

# Computerized Analysis of Student Writing and Student Ideas about Scientific Concepts

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## Introduction

- Students in introductory biology course struggle with chemistry concepts despite a chemistry course prerequisite.
- Constructed-response assessments reveal student thinking and conceptual barriers. (Birenbaum & Tatsouka, 1987)
- Students have complex, heterogeneous ideas which may not be captured by multiple choice questions. (Nehm & Schonfeld, 2008)
- We use a linguistic-feature based approach to automated analysis (Deane, 2006)

## Assessment item and student responses

Q: Consider two small organic molecules in the cytoplasm of a cell, one with a hydroxyl group (-OH) and the other with an amino group (-NH<sub>2</sub>). Which of these small molecules (neither or both) is most likely to have an impact on the cytoplasmic pH?

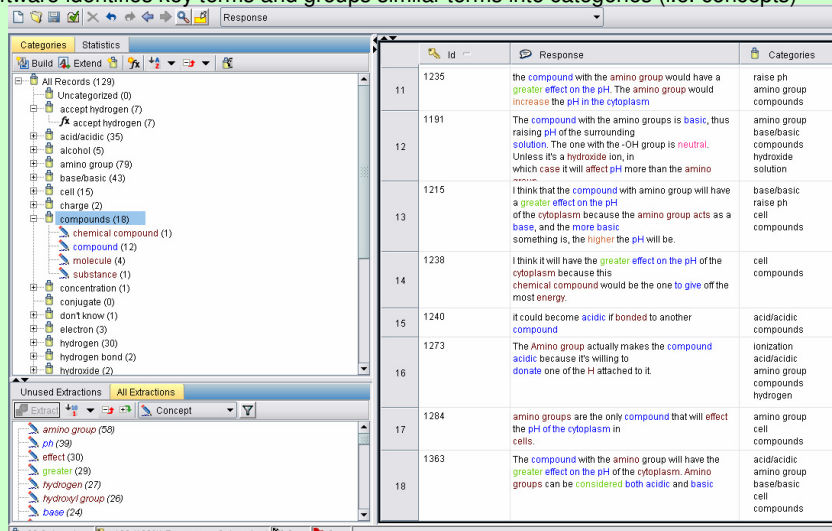
- A. Amino (35 %)  
B. Hydroxyl (45 %)  
C. Both (13 %)  
D. Neither (7 %)

Please explain your answer.

- Homework in introductory biology course.
- 374 responses collected via online course management system.
- Analyzed explanations for **correct multiple choice selections**.

## Term extraction

- Lexical analysis can process large numbers of responses easily
- Software identifies key terms and groups similar terms into categories (i.e. concepts)



Lexical analysis software showing the terms extracted (lower left panel), categories (upper left panel), student responses (right panel). Each response is placed into one or more categories (rightmost column).

## Expert scoring

- Two expert scorers rated using 3-level rubric; agreement on 113 out of 129 (interrater reliability=0.92; intraclass correlation)

Level	Number	Rubric	Example
1	41	Totally correct explanation	Amino groups act as a base and pick up a hydrogen ion from its surrounding solution.
2	14	Partially correct explanation	The amino group acts as a base. It will lower the pH of the cytoplasm toward base (8+).
3	58	Totally incorrect or irrelevant explanation	Amine has two H atoms it may give up, but hydroxyl has only one OH molecule it may give up.

Scoring rubric used to rate student explanations. Numbers of correct multiple choice responses at each scoring level are indicated, along with an example student response.

## Automated Analysis of Constructed Response (AACR) Research Group

### Who we are:

- Michigan State University
- The Ohio State University
- University of Colorado – Boulder
- University of Washington
- Grand Valley State University

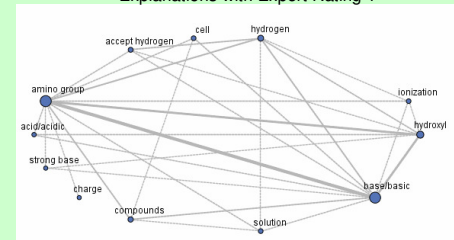
### What we're doing:

- Metabolism Diagnostic Question Cluster (DQC)
- Genetics Concept Assessment (GCA)
- Geoscience Concept Inventory (GCI)
- Evolution : ORI / EGALT / ACORNS

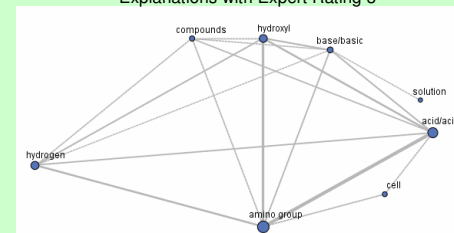
## Category building

- Lexical analysis can reveal complex patterns in students' concepts.

### Explanations with Expert Rating 1



### Explanations with Expert Rating 3



A category web of the category "amino group". These diagrams show shared responses (denoted by gray lines) between the category "amino group" and other categories (denoted by blue nodes). Size/thickness indicates frequency of occurrence.

## Statistical modeling

- Statistical functions can predict expert scoring at 77% accuracy
- Computer-expert interrater reliability =0.84 (intraclass correlation)

Computer Predicted Score			
	1	2	3
Expert Score 1	82.9	12.2	4.9
Expert Score 2	21.4	42.9	35.7
Expert Score 3	6.9	12.1	81.0

Classification percentages of cross-validated student responses for functional group classified at each level.

### Acknowledgements

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