Student Comprehension of Energy Flow in Food Webs: A Comparison of Human Coding and Computerized Text Analysis

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Introduction

- Science students often have difficulty with deeper understanding, procedures of processes, or problem solving with questions dealing with energy (Carlsson, 2002; Chabalengula, et al., 2011).
- Instruction that moves away from rote memorization and encourages writing can help identify student misconceptions about energy through formative assessment (Hartley, et al., 2011).
- Earlier studies have used interviews, multiple choice questions, or student writing responses to examine student understanding of energy.
    - Student writing seems to give best perspective on how they think (Chabalengula, et al., 2011).
- Lancor, 2013 and other researchers use qualitative human coding to classify responses as biology students write about energy in ecosystems.
- Our study compares qualitative human coding to a novel approach: computerized text analysis.

Research Goal

The research question of this study was to identify how students trace energy on an ecosystem level and observing how human coding compares and contrasts to computerized text analysis of student responses.

Methods

- **Data collection:** 170 student written responses to answer a question about tracing energy through an ecosystem with respect to food webs.
- **Question**: "Explain why food webs tend to have five or fewer levels."
- **Human coding:** three human coders identified concepts (Fig 1.) with an interrater reliability of 0.7 (acceptable) to 1.0 (perfect agreement).
  Responses were coded 1 if student included concept in their response and 0 if not.
- **Computerized text analysis:** IBM SPSS Modeler 16.0 software extracted words and phrases from student responses and assigned them to categories (Fig 2.). The library of terms and categories were manually organized.
- **Web diagrams:** Depict co-occurrence of categories (Fig 3.).

Results

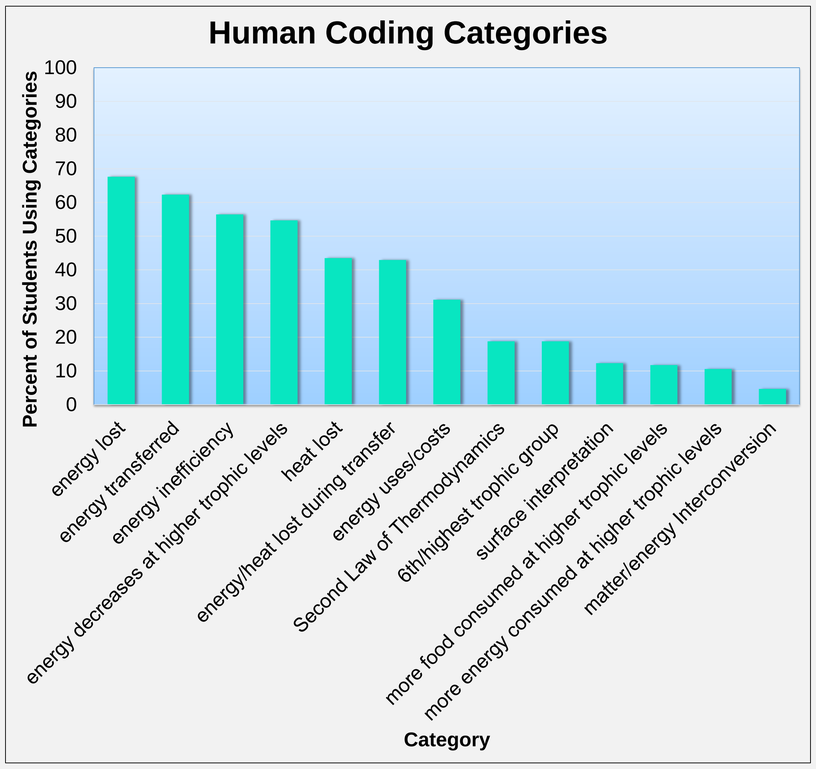

Figure 1. Human coding identified 15 concepts, most frequently describing energy and heat loss, energy transfer, and energy inefficiency.

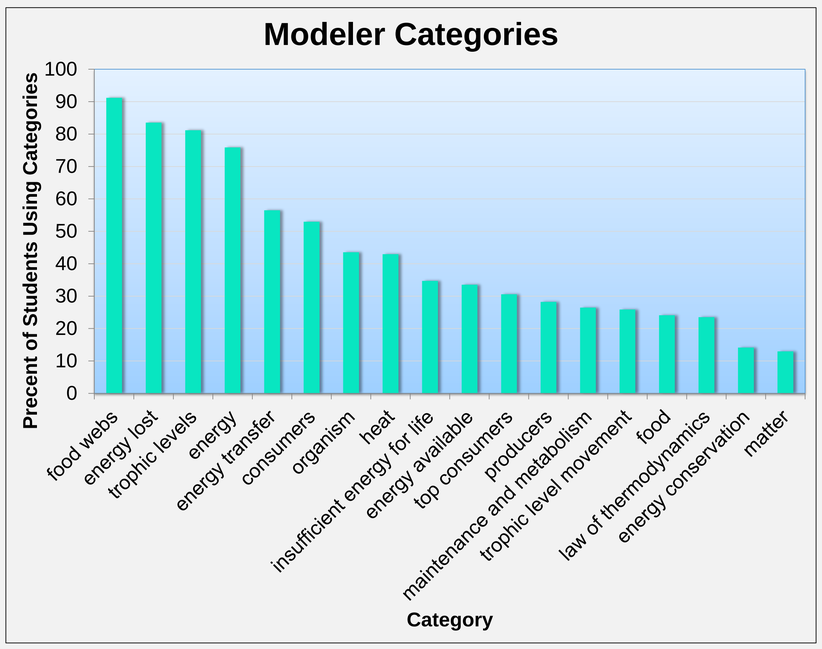

Figure 2. Text analysis identified 28 categories with responses most commonly assigned to food webs, energy lost, and trophic levels.

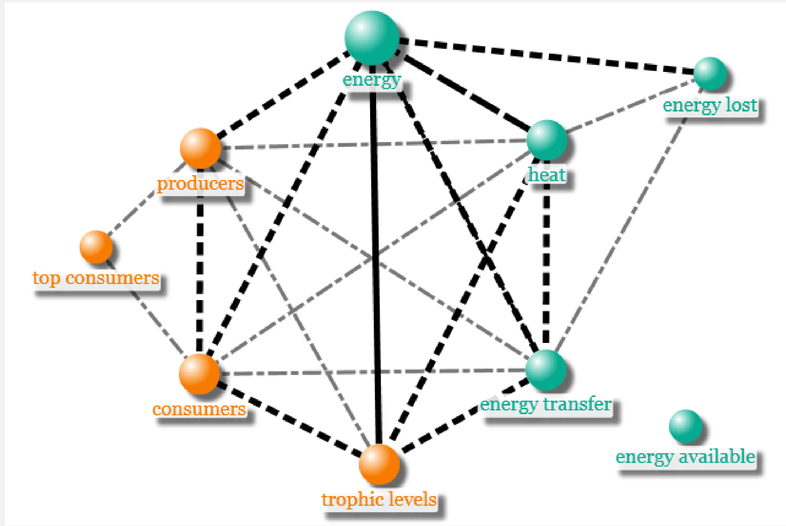

Fig. 3 Web diagram showing the connection between concepts in student writing. Each circle represent one idea represented by a text analysis category

Trophic group categories Energy categories

Lines represent % of responses shared by 2 categories
Solid line: >40% responses shared; Long dashed line: >30%
Short dashed line: >20% ; Grey, thin dashed line: >10%

Conclusions

- Many concepts occurred at about the same frequency in both methods of coding:
    - Energy lost and transfer (>50% for all); Heat lost ~40%; Second Law of Thermodynamics ~20%
- Students with misconceptions that matter and energy can be interconverted:
    - Human coding: 5%
    - Modeler categorization: 0.6% (not pictured)
- Written response moves beyond rote memorization in showing that students understand that energy inefficiency during transfer is the main limitation of trophic levels in an ecosystem. Computerized text analysis can recognize many of the same categories as human coding.
- The web diagram shows that energy and trophic levels were most often connected, followed by energy and heat. Responses describing energy available did not overlap with other main categories.
- Future research will build a model to predict human coding from the text analysis categories so that student responses can be automatically scored to facilitate written assessment in large-enrollment courses.

References

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