A Protocol For Exploring Students' Patterns of Reasoning

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Introduction

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

Background

Anderson's Two Dimensional Taxonomy (Expansion of Bloom's Taxonomy [2])

Table 1 - 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)

Table 2 - 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

Question Design

▪Designed to elicit students' reasoning patterns as they apply scientific concepts
▪Structured with defined level of abstraction
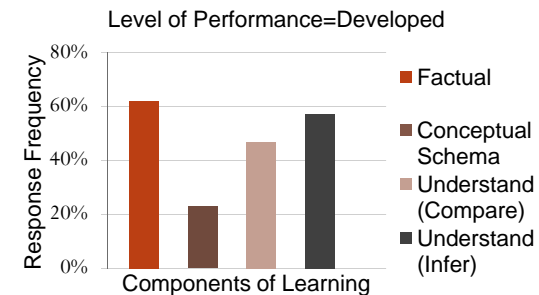▪Generalized from application of recently learned concepts in a new context

Rubric

▪ Constructed a framework by defining three levels of performance (*In-depth, Developed, Naïve*)[3] for each component of Bloom's taxonomy
▪Interpreted students' answers in terms of components of revised Bloom's taxonomy
▪Identified students' levels of performance for each component according to the definitions
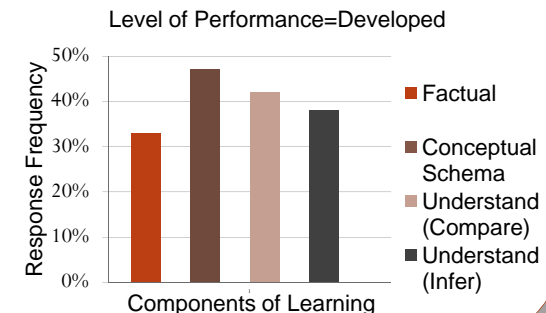
Data Analysis for Two Example Questions

▪ **Example 1 - Density**
A toy metal ship is floating in a container of distilled water. Explain why a metal ship can float.

Level of Performance=Developed

(Bar chart: Response Frequency vs Components of Learning — Factual, Conceptual Schema, Understand (Compare), Understand (Infer))

▪ **Example 2 - Chemistry**
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 does sugar not have the same effect?

Level of Performance=Developed

(Bar chart: Response Frequency vs Components of Learning — Factual, Conceptual Schema, Understand (Compare), Understand (Infer))

References

1. http://nseus.org
2. L.W. Anderson and D.R. Krathwohl, *"Taxonomy for Learning, Teaching, and Assessing,"* Longman, New York (2001).
3. G. Wiggins and J. McTighe "*Understanding by Design,"* Association for Supervision and Curriculum Development, Virginia (1998).

Conclusion

Both content questions (Examples 1 & 2) have the same level of thought processes. We compared the reasoning patterns in those responses by comparing the associated histograms. Preliminary results show that this method will allow the comparison of students' responses and their reasoning across disciplines.