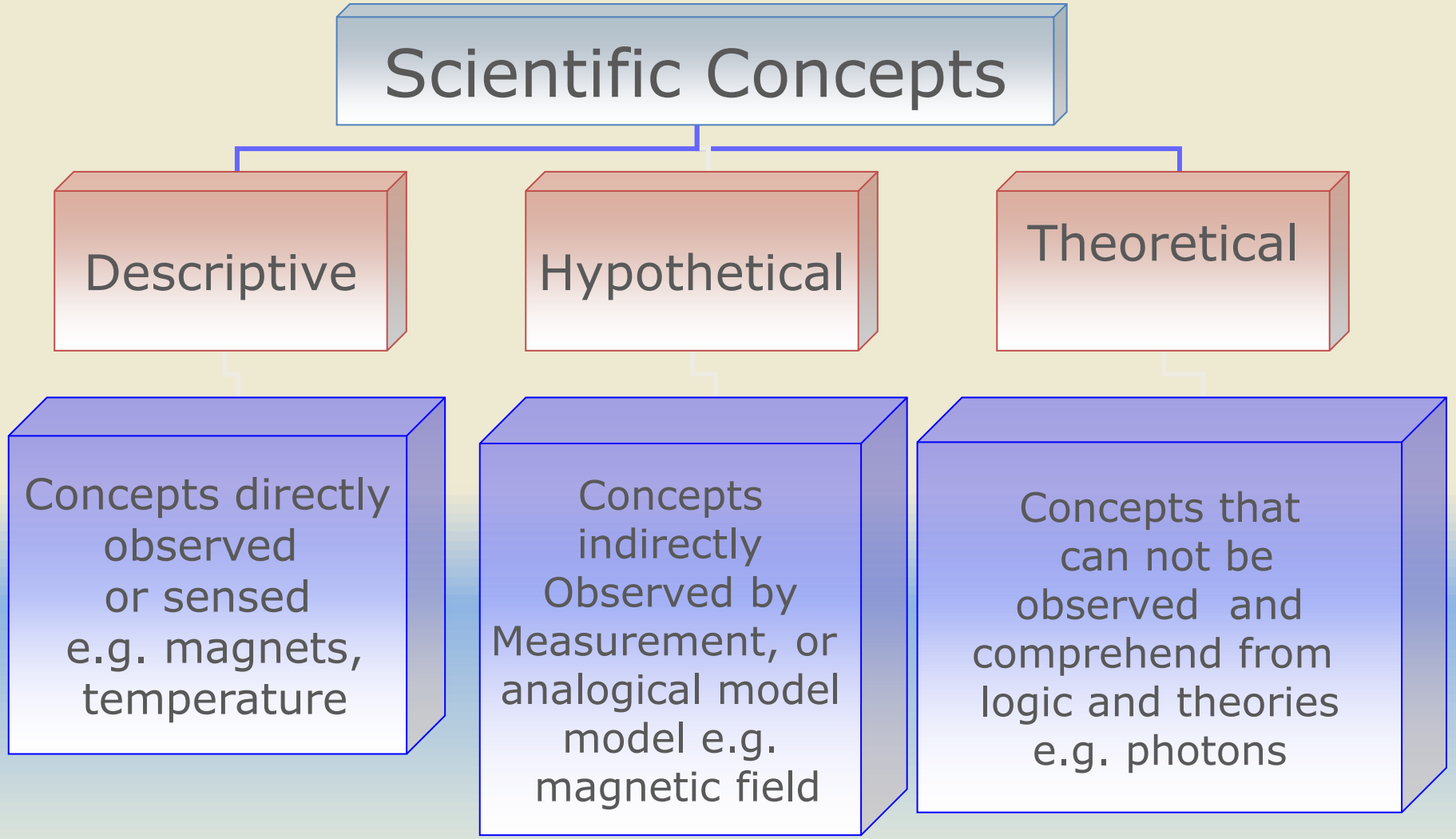
Table 1- Selection from Knowledge Dimension	
Factual knowledge	Knowledge of elements and essential facts
Conceptual knowledge	Knowledge of classification ,principles , theories and structures, Conceptual schema
Procedural knowledge	Knowledge of subject-specific skills, algorithms, techniques, methods and procedures

1-Anderson et. al, 2001

Bloom's revised taxonomy for classifying the components of reasoning, Cont.

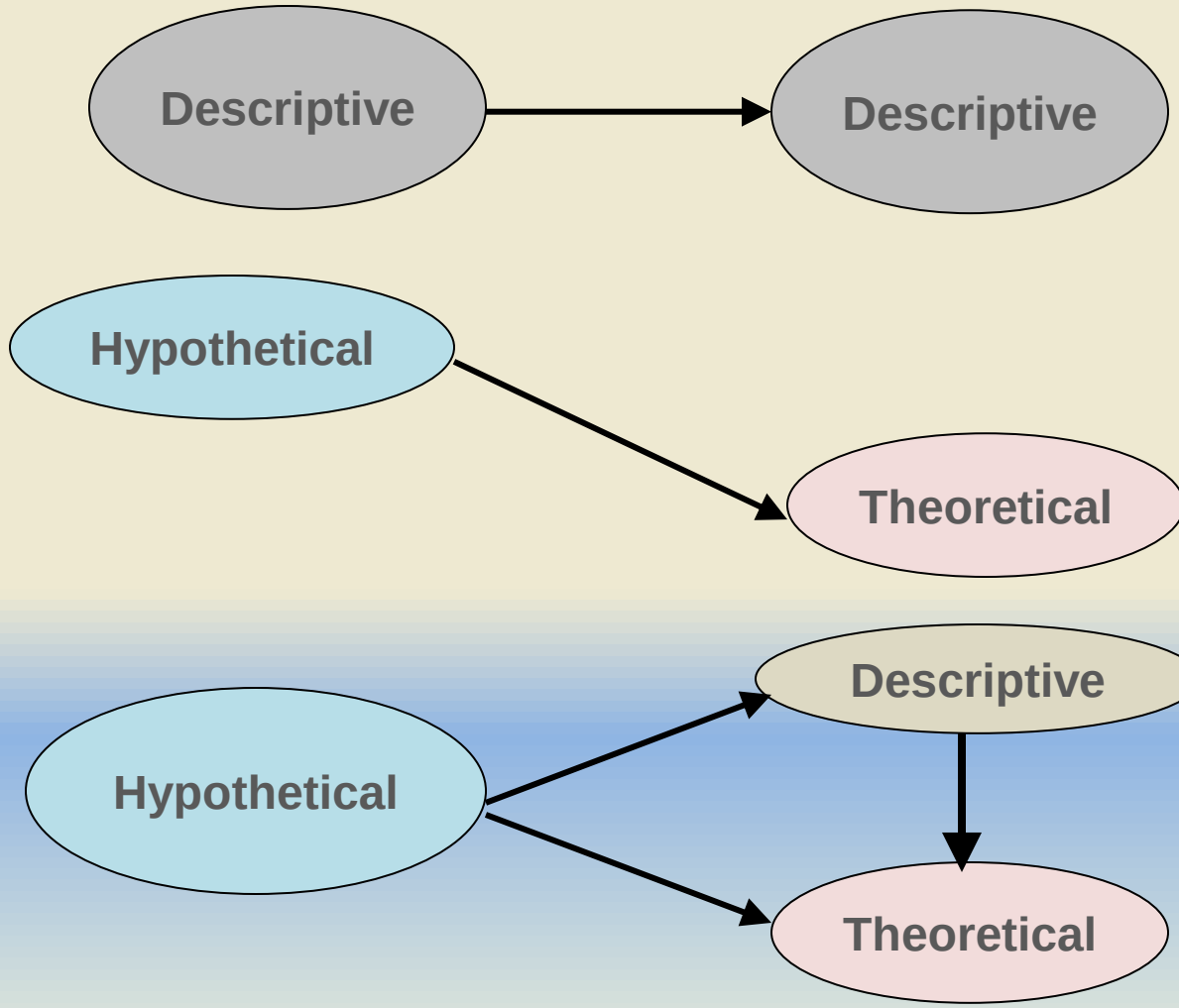
Table 2- Selection from Cognitive Dimension	
Remember	Recognize (identify), Recall (retrieve from memory)
Understand	Interpret (paraphrase, change representation), Infer (draw logical conclusion), Classify (categorize),Compare and Contrast, Explain (construct cause and effect model)
Apply	Implement (apply a procedure to an unfamiliar task), Execute (apply a procedure to a familiar task)

Modification to Lawson's[2] definition to make it appropriate for physics contexts



2-Lawson et. al (2000)

Type of concept links[3]



One Concept-Level link

Cross Concept-Level link

Multi Concept-Level links

3-Neiswandt & Bellemo 2009

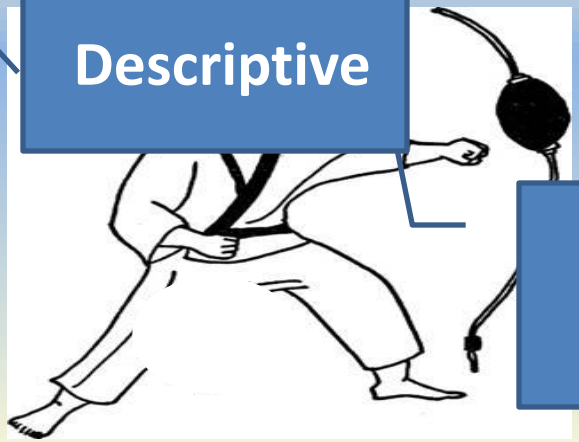
Content questions
Structure and level of abstraction

- Concept construction and intellectual development proceeds from descriptive concepts toward theoretical concepts (Lawson et. al, 2000)
- The level of abstraction proceeds from one-concept level links toward multi-level links (Neiswandt, et. al 2009)
- The level of abstraction may increase if we move toward higher levels of cognitive processes and knowledge types in Bloom's taxonomy (Anderson et. al, 2001)

Applying taxonomy and concept categorization to a content question

- Recently learned Concept
  Explain how the stability relates to the width of the base and the height of center of mass above the base? Explain in terms of forces and torques.

- Application to real life
  To protect against attacks the man takes on particular fighting stances. Explain why this fighting stance makes it difficult for opponents to knock him down?



Descriptive

Theore

Apply

Hypothetical

Rubric

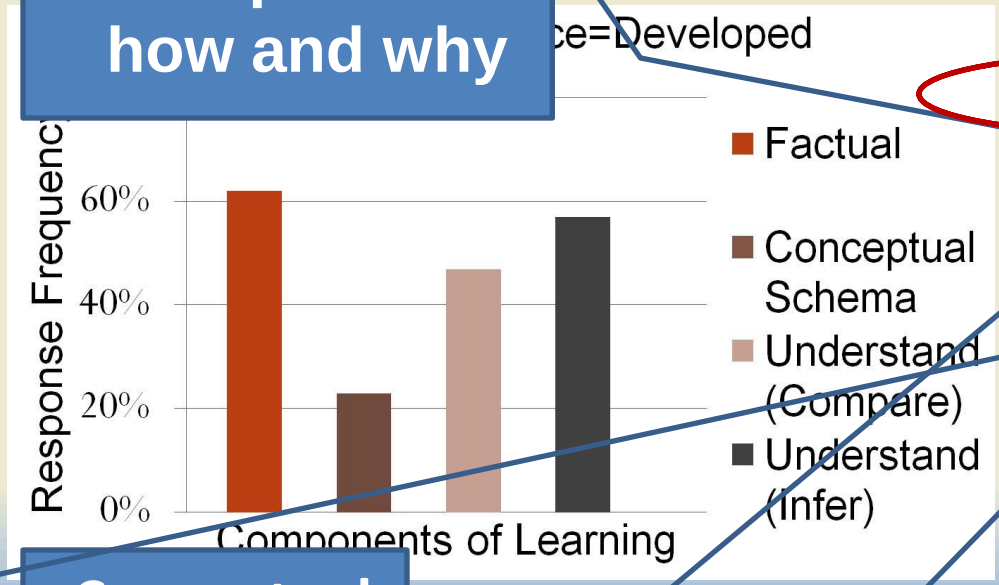
- Interpret students' responses in terms of components of Bloom's revised taxonomy
- Construct a framework by defining three levels of performance(*In-depth, developed, Naïve)*[4] for each component of Bloom's Taxonomy
- Identify students' levels of performance for each component according to the definitions

4-Wiggins and J. McTighe (1998)

▪Example1)Density (Active learning class)

A toy metal ship is floating in a container of distilled w hy a metal ship can float.

Doesn't Compare how and why



Sample Answer:

"A larger surface area causes less force allowing it to float. Distilled water has a high surface tension let it to float".

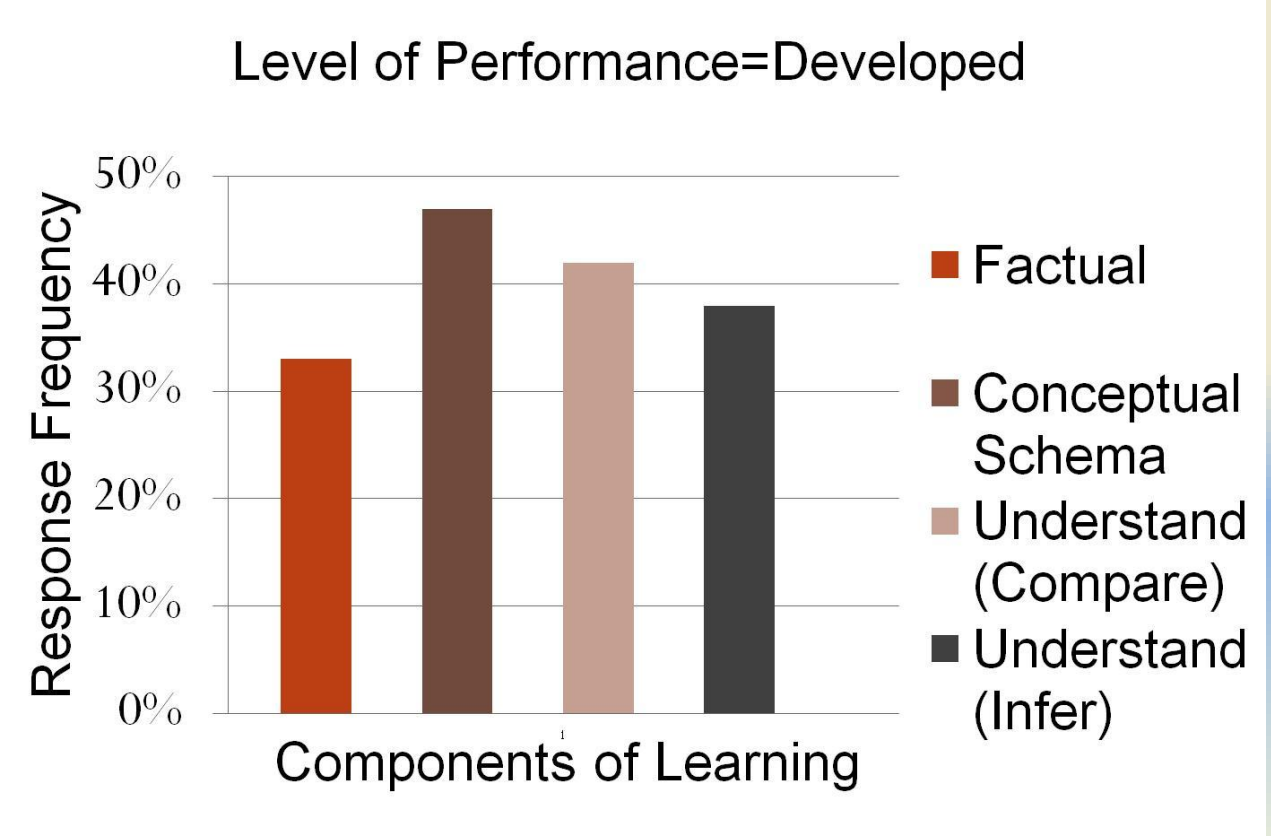
Conceptual schema

Infer: The chain of cause and effect is not complete

Factual knowledge: What other facts?

- **Example 2)Chemistry (Traditional Class)**

In the winter time spreading salt on the road can melt ice. Explain how the chemical structure of salt affects the properties of the solution? And why sugar, does not have the same effect?



Conclusion

- ✓ We can compare students' reasoning patterns as displayed on the responses by comparing the associated histograms
- ✓ We can devise content questions with the same level of thought processes in different disciplines
- ✓ We can find the weaknesses and strengths of students' reasoning in our classification scheme(concept structure, type of knowledge or cognitive process)
- ✓ This method will allow the comparison of students' responses and their reasoning across disciplines.

Thank you

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