Ecosystem Food Web Lift-the-Flap Pages

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Journal of STEM Arts, Crafts, and Constructions
Volume 2, Number 1, Pages 16-31.

The Journal's Website:
http://scholarworks.uni.edu/journal-stem-arts/

Abstract

In the lesson on which this practical article is based, third grade students constructed a "lift-the-flap" page to explore food webs on the prairie. The moveable papercraft focused student attention on prairie animals' external structures and how the inferred functions of those structures could support further inferences about the animals' diets. In general, most students made simple causal connections between an animal's observable characteristics and the food it would probably eat. Some students were also able to make multi-agent connections to develop a more complex mental model of a food web. Ultimately, the lift-the flap project was engaging to students and motivated them to focus their attention on the characteristics of animals of different ecosystems to infer their probable diets.

Key Words

STEAM, STEM, Moveable papercraft, lift-the-flap, food web, ecosystem, structure and function, cause and effect.

Introduction

This lesson simultaneously engaged students in engineering a paper construction with science content about ecosystems and the interdependence of organisms. Although the lift-the-flap concept has often been used in children's picture books (e.g., Daynes, 2016; Farndon, 2016) and has been used in simple picture – picture or picture – word activities in which students glue or tape a paper rectangle to a page to make a flap (e.g. James, 2011; Small, 2013), the activity we describe here is more complex. Students learn to cut small hinged doors in a pictorial ecosystem page and to fill aligned spaces on a backing page with drawn images related to food webs. During the lesson, students evidenced a lack of prior experience with engineering paper constructions and therefore, additional evidence that the activity was novel and challenging. The result was an opportunity for students to demonstrate their knowledge of food webs in a new way.

Literature Review

The following literature review examines the importance of spatial thinking skills to STEM career choice

before defining moveable papercraft and examining recent studies that have employed movable pages in science projects. Finally, the recent literature pertaining to elementary students' stages of thinking in explaining ecosystem cause and effect relationships is discussed.

Importance of Spatial Thinking Skills

Well-developed spatial thinking skills are associated with choosing a career in STEM areas because spatial thinking allows students to solve problems and build understandings of difficult concepts before they have developed deep knowledge in the domain (Uttal & Cohen, 2012). At all ages, males tend to outperform females in spatial thinking skills, affecting the number of females that contemplate STEM careers (Voyer, Voyer, & Bryden, 1995). However, activities that exercise spatial thinking can help females attain the skills and confidence to consider taking a STEM career path (Vasta, Knott, & Gaze, 1996). Construction of lift-the-flap pages, as described in this article, assists students in noticing how flaps are cut to open in a desired direction and how pages are superimposed on each other to allow images to show through flaps. These spatial thinking skills are a small, but important, part of a foundation for spatial thinking.

Moveable Papercraft Science Lessons

What are Movable Papercrafts? "A *moveable* is a papercraft in which the user touches or moves one or more elements to generate an *effect*" (Annett, Grossman, Wigdor, & Fitzmaurice, 2015, p. 565). The effect might be to reveal an image or text underneath a flap, or to have an image move when a tab is pulled. Movables can transform conventional images into a unique, game-like experience to increase interest, improve comprehension, and connect oral language with text (McGee & Charlesworth, 1984). The popularity of making moveable books has spurred the development of software to assist in movable book creation (Annett et al., 2015). Makerspaces in school libraries often provide a place for elementary students to explore papercrafts and movable designs (Lamb, 2015), indicating the popularity of this approach.

A simple-to-make type of movable papercraft is a Foldable™: interactive graphic organizer made of folded paper generally glued to the page to create flaps that are used to display information. Foldables™ allow students to record, organize, and retain information (Zike, 1999). A counterbalanced repeated measures study of third graders using Foldables™ in one of two social studies units showed a significant increase in positive attitude compared to the control condition of using worksheets that addressed the same content while there was no significant difference in content gain scores (Casteel & Narkawicz, 2007).

Paper Constructions Generate Student Interest. Engaging elementary students in arts and crafts creates interest and focuses student attention on content. In one elementary student science project (Rule & Webb, 2015), second grade students increased their understanding of mechanisms for day and night by creating movable books that included a rotating earth that moved under a half-shadowed plastic film and a merry-go-round of animals viewing different scenes as they rotated. A movable book project developed to teach students about animal skulls features and functions (Klein, Gray, Zhbanova, & Rule, 2015) included two types of pop-ups showing animal skulls, a turning wheel behind the page with windows that showed selected parts of the printed wheel to explain tooth types and functions, and a lift-the-flap page with skulls on the flap and the corresponding animal's head below the flap. These authors pointed to the attention and focus that students have while constructing the movable pages. Hand movements and tactile examination of objects are key in maintaining student attention as they cut, fold, glue, color and arrange the paper objects (Lillard, 2005; Sobe, 2004). The making of movable book pages was met with great enthusiasm and interest during Klein et al.'s project (2015), as students remarked how cool the books were and stated their desire to make one.

Pop-up Constructions in Environmental Science. Another elementary student paper construction project featuring pop-ups (Olsen, Zhbanova, Parpucu, Alkouri, & Rule, 2013) indicated that combining art with environmental and ecology issues through pop-up constructions allowed fourth and fifth grade students to be creative, and to engage in inquiry or concrete activities,

using motor and spatial skills. In this project (Olsen et al., 2013) students made pop-ups in file folders with images cut from magazines to express their views of environmental problems and solutions in which elementary students could be involved. A study of upper elementary students (Gray, Elser, Klein, & Rule, 2016) explored what youth can do to solve environmental issues through reading pertinent texts, applying a system of thinking skills to the problem, writing essays, and making pop-up scenes of solutions. The authors (Gray et.al, 2016) found that the construction of pop-ups motivated students and allowed them to creatively showcase their ideas. An additional resource of ecology undertakings for elementary students (Rule & Vander Zanden, 2012) addressed multiple intelligence areas and included jointed models of small mammals to make along with hands-on activities such as pop-ups, cartoons, dioramas, and maps. Lift-the-flap pages appear to be a new addition to the environmental science professional literature. This practical article shows how this paper construction technique was used to motivate and challenge students as they explored ecosystem food web relationships.

Movable Papercrafts and STEM Education. In the previous section on spatial thinking skills, we identified the need for strong spatial thinking skills for success in STEM education. STEM projects that integrate spatial reasoning, such as this lift-the-flap ecosystem food web activity, serve the dual purpose of practicing science content and spatial skills together.

Stages of Elementary Students' Learning about Ecosystems

Two recent studies have explored elementary students' conceptions of ecosystem relationships, the topic of our lift-the-flap activities. Both of these studies examined how student reasoning became more complex as their understandings of ecosystem relationships expanded.

Researchers (Lehrer & Schauble, 2012) worked with kindergarten through sixth grade students to assist them in developing models of how ecosystems, among other big ideas of science, operate. According to the results of their work, elementary students can best begin to understand ecosystems by examining local ecosystems, even as close as the school's backyard. Attention should be drawn to how various areas of the system provide conditions for supporting organisms and to observations of an organism's form, structure, features, or behaviors that permit it to use the resources in its habitat. Attempting to view the place an organism lives from its perspective helps students to grasp the differences between locations in the ecosystem's area. At the next level, students begin to describe interactions between organisms and parts of the environment. At first these may be simple causal chains, but eventually, students begin to describe multi-agent interactions and feedback cycles over time and across different scales in the ecosystem. Finally, students are ready to investigate the effects of different perturbations on the system such as loss of a species, invasion of a new species, or climate change (Lehrer & Schauble, 2012).

Similar work by later researchers focused more on student reasoning about ecosystems. A structured interview study of 44 elementary students in grades first through fourth (Hokayem & Gotwals, 2016) defined stages in a learning progression of how elementary students use reasoning to explain ecosystem interactions. These researchers identified five reasoning patterns. The earliest pattern was anthropomorphic reasoning based on personal feelings without objective mechanism or cause, such as giving an emotional reaction to the death of animals. At the next stage, students used concrete practical reasoning based on obvious patterns in their own experiences with the natural world to explain events or interactions, such as explaining that "they are dead" as the effects of the loss of insects. More logic was used in the third level, simple causal reasoning, in which students use one external factor to explain an ecosystem change, for example, giving one effect of all blackbirds dying as foxes will then eat more opossums. Semi-complex causal reasoning occurred fourth in which students considered multiple external factors in an ecosystem and a chain of causes and effects; and finally, complex causal reasoning in which a network of interconnected relationships is acknowledged and used to reason. These researchers found that students made use of multiple stages in their explanations of ecosystem dynamics.

The ecology lesson currently being described in this article focuses on student reasoning about food web

interactions in the ecosystem. The authors employed lift-the-flap constructions to allow students to record their understandings of the diets of different members of an ecosystem and therefore their interactions with other organisms and resources of the ecosystem. This was an initial lesson in ecosystems for the participating third graders and was followed by many others.

Standards Supported by the Lesson

The described lesson took place in Iowa. The Iowa Core Science Standard (Iowa State Board of Educators, 2015) related to the lesson was Ecosystems: Interactions, Energy, and Dynamics, 3–LS4–3: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. This standard was supported by examining the dietary needs of key animals of various ecosystems to later draw inferences about survival and ecosystem interactions.

A Next Generation Science Standard (NGSS Lead States, 2013) for fifth grade students were supported by this lesson, Interdependent relationships in ecosystems 5-LS2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. This standard was supported as students identified food sources for the animals in an ecosystem and traced the base food source to plants.

A National Core Arts Standard (National Coalition for Core Arts Standards, 2013) for third grade related to Anchor standard 2: Organize artistic ideas and work, was addressed by this lesson. More specifically, students' work supported the visual arts creating standard 2.1.3a: Create personally satisfying artwork using a variety of artistic processes and materials, as they learned the new paper engineering process of making a lift-the-flap page and drew and colored images of food for different animals in an ecosystem during the expansion phase.

Method

Twenty third grade students (11 male, 9 female) attending a middle class elementary school in a mid-sized city in the central United States participated in the lesson. Students were arranged in five groups of four students each. The classroom teacher arranged the students into ten pairs of partners who would work together well.

Materials and Equipment

This lesson included hands-on crafting materials as well as the integration of educational technology. The materials used for this lesson were scissors, white craft glue, and color print-outs on cardstock of the lift-the-flap page fronts and backs for various ecosystems. After the initial work in reproducing a lift-the-flap page designed by the researchers, students used computers to research animal diets as they tried to construct the lift-the-flap cards for a new, given ecosystem. The Appendix provides the cover pages of five different ecosystems provided to students. Additional technology used during the lesson was the document camera and multimedia projector the teacher used to project an up-close view of the images on the cards and the technique for properly cutting the flap doors. All graphics were created by one of the authors. Copyright-free clipart from Microsoft PowerPoint was used in the creation of the ecosystems, along with some images drawn by an author in PowerPoint.

The Lesson

The lesson was taught through the 5E's Learning Cycle Model (Bybee et al, 2006) to promote student inquiry into the lesson topic. The following sections detail the lesson procedures and results.

Lesson Engagement Activity

The guest teachers began the lesson by showing students an example lift-the-flap page of a woodland or temperate forest biome. One example was given to each group of four students. Students were very excited to examine the lift-the-

flap page of a woodland ecosystem. See Figure 1. The guest teacher gave directions to choose an animal, guess what it eats, open one window or flap to see its diet, and then pass the page to the next person to do the same. Students took turns guessing the foods that the animals ate; they were correct much of the time, showing the teacher that they had some background knowledge of these animals. Figure 2 shows students checking their ideas by lifting a flap on the example lift-the-flap page. Handling the lift-the-flap page certainly gained student attention and focused it on food interactions in an ecosystem web. The classroom was a happy buzz of activity as students guessed the foods of the animals and speculated about whether they might be making a lift-the-flap page themselves.

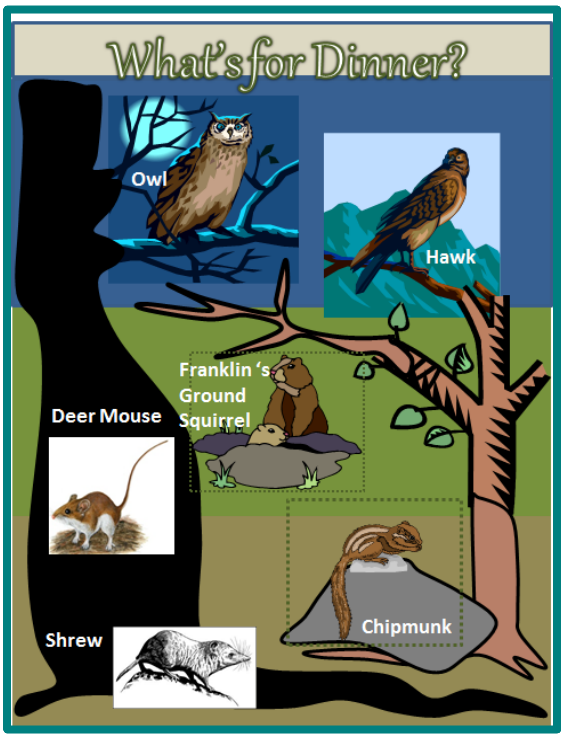

Figure 1. Front of the lift-the-flap ecosystem example supplied to students.

Figure 2. Students checking their ideas about the diet of an animal by lifting the flap.

Exploration Phase

The guest teacher asked students to name animal needs in a biome or ecosystem to determine their prior knowledge. Students suggested that they have to have air; need food; need living plants like trees or grass; must have a source of water; a shelter; and need to be from the habitat; and need other animals of their species. Students also mentioned that invasive species like the snakehead fish and Burmese python can ruin a habitat. Students were visibly interested in ecosystems and eager to share their previous knowledge.

Cardstock color-copies of the parts of a new lift-the-flap page about the prairie ecosystem were provided to students. See Figure 3. The guest teacher asked students to look at the six animals (thirteen-lined ground squirrel, hawk, owl, badger, mole, and vole) to determine which ecosystem was being portrayed. Students suggested desert, cornfield, wheat field, and finally, prairie. These guesses, again, indicate that students had quite a bit of background knowledge of the ecosystem. All of the guesses were at least somewhat logical, considering the given animals.

During this phase of the learning cycle, students self-questioned themselves about their understandings of the given animals. They experienced some disequilibrium as they wondered what they would do during the main part of the lesson. The teacher also learned what students did and

did not understand about ecosystems and this knowledge helped prepare her to guide students during the next lesson phase.

Explanation Phase

The guest teacher gave directions for folding the cardstock page in half and then cutting along the fold. Students then cut off the strip at the top of the page that featured six rectangular diets that were made with small clipart images. They cut the "windows" or "doors" or "flaps" on each of the rectangles that showed the six prairie animals by cutting three sides of the rectangles around each of the animals. To begin the cutting, the paper was gently folded across one side of a rectangle and pinched to snip a slit along one side of a rectangle. Then, one of the scissors blades was inserted into that slit and the rest of that side and two more sides of the rectangle were cut out to make the flap. The flap was then folded on its "hinge." After all flaps had been prepared, students placed the backing with pale rectangles behind the front to make sure these rectangles could be aligned with the open flaps. They did not glue the backing at this time. Students were given a few minutes to try to place the correct diet behind each animal's flap. This diet was not yet glued into place. See Figure 4, a composite of photos of students working on this part of the project.

Figure 3. The color page printed on cardstock paper that will be assembled to make a lift-the-flap page.

The guest teacher led a discussion, asking students to suggest a diet for one of the animals and to justify it with reasoning. Other students could then agree with different reasons, or suggest another diet and give their reasoning. Students were directed to think about the various features the animals have, where they live, and what features make them successful in their habitat. The following excerpts show example student responses.

Ideas about the Badger:

- The badger seems to be a bigger animal. I know the coyote eats high protein because it is a bigger animal; so the badger will probably eat bigger food like the diet of small mammals.
- A classmate says she has seen a badger and they are smaller than a coyote. However, she agrees with the small mammal diet because badgers have long front claws for digging and can dig out little animals from burrows.
- Another student remarks that he saw a badger eat insects at a zoo.

Ideas about Eastern Mole:

- A student notes that moles dig tunnels and live underground. She suggests that the orange part of a carrot is underground and may be eaten by a mole.
- There are a lot of bugs underground and so I think moles eat bugs, suggests a student.
- Another student says that moles have whiskers and are blind and they eat a lot of bugs underground.
- A student remarks that she had a mole in her back yard and she saw it eat something that was moving.
- Another student states that a mole might come up and hunt, but if it is blind it might have trouble catching something.

Ideas about Meadow Vole:

- The meadow vole is small and so it eats small food.
- It probably eats grasshoppers and seeds because it lives above ground and can dig underground.
- Another student agrees “because you can find bugs and seeds above ground. It is more likely to eat insects- I have seen mice eat insects.”
- I think the vole eats all plants because it is small.

Students were asked to consider which animal spends the most time underground and what body features might be evidence of that underground lifestyle. Students answered that the small eyes and digging claws of the mole were such features.

Ideas about the thirteen-lined ground squirrel:

- May eat grasses and mushroom because they are on top of the ground.
- Might eat carrot, worms, mouse, and frog; gopher eats this because it seems to be in a burrow in the picture and has digging claws.
- The ground squirrel should eat mushrooms because they run into them. They are easy to find and barely run out (are not scarce).

These responses show the logic students used to draw conclusions from known animals like the coyote to a lesser-known animal like the badger. Although all ideas were not supported by the actual diets of the animals, students exercised appropriate thinking skills in attempting to determine the animals’ food sources. Most student reasoning was at the “simple causal” or “semi-complex causal” reasoning stages (Hokayem & Gotwals, 2016) using either one factor to explain an ecosystem (e.g. “I think the vole eats all plants because it is small) or using multiple external factors to develop a chain of related causes and effects (e.g. noting that “moles dig tunnels and live underground. [Therefore] she suggests that the orange part of a carrot is underground and may be eaten by a mole.) Because this was an introductory ecosystem lesson, it is appropriate that most students would be describing simple causal chains while learners with more advanced reasoning were describing multi-agent interaction (Lehrer & Schauble, 2012).

The guest teacher then passed out completed lift-the-flap cards of the prairie for students to check their work. There was a brief discussion of the correct diets. Now, students were ready to glue the correct diet onto the pale rectangles of the backing and glue the top part (but not the backs of the flaps) on top to make a complete lift the flap page. See Figure 5.

During the explanation phase, students came back into equilibrium regarding how the lift-the-flap page can be used to show animal-food relationships. Students discussed their ideas about the animals of the prairie ecosystem, learned the actual diets of the animals, and learned to construct the lift-the-flap pages. Just as Lillard (2005), Sobe (2004), and Klein et al. (2015) observed, students exhibited great enthusiasm while simultaneously paying close attention to the ecosystem content in the lift-the-flap project as they folded, cut, and glued the project together.

Figure 4. Students working on cutting the lift-the-flap page parts and flaps.

Figure 5. Cut (left) and glued (right) lift-the-flap pages.

Expansion or Elaboration Phase

Students were told that they would now make another lift-the-flap page for a new ecosystem, but this time they would have to research the diets of the six animals and draw them to make the page. Cardstock color images of animals from five different ecosystems: the arctic tundra, the temperate rainforest, the temperate wetland, the temperate forest, and the desert were provided to the groups so that members of each group worked on the same ecosystem and each student was involved in making a lift-the-flap page of his or her own. See the Appendix for these materials.

Students were called by groups to pick up their computer laptops from their storage area. As a group, students decided who would investigate the diet of which animal. They researched the diets of the animals on the ecosystem they received, informed the group, and drew two or three foods for each animal. Then, they assembled the lift-the-flap page. These same ecosystems will be used in other future lessons, so this lesson provides a good knowledge foundation for those later lessons. In this phase, students practiced their new learning and created a new lift-the-flap page with information they researched themselves.

Evaluation

The lift-the-flap pages were examined and scored by the classroom teacher. She used the following criteria: completeness of having at least two food items for each of the animals; accuracy of these food items being part of the actual diet of the animals; fit of the drawings into the provided space; recognizable portrayal of the foods in the drawings; thoroughness of gluing; functionality of the lift-the-flap page, and overall appeal. See Table 1 for the rubric.

Table 1. Rubric for Scoring Student Work

Criteria Questions	Scoring				
	Yes, entirely	Mostly	Somewhat	A little	No
	4	3	2	1	0
1. Did the student draw at least two foods for each animal?					
2. Were the food items depicted correct for that animal?					
3. Did the drawings fit into the required space under each flap?					
4. Were the drawn foods recognizable?					
5. Was the lift-the-flap page thoroughly and neatly glued?					
6. Was the lift-the flap page functional and well-made?					
7. Was the work overall appealing and correct?					
Possible Points = 28					

Conclusion

The lift-the-flap page construction project was well-received by students who were eager to learn a new construction technique for presenting information in a puzzle-like manner. The web of animal food interactions was a compelling topic for the third grade students. All students were successful in assembling the lift-the-flap pages.

Tips and Suggestions

- Demonstrate for students how to keep the windows or flaps bent open during the gluing stage so that they are not accidentally glued shut.
- Use a document camera to project enlargements of images on the cards and the techniques for cutting three sides of each flap and then keeping the flaps open while gluing.
- Break the lesson up into two or three shorter sessions so that students are able to move around more. Working at their desks for 90 minutes may be too long to keep their attention focused on one task.

Acknowledgements

This material is based upon work supported by NASA under Grant No. NNX15AJ16H. A grant from the Iowa Biotechnology Association also supported this work.

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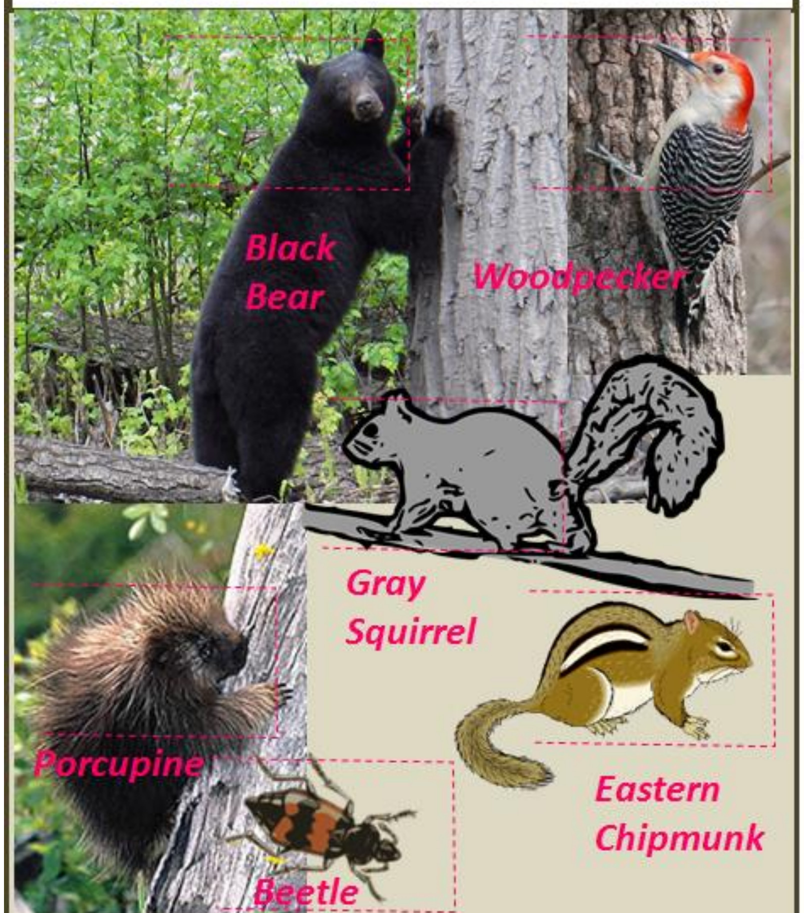
Appendix of Lift-the-Flap Pages for Assembly Begins on the Next Page

Wetlands: What will I eat?

Desert: What will I eat?

Temperate Rainforest: What will I eat?

Temperate Forest: What will I eat?



Tundra: What will I eat?