Can You Build It? Using Manipulatives to Assess Student Understanding of Food-Web Concepts

RICHARD GRUMBINE

Abstract

This article outlines an exercise that assesses student knowledge of food-web and energy-flow concepts. Students work in teams and use manipulatives to build food-web models based on criteria assigned by the instructor. The models are then peer reviewed according to guidelines supplied by the instructor.

Key Words: *Ecology; food webs; energy flow; trophic levels; manipulatives; assessment.*

The *National Science Education Standards* (National Research Council, 1996) include the concept that "Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers" as one of five statements that address the life-science content standard "The Interdependence of Organisms." Several researchers have catalogued the many and varied student misunderstandings about this overarching food-web concept. For example, students incorrectly identify the direction of energy flow and fail to precisely differentiate the concepts of food chains and food webs (Adeniyi, 1985; Munson, 1994; Hogan, 2000; Özkaya et al., 2004).

This activity lays out a method for assessing student understanding of these concepts in the context of an ecology unit at the high school level. The activity uses either of the commercial toy products Fiddlesticks or Tinker Toys as tools for students to demonstrate their knowledge of energy flow in food webs. They work in teams and generate concrete models of their conceptual understanding. The scaffolded design of the activity incorporates problem solving and peer review. Students find it challenging, fun, and engaging. I present this activity after a lecture- and diagram-based introduction to the key ideas and terms associated with energy flow and trophic levels. For the instructor, it serves as a formative assessment of student progress with the ecology concepts of trophic levels, energy flow, and energy loss in food webs.

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This activity provides an easily adaptable example of using manipulatives – small items that can be handled, arranged, and assembled – to create or represent abstract concepts. Including active or "hands-on" activities enhances student learning and makes it more efficient when combined with traditional lecture-based instruction (Eyster & Tashiro, 1997). There have been many clever examples of using manipulatives in the science-education literature (Miller, 1998; Clark & Mathis, 2000; Grumbine, 2006). Manipulatives are implemented mostly at the elementary school level, but their use at the high school and post-secondary levels is increasing and welcome (Krontiris-Litowitz, 2003).

○ Protocol

Student teams of two or three are recommended. The entire exercise can be completed in about 20–30 minutes. Each team gets a set of materials (Fiddlesticks or Tinker Toys) that includes at least four wooden disks, at least four yellow sticks, at least one green stick, at least two blue sticks, and one wad of yellow Play-Doh or modeling clay. (Stick colors can vary according to availability. The colored sticks should all have a clearly marked permanent arrow drawn on them. See Figure 1.)

Distribute sets of materials to each student or student team in the class. Post the following prompts on a projector slide and/or distribute on paper to each student team:

Wooden disks = organisms
Yellow sticks = chemical energy
Green stick = light energy
Blue stick = heat energy
Wad of yellow Play-Doh/modeling clay = sun

Please do the following with your team:

(1) Starting from the sun, put together a food chain that ends with a secondary consumer.

(2) Add a tertiary consumer.

(3) Add a way to represent energy loss from the food chain. [Note: Adding a representation of energy loss at each trophic level,

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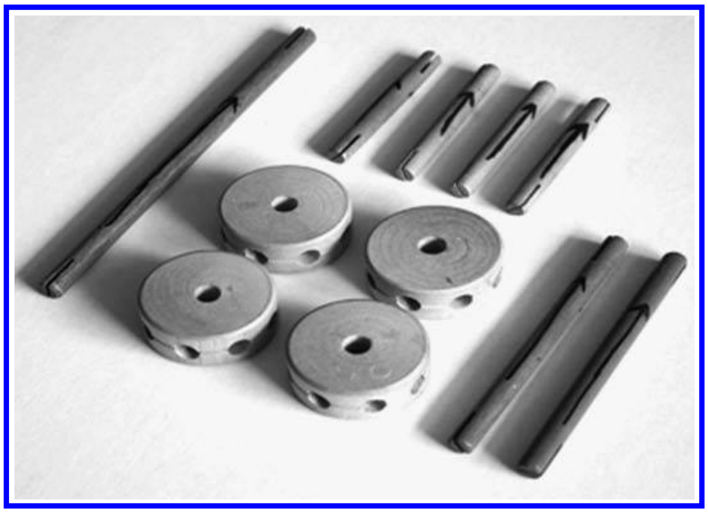

Figure 1. Materials, including colored wooden sticks and wooden disks.

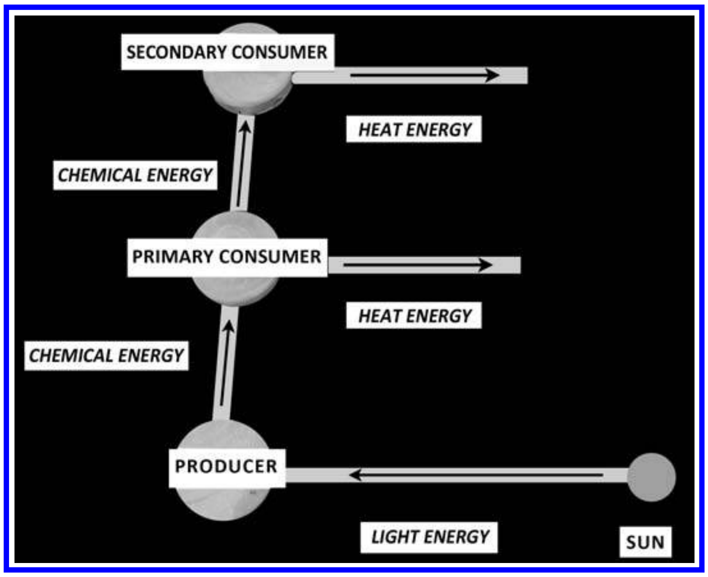

Figure 2. A sample food chain showing, from bottom right: sun with light energy flowing to a producer, chemical energy flowing to a primary consumer, heat loss from the primary consumer, chemical energy flowing to a secondary consumer, and heat loss from a secondary consumer.

while important conceptually, would make the models unwieldy and confusing.]

(4) Partner with another team, combine your raw materials, and rearrange your structure to make it a food web instead of a food chain, with a maximum of three trophic levels. Use as much of your material set as possible. [See Figures 2 and 3 for examples of a food chain and food web.]

(5) Optional challenge: Add a tertiary consumer and a representation of heat loss.

○ Assessment

Tasks 1–3. As student teams finish tasks 1–3, circulate through the classroom area and check on their models, providing appropriate feedback as needed. Ask students to use the relevant terms (trophic-level names, the kinds of energy flow and loss, etc.) to explain their models.

Task 4 and 5 (if assigned). When students have completed their food-web models for task 4, have them exchange models (or exchange places if the models are too delicate to move) and begin a peer review process. Supply the following guiding questions on a projector slide or on paper to each team as a focus for the review:

(1) Does the food-web model follow the criteria assigned? If not, what are the specific problems with the model?

(2) Is the energy flow all in the proper direction?

(3) Count how many examples of each trophic level are represented in the sample food webs.

When the reviews are completed, have the teams join together to share their respective feedback with each other. The instructor may need to referee at various points and resolve disputes that arise. Emphasize respectful discourse in the spirit of learning.

○ Extensions

There are many possible extensions or additional tasks an instructor could add to this activity. I will suggest a few here.

- Given that it is important to recognize the essential role of decomposers/detritavores in a food web, challenge students to discuss and find a way to integrate these organisms into their food-web models.
- Give students the additional task of identifying and/or researching real examples of organisms that represent the trophic levels in their food-web models. This could be done with labels or photographic images placed over the food-web model disks.

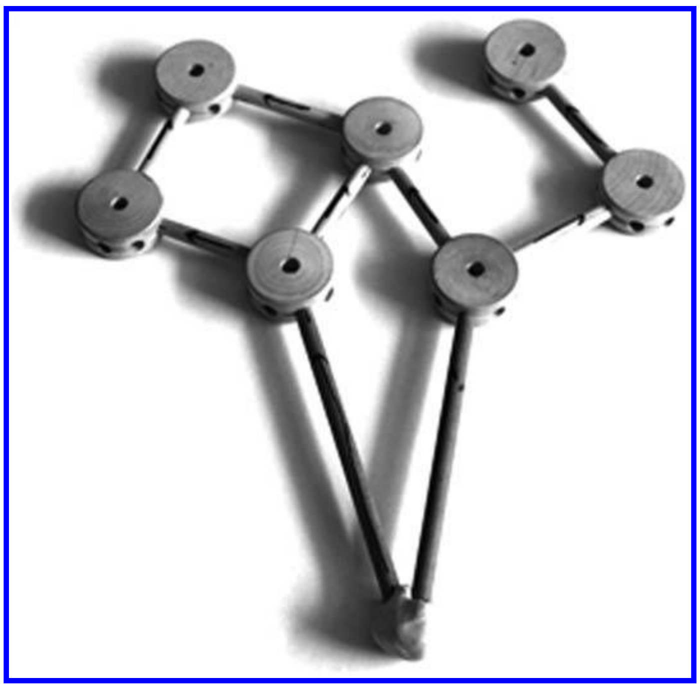

Figure 3. A sample food web with a maximum of three trophic levels. This sample has two producers, three primary consumers, and two secondary consumers.

- Consider using these same Fiddlesticks or Tinker Toys pieces (disks and sticks) to use as materials to model nutrient cycles, such as the carbon and nitrogen cycles. The disks would represent the living and nonliving components of the cycle, and the sticks would represent the movement or pathways of nutrients between the components. This would concretely emphasize the cyclical flow of nutrients vs. the one-way flow of energy in a food web.

○ Conclusion

I have found that this activity quickly identifies areas of student strengths and weaknesses in comprehending food chains and food webs. It helps the instructor in tailoring specific follow-up instruction to improve student learning. Students enjoy the challenge the activity offers and have consistently shared positive feedback after the activity has been completed. It gives an opportunity for students with weaker verbal skills to show their understanding through the proper building of models and helps them build a bridge toward better expression of the vocabulary. Those students with stronger verbal skills have a chance to show their understanding through the peer-review component of the activity.

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RICHARD GRUMBINE is Associate Professor of Natural Sciences at Landmark College, River Road, Putney, VT 05346. E-mail: rgrumbine@landmark.edu.