

# Assessing Students’ Ability to Trace Matter and Energy Using Lexical Analysis of Written Assessments

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## Introduction

- Why use written assessments?  
Constructed responses assessments, including written assessments:
- Allow students to represent their understanding in their own words (Keuchler and Simpkin, 2010)
  - Give faculty greater insight into student thinking compared to multiple choice assessments (Birenbaum and Tatsuoka, 1987)
  - Students treat constructed response and multiple- choice assessments as different cognitive tasks and prepare for them differently (Stanger-Hall, 2012)

## Research Question

What can written assessments tell us about student understanding of matter and energy transfer?

## Methods & Results

We collected written responses to the question below from 170 students in an introductory biology course at a large southeastern public university. Responses were coded by 3 researchers using a grounded theory approach and analyzed using lexical analysis tools.

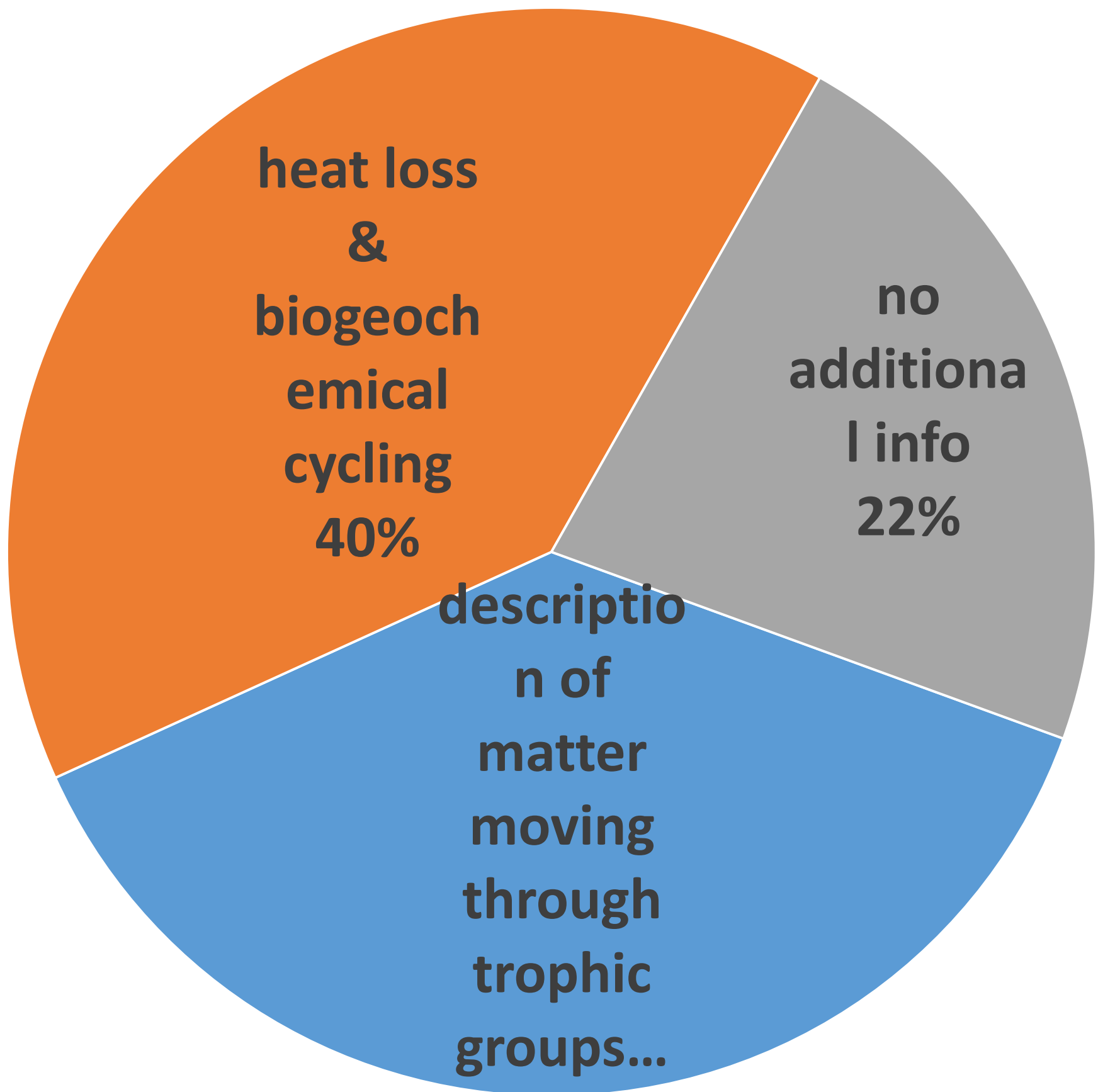
**Question:** A tropical rainforest is an example of an ecosystem. Which of the following statements about matter and energy in a tropical rainforest is the most accurate? Please choose ONE answer that you think is best.

- A) Energy is recycled, but matter is not recycled. **4%**  
B) Matter is recycled, but energy is not recycled. **83%**  
C) Both matter and energy are recycled. **13%**  
D) Neither matter nor energy is recycled. **0%**

Explain your answer.

**Most students correctly identify that matter is recycled and energy is not. However further analysis of their written explanations revealed multiple ideas – both correct and incorrect.**

**Cluster Analysis showed students’ written answers fall into 3 main groups based on mostly scientific ideas**



### Sample Student Responses for Each Cluster

#### Heat Loss and Biogeochemical Cycling

“The carbon, nitrogen, and phosphorous cycles are all examples of matter being recycled through an ecosystem. Energy, on the other hand, can only be converted and is therefore not recycled. Energy can not be recycled through an ecosystem because it moves through the ecosystem only once; some of it is lost as heat while some of it is lost while being passed from producer to consumer through each trophic level.”

#### Description of matter moving through trophic groups

“While energy is lost at each trophic level, the sun provides a steady flow of energy. Matter is recycled through decomposition. When leaves fall of a tree or animals die, they decompose and turn into nutrients and soil. Animal remains and excrement essentially turn into plant food.”

#### No additional info

“Matter is reused in forms of different organism. energy dies with the organism”

**Grounded Theory coding revealed both scientific and non-scientific ideas in students explanations**

| Scientific Ideas                                    | Percentage |
|---|------------|
| Heat loss   | 69.4       |
| Description of matter moving through trophic groups | 40.0       |
| Energy inefficiency                                 | 38.8       |
| Biogeochemical cycling                              | 27.1       |
|   |            |
| Non-scientific Ideas                                | Percentage |
| Energy converted into Matter                        | 11.8       |
| Matter converted into energy                        | 8.2        |

### Sample Student Response: Scientific Ideas

“In a tropical rainforest, matter is recycled, but energy is not. While energy is lost at each trophic level, the sun provides a steady flow of energy. Matter is recycled through decomposition. When leaves fall of a tree or animals die, they decompose and turn into nutrients and soil. Animal remains and excrement essentially turn into plant food.”

### Sample Student Response: Non-scientific Ideas

“Since energy cannot be reused after it is dissipated to the environment, animals and other organisms may only recycle the organic matter. This is exemplified by decomposers that transform dead matter into energy for themselves.”

## Conclusion

Multiple choice assessments may mask the complexity of student ideas.

Text analysis combined with cluster analysis identified the main scientific ideas that students include in their responses.

About 20% of students demonstrate difficulty tracing matter and energy.

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