How Middle School Students Talk about Energy with Project-Based Inquiry Science

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Introduction

We examine the types of emergent language 8th grade students in rural Maine middle schools use when they discuss energy in their first experiences with Project-Based Inquiry Science: Energy,[1] a research-based[2] curriculum that models a specific language for talking about energy. By comparative analysis of the curriculum materials to students' language, we find that students' talk is more aligned with a Stores and Transfer model of energy than the Forms model supported by the curriculum.

Language and Learning Physics

How students talk about energy is likely to provide clues about how they think about energy.[3] Lemke[4] asserts that "Learning science means learning to talk science" (pg. 1) and Roth and Lawless[5] note that "science as culture [is] strongly characterized by its language." (pg. 369) Microanalytic treatment of students' emergent discourse in science classrooms has proven to be a powerful tool in exploring how students develop new ideas.[5,6]

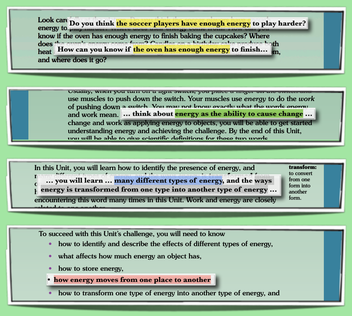
PBIS Model of Energy

a) Objects *have* energy.

b) Energy is the ability to cause and involves *change*.

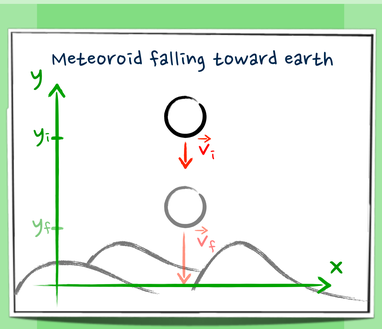
c) Energy has different *types* and can be *transformed* from one type to another.

d) Energy can be *transferred* from one object to another.



Forms Model[7]

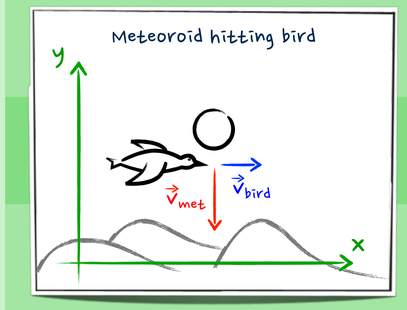
Objects *have* different *forms* of energy that are associated with observable, *changeable* properties of objects.



Property	Form of Energy
speed v	kinetic
position y	gravitational potential

Energy *transformation*:

v and y *change* simultaneously



Energy *transfer*:

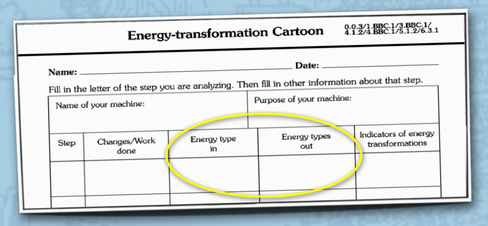
v_{met} and v_{bird} *change* simultaneously

The mechanism for change (process) is not relevant in this model.

Students Talk about Energy

An introductory activity asks students to identify energy transformations in a Rube-Goldberg-like cartoon and record their observations on a worksheet.

We analyzed selected video episodes for the language students used to describe the ***energy types in*** and ***out*** of each step in their respective Rube Goldberg machines.



(a) Narrative
descriptive language

Example: "Girl dumps trash"

- direct translation of pictures into words - no abstraction

- details provide what/how/why, potentially useful for energy story - unused by students

Further Examples:
Burns rope, Ball goes down a ramp

(b) Physics Vocabulary
single-word terminology descriptors

Example: "Kinetic"

- focus on physics terminology - application of physics concepts? No clear indication!

- descriptors as types of energy - related to "Forms" model

Further Examples:
Potential, Sound, Solar, Heat

(c) Object Acting
noun + verb-ing

Example: "Trash falling"

- grammatical function/meaning unclear - compound word or abbreviated sentence?

- description of the process trash is undergoing - details missing

Further Examples:
Hand moving, Bag inflating

(d) Action on an Object
verb-ing + noun

Example: "Dumping the trash"

- verb-ing used as noun: gerund - emphasis on process, trash is grammatical (and physical) object

- description of a process - details of picture missing

Further Examples:
Pulling a string, Burning something

Only the category **Physics Vocabulary** seems directly related to the PBIS or Forms model of energy.

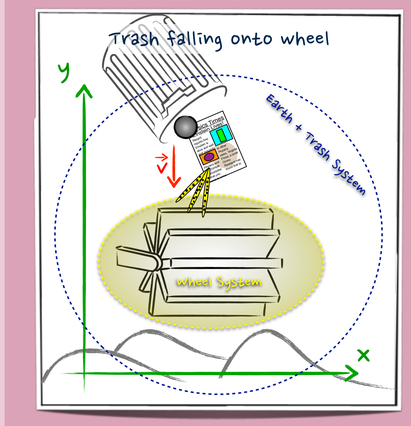
Emphasis on processes in the categories involving ***verb-ing + noun*** goes beyond the language used in a Forms model (although processes and mechanisms are important for understanding physical scenarios).

A different model places emphasis on processes of transfer and transformation: **Stores & Transfer**.

Stores & Transfer Model[8]

Energy is *stored* in three different ways in a system.

It can be *transferred* within and across the boundaries of the system.



While the trash is falling, energy is *transferred within the system* from the position store to the motion store:
Transformation of energy.
Mechanism/Process: Work done by gravity.

When trash hits the wheel's paddles, energy is *transferred across the boundaries* of the two systems.
Mechanism/Process: Matter transfer from trash-earth system to wheel system.

Conclusion

Students' use of constructions involving *verb-ing* and a *noun* suggests that their thinking is focused on processes. This focus on processes would allow students to describe how energy is *stored* in a system (e.g. "falling" and "pulling" both describe motion), and how energy is *transferred* across system boundaries (e.g. matter transfer through "trash falling", work done by "pulling a string"). We do not mean to imply that students are using the Stores and Transfer model, but rather that their language is more aligned with this model than with a Forms model as used by PBIS.

References

[1] J.L. Kolodner, J.S. Krajcik, D.C. Edelson, B.J. Reiser, and M. L. Starr, Project-Based Inquiry Science: Energy, Student Edition, It's About Time, Armonk, NY (2010).
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